Governing a Volcanic River Basin

A culture-sensitive inquiry into the current water resources management practices of Opak Sub-Basin, Indonesia

Vicky Ariyanti

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Besturen van een vulkanisch stroomgebied
Een cultureel gevoelig onderzoek naar de huidige waterbeheerpraktijken
van Opak Sub-Basin, Indonesië

Thesis

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Executive Summary

On a beautiful day in November 2010, the Mt. Merapi volcano on the island of Java erupted. The inhabitants were unaware that this time it was not the usual 4-year cycle eruption. The 2010 event was a 100-year cycle eruption. It devastated and crippled the region for a month and resulted in five years of rehabilitation and reconstruction. Inhabitants from the upstream region of Merapi fled to urban areas. After shelter, water was their next most urgent need. Clean water became scarce, due to ash rain, lahar floods in rivers, and sulfur infiltration into groundwater. This is where indigenous knowledge became useful. Indigenous inhabitants provided an alternative way to manage the water based on historical experiences. Examples include: accessing a river's base flow for drinking water, rather than waiting for water tankers to deliver water; checking whether well water has been contaminated by sulfur infiltration by tasting it rather than waiting for laboratory results of water quality testing; avoiding lahar risk by not crossing the river when it has rained; listening to the type of flow coming down the river to ascertain whether it is a lahar flow. In these conditions, local knowledge played a role in the way people reacted to their natural surroundings. These facts triggered the researcher to study the theme of cultural ecological knowledge in water resources management practices under volcanic conditions.

The research starts in Chapter 1 with an explanation of the context of a volcanic river basin, elaborating the example of the Indonesian archipelago located in the Pacific's Ring of Fire. This chapter also defines the objective of the research, which is to answer the main research question (RQ): How does cultural ecological knowledge contribute to the integrated water resources management of a volcanic river basin? This question prompts the other sub-research questions (sub-RQs) on the current implementation of management practices for water, lahar, and volcanic river basins and their link to the use of cultural ecological knowledge.

The literature review in Chapter 2 explains the concepts used in this thesis. The concepts are cultural ecological knowledge (CEK), integrated water resources management (IWRM), lahar risk/resources management (LRM) relating to the disaster risk reduction (DRR) framework, volcanic river basin (VRB), multilevel governance (MLG), interaction attempts, and integration level. Interactions occur where actors across levels and sectors congregate to discuss problems and negotiate. In this study, these interactions are termed as interaction attempts because they are not always successful. The integration level is determined from low to high: coordination, collaboration, and coordination. An initial conceptual framework links these concepts. The framework clusters the concepts into (1) an independent variable: CEK and (2) a dependent variable: volcanic river basin management (VRBM), which encompasses IWRM, LRM, and MLG. The conceptual framework proposes possible relationships (positive, negative, or neutral) between the independent and the dependent variable.

Chapter 3 explains why the researcher chose to use purely qualitative methods. This choice was based on the nature of the study, which needs in-depth knowledge of a specific culture rather than an extensive understanding (Yin, 2009, Flick, 2008, Kothari, 2004, Berkes, Folke, et al., 1995, Inglis, 1993, Steward, 1972). Therefore, an embedded case study was chosen to address the scope of a volcanic river basin. This research design is relevant to examine the blurred boundaries between the phenomenon of interest (VRBM) and the context (volcano). For this chosen method, the researcher utilizes rich data collected from interviews, observations, and focus groups – based on two periods of fieldwork – and secondary data from regulations, reports, planning documents, policy briefs, and minutes of meetings of related actors. The first fieldwork, conducted in the dry season from August to September 2016 (two months), included observation periods and 47 interviews in the sub-cases (up-, mid-, and downstream communities) and organizations (national, regional, municipal) as well as with experts. The second fieldwork was in the rainy season, from the end of December 2017 to January 2018 (1 month), which included 10 more in-depth interviews as a validity check with respondents in organizations and experts. The analysis used Atlas.ti software to form an axial coding based on the theoretical concepts. Constant comparisons of data are used throughout Chapters 4 to 6, with more in-depth, meta-level analysis in Chapters 7 and 8. The analysis presents the implementation of the concepts, which are clustered into themes of findings. It also explains the interaction attempts in each of the themes. From these, levels of integration are determined, whether coordination, collaboration, or cooperation.

Chapter 4 presents the answer to the sub-RQ: What are the main elements of cultural ecological knowledge in a volcanic river basin, and how is it formulated? Consequently, it explains the five existing CEK forms, specifically in the context of water resources management in a volcanic basin. The forms are also known as the mechanisms of transfer. These are philosophies, internalization, artifacts, resources management practices, and five senses wisdom. Three of them – artifacts, resources management practices, and five senses wisdom – are 'hard' CEK. They are directly used and have tangible results. The last two – philosophies and internalization – are 'soft' CEK; these are embedded in the CEK agents' minds and reflected in their activities or decisions. The CEK agents are those who practice CEK in current management practices.

CEK formulation is based on historical experiences, legitimization, and symbolization. The more extreme these historical experiences are, the more successfully is CEK embedded. Another factor is legitimization, either orally by cultural figures or written (in ancient scriptures or current regulations). In the process, CEK agents are rooted in communities. These CEK agents are essential actors in interaction attempts in later chapters. The more symbolized a form of CEK is into other forms; the deeper it is embedded in society. An example of a significant CEK is the philosophy of *hamemayu hayuning bawono* (beautifying the world's beauty) symbolized in the philosophical axis and internalized in the rituals of *labuhan* (thanksgiving), also the sacred artifacts of upstream Opak River at Mt. Merapi and the Parangkusumo Beach estuary. This formulation process provides the foundation for a culture-sensitive approach to the management of this VRB.

Chapters 5, 6, and 7 explain the dependent variable (VRBM). The MLG lens is used to untangle the boundaries of management (IWRM and LRM) within the complicated VRB conditions. The lens is helpful in revealing existing boundaries, such as jurisdictions, themes, and administrative levels.

Chapter 5 answers the sub-RQ: How is the integrated water resources management (IWRM) approach implemented in a volcanic river basin? The chapter highlights some of the most valuable experiences on how to implement this approach in the VRB context. The implementation embodies Indonesia's main pillars of water resources management: conservation, utilization, and hazard control. These pillars are handled not by one organization, but by multiple actors. This chapter found that the IWRM implemented in this basin is similar to that implemented in other non-volcanic locations in Indonesia, although this VRB has a special hazard control treatment, as it experiences flood, drought, landslides, and also lahar flows.

The MLG concept is used to explain the IWRM implementation. The following are the findings for each level.

(1) The policy setting is based on the IWRM approach, but the Indonesian law for water management is currently annulled, creating uncertainty regarding implementation.

(2) The managerial context uses the river basin territory (WS), river basin (DAS), and existing administrative levels as the management scale. Like the implementation itself, this chapter also uses the Indonesian IWRM main pillars of conservation, utilization, and hazard control. Each sub-case has different pillar priorities. For example, sub-case 1 prioritizes hazard control and conservation, sub-case 2 is more concerned with flood hazard control, and sub-case 3 focuses more on utilization. In general, the IWRM implementation is found to be 'boxed' sectorial management: conservation is undertaken by the forestry sector, utilization by the public works sector, and hazard control by the disaster sector. However, this boxed management congregates at regional level, because that is where the municipal, regional, national, WS, and DAS actors gather. Notably, the congregation reflects the implementation pillars of hazard control and utilization.

(3) Interaction attempts at IWRM implementation are themed as budget, water, and disaster, with budget and water themes as dominant interactions.

(4) The integration level of IWRM is determined based on successful interaction attempts at each IWRM pillar within each governance level. The interaction attempts display varying levels of integration across the IWRM pillars. The highest level – cooperation – belongs to the hazard control pillar, with disaster and budget interaction attempts. The mid integration level – collaboration – belongs to the utilization pillar, with water- and budget-themed interaction attempts. The lowest level – coordination – is found in the conservation pillar, with water and budget interaction attempts.

The varied levels arise from the different intensity of interaction attempts and the quality of actors who act as the communication bridge. The actors contributing to the integration level are located in the water interaction attempts, between government and communities. They are known as 'whisperers.' They operate subtly and nudge gently to encourage others to adopt their suggestions. The more whisperers are found, the higher is the level of integration. In summary, the regional level has more whisperers than the other levels and the highest level of integration. This level is indicated as 'the priority playing field' for IWRM implementation in a VRB.

Chapter 6 answers the sub-RQ: What constitutes lahar management (LRM) and how is it implemented in a volcanic river basin? LRM is based on the disaster risk reduction (DRR) framework and divided into three disaster phases: pre-eruption, eruption onset, and post-eruption. The pre- and post-eruption phases are part of IWRM, whereas the eruption onset phase relates purely to DRR. Lahar <u>risk</u> management takes place in all phases, but lahar <u>resources</u> management relates only to the post-eruption phase. The following items characterize LRM implementation.

(1) Non-existence of direct lahar policy setting. Bits of related policies are scattered in the hazard control pillar of water management, lahar control in volcanology, and disaster management.

(2) Lahar management is a multilevel governance condition and strongly based on the administrative governance level with the disaster management agencies as leading actors.

(3) Interaction attempts found are similar to those in Chapter 5, themed as water, budget, and disaster.

(4) Integration levels are found to be highest in the eruption onset phase with disaster interaction attempts. This phase has the highest level of integration because it combines formal and informal ways of interacting and is located at regional level.

This chapter also highlights the shifting roles of actors within interaction attempts during eruption phases. As lahar does not relate to specific interaction attempts, it is discussed through the three existing interaction attempt themes: budget, water, and disaster. More attention is given in disaster attempts, as lahar is more likely at the onset of an eruption. In these attempts, another type of bridging actor is found, called the 'contact person.' Such persons exist in informal ways in disaster interaction attempts. As they are more often found during the disaster onset phase, they are short-term actors. The more informal interaction ways combine with a high urgency phase for eruption, the more integrated is the level of LRM implementation. The integration level is higher for LRM than for IWRM implementation, primarily during eruption onset. Pre- and post-eruption, the integration level diminishes. This different level of integration results from the difference in the quantity and quality of informal interaction ways and contact persons, who are more engaged and insistent during eruption onset. Moreover, lahar can be more flexibly managed in terms of budgeting and can use all kinds of interaction attempts during all phases.

Chapter 7 answers the sub-RQ: How and why does lahar management related to integrated water resources management in a volcanic river basin? For the 'how' part, the researcher assessed the existing overlap between the implementation of IWRM and of LRM. Here, the VRBM concept is introduced as an integrated approach for the overlapping activities in a VRB. It starts with the clustering of activities in the IWRM pillars (water conservation, utilization, and hazard control) into the LRM temporal scales: pre-, onset-, and post-eruption. The clustering is presented as three phases of VRBM, termed as Normal VRBM, Disaster VRBM, and Normal+ VRBM. Normal VRBM consists of a pre-eruption condition where *in-situ* water conservation and utilization are functional. Disaster VRBM includes *in-situ* hazard control and *ex-situ* water utilization, without water conservation. Normal+ VRBM consists of all pillars in Normal VRBM plus lahar sediment utilization or sand-mining activities.

Within these VRBM phases, the actors are those managing water and lahar. The chapter reveals several main findings.

(1) The Normal and Normal+ VRBM have similar policy settings. Both use water management and spatial planning policies. Meanwhile, Disaster VRBM uses disaster and volcano management policies.

(2) All of the phases prioritize the regional level. This condition occurs because all managerial contexts of water, volcano, disaster, and lahar focus on this level. Whether river basin territory, catchment, volcano, or administration boundaries are used as the unit of management, all congregate there. The key for all VRBM phases to function correctly is the flexibility of actors, which take different roles within each VRBM phase.

(3) The interaction attempts differ for each VRBM phase. For example, during Normal and Normal+, both water- and budget-themed interactions take place, whereas, for Disaster, only disaster-themed interaction takes place. This fact suggests that management flexibility is needed to perform such tasks.

(4) The integration level is highest in Disaster VRBM, as it combines the highest integration level of hazard control pillar (IWRM) and eruption onset condition (LRM) cooperating in coping with the eruption phase. Normal VRBM ranks second, where water conservation and water utilization pillars combined with the pre-eruption condition produce collaboration activities. Normal+ VRBM ranks lowest in integration level because sand-mining activities and the post-eruption condition contain no integration attempts.

The reason why lahar management relates to the IWRM of a VRB is the overlapping activities of IWRM and LRM. This chapter reveals a factor undetected in the conceptual framework of Chapter 2. This factor has been categorized as 'sectorial boundary spanners,' who exist within interaction attempts and bridge different sectors. They are known as boundary organizations and boundary spanners in governance theory. The river basin organization handles the overlapping of boundaries at organizational level. At individual level, many actors perform overlapping activities. The actor in the budget attempt is the 'broker.' Brokers bridge the levels of government or inter-ministerial interactions. However, financial gains tend to accrue in their operation, and the person is changed annually. Another type of actor is the contact person, as recognized in Chapter 6. Such persons operate as the 'go-to' person in a disaster, profoundly sincere, but short-lived as they exist only during a disaster onset. The whisperers, as in Chapter 5, are honest boundary spanners and exist in all interaction attempts. The whisperers achieve sustainable networking with existing organizations from the interaction attempts. The level of embeddedness of these connecting actors from shallow to deep is as follows: brokers, contact persons, and whisperers. Therefore, the VRBM phase that has the most sectorial boundary spanning actors enjoys the highest level of integration – Disaster VRBM.

Chapter 8 focuses on answering the last sub-RQ: How and why does cultural ecological knowledge impact the management of a volcanic river basin? The 'how' is answered by the types of CEK impacts projected to VRBM; when CEK exists and is used, it is signaled as (+), when it does not exist, this is marked as (0), and when it exists but is not used as (-). The chapter unfolds the CEK impacts as follows.

(1) Regarding policy setting, the (+) CEK impacts for Normal VRBM result from the mainstreaming of CEK in nature conservation policy. The (+) CEK impacts for Disaster VRBM result from CEK being considered as an essential asset in disaster management policy. Finally, the (-) impacts for Normal+ VRBM result from sand-mining management having no relation to CEK.

(2) The managerial contexts also reveal that the (+) impacts are more evident in Disaster VRBM and Normal VRBM phases than in Normal+ VRBM. These impacts occur at regional and municipal level. The Normal+ VRBM has (-) impact, as it does not use any CEK in management implementation, resulting in the overmining of sand in the riverbed.

(3) The interaction attempts with (+) CEK impacts are located mostly at regional and municipal level, where the researcher found actors known as 'cultural boundary spanners.' These actors are similar to the actors found in Chapter 7, known as sectorial boundary spanners, but here their function is to deliver CEK to the interaction attempts.

(4) The integration level is highest when most (+) CEK impacts occur. This condition correlates with the existence of cultural boundary spanners. The spanners are more evident in informal ways of interaction attempts than in formal ways. Therefore, the more informal ways are found, the higher is the integration level achieved.

The latter part of Chapter 8 explains why CEK impacts VRBM. The answer lies in the presence of the cultural boundary spanners. These actors are not detected in only one VRBM phase, but rather throughout all VRBM phases. These cultural boundary spanners are called 'attached' when they belong to an organization and 'free' when they function as a catalyst and do not belong in any organization. At regional level, in this study, the attached type detected is the founder of Pammaskarta DIY, who acted as a whisperer and a facilitator. The free type detected is the Prince of the Kraton, who became the discussant during the meetings on water catchment regional regulation (PerdaDAS DIY) formulation. At municipal level, most cultural boundary spanners are the attached type and belong to community-based organizations. The chapter found that the whisperer as the honest spanner has a better chance of delivering CEK, primarily because whisperers operate using CEK values.

Another critical factor is the existence of a conducive atmosphere, which makes it easier to implement CEK in the daily practice of water resources management. This atmosphere results from activities by boundary organizations and boundary spanners, allowing CEK to manifest within VRBM. The Indonesian national level has an embryo of such atmosphere in the River Jamboree, but the activity was not part of this research observation period. Therefore, this section focuses only on informal regional and municipal attempts. The components of the conducive atmosphere are as follows. (1) Both boundary organizations and boundary spanners have to be present to set the stage for CEK utilization. (2) Because of the first stage, fear is eliminated by talking outside of scientific boundaries. In this case in this study, connections were made with the precisely relevant personnel in the government organization and, furthermore, trust in using CEK in current management practices was developed.

The last chapter summarizes the answers to each of the sub-RQs. The explanations for each sub-RQ function as reminders of the content of the full chapters (4 to 8), which are the building blocks toward answering the main RQ: How does cultural ecological knowledge contribute to the integrated water resources management of a volcanic river basin? The research answers the main research question by providing an insight into the types of soft and hard CEK that have contributed to enhancing the level of VRBM integration. CEK is not attached to one type of resource; rather, it sees all resources as part of nature. It is therefore sufficiently flexible to embed in any kind of resources management that focuses on the interrelations of water, lahar, and volcano governance. CEK also enhances the conservation aspect of VBRM by guiding wiser utilization of water and related resources and limiting exploitation to ensure the sustainability of the ecological system.

Chapter 9 provides a synthesis of the whole research and an adjusted conceptual framework for future research. The synthesis presents the consequences of merging the CEK and VRBM realms. The CEK realm contributes to the VRBM realm by reminding actors how nature and humans are internally bound in the ecological system. However, to enable the contribution of CEK, the cultural boundary organizations and boundary spanners have to take a strategic position in interaction attempts, while creating a conducive atmosphere to conduct CEK practices. The findings show that current VRBM is at the very beginning of aligning these two. However, this study has provided ample data on actively used CEK from both the community and the government side. These data are an essential asset to create a more participative, effective, and efficient VRBM implementation. Policymakers need to consider the findings of this research in revising the country's spatial plan. They should include the meaning of cultural landscape and the philosophical plane (hard CEK) as a basis for the basin conservation area. The study highlights the use of soft CEK practices in interaction attempts to enhance the integration level, namely, the collective action values (*gotong royong*) found in each VRBM phase. It also proves that CEK has profound impacts on the VRBM integration level. It highlights the role of CEK in smoothing the interaction attempts between actors in water and lahar MLG. In addition, it provides a method to create a more culturally sensitive and participative approach to water management. The study is a document for future generations to understand the 100-year eruption cycle and achieve a better integration level of water and lahar management. Furthermore, this study prompts new questions on whether other river basins with different types of hazards can use this approach. It would be interesting to compare what kinds of CEK are used for what kinds of hazard-prone river basin management and come up with a more generalized theory or concept that encompasses these differences.

Samenvatting

Op een mooie novemberdag in 2010 barstte de Merapi-vulkaan uit op het eiland Java. Op dat moment hadden de eilandbewoners niet door dat deze uitbarsting niet paste binnen de reguliere uitbarstingcyclus van de vulkaan. De regio werd door de uitbarsting verwoest en voor een maand lamgelegd. Gedurende vijf jaar werd gewerkt aan herstel en wederopbouw. Inwoners uit het gebied bovenstrooms van de Merapi vluchtten naar stedelijk gebied. Na onderdak te hebben gevonden, was de watervoorziening een urgente behoefte voor hen. Schoon water was echter schaars als gevolg van vulkanische asregen, modderstromen en infiltratie van zwavel in het grondwater. De inheemse bevolking bood alternatieven voor waterbeheer op basis van hun historische ervaring. Gedurende deze omstandigheden speelde andere lokale kennis een rol in de manier waarop mensen op hun natuurlijke omgeving reageerden. Deze inzichten vormden voor de onderzoeker de aanleiding om het thema van cultureel-ecologische kennis (CEK) binnen de praktijk van het waterbeheer in een vulkanische omgeving te gaan onderzoeken.

In dit onderzoek wordt eerst uitgelegd wat een vulkanisch stroomgebied is, waarbij dieper ingegaan zal worden op het voorbeeld van de Indonesische archipel, gelegen in de 'Ring van Vuur' in de Stille Oceaan. Ook worden de doelstellingen van het onderzoek gedefinieerd, om deze onderzoeksvraag te beantwoorden: "Hoe draagt culturele ecologische kennis (CEK) bij aan integraal waterbeheer in een vulkanisch stroomgebied?" Deze hoofdvraag vormt het vertrekpunt voor de verschillende sub-vragen rondom de uitvoering van de huidige beheersactiviteiten inzake water, modderstromen en vulkanische stroomgebieden in het algemeen. Hierbij wordt steeds de koppeling gemaakt naar het gebruik van lokale cultureel-ecologische kennis.

In hoofdstuk 2 worden, op basis van literatuuronderzoek, de centrale concepten voor deze thesis verder toegelicht. De concepten zijn: cultureel-ecologische kennis (CEK), integraal waterbeheer (IWRM), modderstromen, risico- en bronbeheersing (LRM). Verschillende actoren komen uit verschillende organisaties en niveaus samen en pogen via samenwerking en interacties te komen tot integratie van water, modderstromen en rampbeheersing in een vulkanische stroomgebied (VRB). De (pogingen tot) samenwerking wordt in deze studie aangeduid als interactiepogingen omdat interacties niet altijd succesvol waren. Deze niveaus van integratie van sectoren lopen van laag naar hoog: afstemming (*coordination)*, medewerking (*collaboration)* en samenwerking (*cooperation)*.

In hoofdstuk 3 worden de onderzoeksmethoden beschreven. Er is gekozen voor een kwalitatieve benadering. Deze keuze is ingegeven door de aard van de studie, die vraagt om diepgaande kennis van een specifieke cultuur. Er is gekozen voor genest casusonderzoek om het onderwerp van vulkanische stroomgebieden te bestuderen. Deze gegevens zijn verzameld door middel van interviews, observaties en focusgroepen tijdens twee veldwerkmissies. Ook wordt gebruik gemaakt van secundaire bronnen zoals regelgeving, rapporten, planningsdocumenten, beleidsdocumenten en vergadernotulen. Het eerste veldwerk vond plaats tussen augustus en september 2016, gedurende twee maanden tijdens het droge seizoen van augustus en bestond zowel uit periodes van observaties en het houden van 47 interviews met experts en (nationale, regionale en gemeentelijke) organisaties in drie sub-cases. Deze sub-cases worden gevormd door gemeenschappen in het bovenstroomse, benedenstroomse en tussengelegen gebied. Het

tweede veldwerk duurde een maand en vond plaats tijdens het regenseizoen, vanaf eind december 2017 tot eind januari 2018. Hier zijn toen ook tien diepte-interviews gehouden bij wijze van validiteitscontrole richting de experts en respondenten in de organisaties. Voor de analyse van deze gegevens is gebruik gemaakt van het softwareprogramma Atlas.ti om axiaal te coderen op basis van de theoretisch gedefinieerde concepten. In hoofdstuk 4 tot en met 6 wordt vergeleken tussen de cases, terwijl de hoofdstukken 7 en 8 een diepgaande analyse op metaniveau beschrijven.

Hoofdstuk 4 geeft antwoord op de sub-vragen: “Wat zijn de belangrijkste elementen van cultureel-ecologische kennis (CEK) in een vulkanisch stroomgebied?” en “Hoe komt CEK tot stand?” Het hoofdstuk beschrijft de vijf bestaande vormen van CEK in de context van waterbeheer in het vulkanische stroomgebied. Deze vormen staan ook wel bekend als overdrachtsmechanismen *(transfer mechanisms)*. Dit zijn filosofieën, internalisering, artefacten, de praktijk van middelenbeheer en zintuigelijke wijsheid. Drie daarvan zijn ‘harde’ CEK, te weten artefacten, praktijk van middelenbeheer en zintuigelijke wijsheid. Ze worden direct toegepast en leveren een tastbaar resultaat. De eerste twee daarentegen, filosofieën en internalisering, zijn 'zachte' CEK; deze zijn ingebed in het gedachtegoed van de “CEK-agent” en worden weerspiegeld in zijn activiteiten of beslissingen. Zij zijn dan ook degenen die CEK toepassen in de huidige beheerpraktijk. CEK wordt gevormd op basis van historische ervaringen, legitimering en symboliek. Hoe extremer de historische ervaringen zijn, hoe meer de CEK wordt geïnternaliseerd. Legitimatie van de CEK vormt een andere factor en kan mondeling plaatsvinden door culturele figuren of geschreven documenten (in oude geschriften of in de huidige wet- en regelgeving). Binnen dit proces zijn de CEK-agenten 'geworteld' in de gemeenschappen. Deze CEK-agenten zijn belangrijke actoren in interactiepogingen. Een belangrijk voorbeeld is de filosofie van *hamemayu hayuning bawono* (de schoonheid van de wereld verfraaien), welke is gesymboliseerd in de ‘filosofische as’ en geïnternaliseerd in de rituelen van *labuhan* (*Thanksgiving*), maar ook de heilige artefacten bovenstrooms in de rivier Opak op de Merapi en het estuarium van Parangkusumo Strand.

In de hoofdstukken 5, 6 en 7 wordt het beheer van een VRB uitgelegd en geanalyseerd. De lens van “multi-level governance” (MLG) wordt gebruikt om de grenzen van beheer (IWRM en LRM) bloot te leggen binnen de ingewikkelde staat van het vulkanische stroomgebied. Deze lens helpt om de bestaande grenzen, zoals jurisdictie, thema's en administratieve niveaus, te ontwarren.

In hoofdstuk 5 wordt de volgende sub-onderzoeksvraag behandeld: “Hoe wordt de geïntegreerde aanpak van waterbeheer (IWRM) geïmplementeerd in een vulkanisch stroomgebied?” Het hoofdstuk belicht enkele van de ervaringen met het implementeren van deze aanpak binnen de context van een vulkanisch stroomgebied. De implementatie laat de belangrijkste pijlers van waterbeheer in Indonesië zien: bescherming *(conservation)*, gebruik *(utilization)* en risicobeheersing *(hazard control)*. Deze pijlers worden niet behandeld door één organisatie, maar door meerdere actoren. Dit hoofdstuk wees uit dat het geïmplementeerde IWRM vergelijkbaar is met andere niet-vulkanische locaties in Indonesië. Het vulkanische stroomgebied heeft echter een speciale behandeling voor gevarenbeheersing, omdat het niet alleen vloed, droogte en aardverschuivingen, maar ook modderstromen behandelt.

Het MLG-concept wordt gebruikt om de uitvoering van IWRM uit te leggen. Hierna volgen de bevindingen voor elk van de niveaus:

(1) De beleidsbepalingen zijn gebaseerd op de IWRM-aanpak, maar de Indonesische wet voor waterbeheer is nog steeds nietig verklaard, waardoor onzekerheden rondom de uitvoering ontstaan.

(2) De bestuurlijke context maakt gebruik van het grondgebied van het stroomgebied (WS), het stroomgebied (DAS) en bestaande bestuurslagen als bestuurlijke schaal. Dit hoofdstuk maakt ook gebruik van de Indonesische IWRM-hoofdpijlers voor bescherming, gebruik en risicobeheersing. Elke sub-case heeft verschillende prioriteiten. Sub-case 1 geeft prioriteit aan risicobeheersing en bescherming, terwijl sub-case 2 inzet op overstromingsrisicobeheersing en sub-case 3 op gebruik. De uitvoering van IWRM blijkt sectoraal georganiseerd; de bosbouwsector werkt aan bescherming, publieke werken richt zich op gebruik en de rampensector doet aan risicobeheersing. Sectoraal beheer wordt vooral gevonden op regionaal niveau, omdat hier de actoren van gemeentelijk, regionaal, nationaal niveau en WS- en DAS samenkomen. Opvallend genoeg wordt deze samenkomst gevonden in de toepassing van gebruik en risicobeheersing.

(3) Interactiepogingen voor IWRM-implementatie hebben te maken met de thema's budget, water en rampen, waarbij budget- en waterthema's de dominante interacties beschrijven.

(4) De integratieniveaus variëren met de IWRM-pijlers. Het hoogste niveau van samenwerking *(cooperation)* hoort bij de pijler van risicobeheersing door het thema van rampen en budget. Het middelste integratieniveau van medewerking voor gebruik *(collaboration)* daarentegen gaat over de interactie tussen water en budget. Het laagste niveau gaat over de beschermingspijler, waarbij ook pogingen tot interactie tussen water en budget zijn gebruikt.

De verschillen in niveaus komen door verschillende intensiteit van interactiepogingen en de betrokken actoren. Deze actoren staan bekend als 'fluisteraars' *(whisperer)*. Ze werken op subtiele wijze en met kleine duwtjes in de juiste richting bewegen zij anderen er toe om hun suggesties op te volgen. Hoe meer *'fluisteraars'* er zijn, hoe hoger het integratieniveau. Samenvattend heeft het regionale niveau meer van deze fluisteraars en daarmee het hoogste niveau van integratie.

Hoofdstuk 6 beantwoordt de sub-onderzoeksvraag: "Wat is lahar management (LRM) en hoe wordt het geïmplementeerd in een vulkanisch stroomgebied?" Het is gebaseerd op het concept voor *disaster risk reduction* (DRR) en verdeeld in drie fasen van een ramp: voorafgaand (*pre)*, tijdens *(onset)* en na een uitbarsting *(post)*. De fasen voorafgaand en na een uitbarsting zijn onderdeel van IWRM, terwijl de uitbarsting zelf enkel tot het domein van DRR behoort. Al deze fasen zijn onderdeel van *lahar <u>risk</u> management*, terwijl de post-uitbarsting fase tot *lahar <u>resources</u> management* behoort. Toepassing van LRM wordt gekarakteriseerd door de volgende elementen:

(1) De afwezigheid van beleidsbepalingen die direct van toepassing zijn op modderstromen, alhoewel er verwant beleid bestaat binnen de pijler risicobeheersing van waterbeheer, modderstroom-beheersing en rampenbeheer.

(2) De gevonden interactie-pogingen zijn vergelijkbaar met die uit hoofdstuk 5 en zijn thematisch georganiseerd rond water, budget en rampen.

(3) Tijdens de uitbarstingsfase wordt het hoogste integratieniveau gehaald, waarbij gebruik gemaakt wordt van interactieprocessen rondom rampen, die zowel formeel als informeel van aard zijn en zich afspelen op regionaal niveau.

Omdat voor het omgaan met modderstromen geen specifieke interactiepogingen bestaan, wordt modder besproken via de drie bestaande thema's: budget, water en rampen. Extra aandacht gaat naar interactiepogingen rondom rampen, aangezien modderstromen vaker optreden tijdens uitbarstingen. Binnen deze pogingen worden een andere soort overbruggende actor gevonden, de 'contactpersoon'. Contactpersonen werken op informele manieren. Omdat ze vaker worden aangetroffen tijdens de eerste rampfase, zijn ze vooral actief op de korte termijn. Het integratieniveau bij LRM is hoger dan bij IWRM, voornamelijk tijdens de uitbarsting zelf. Ondertussen is het integratieniveau lager voorafgaand en na de uitbarsting. De contactpersonen blijken een belangrijke rol te spelen voor het realiseren van integratie tussen lahar en water management. Bovendien geldt voor lahar management een flexibeler beheer op het gebied van budgettering wat de interactie tussen sectoren en partijen bevordert.

Hoofdstuk 7 beantwoordt de sub-onderzoeksvraag: "Hoe en waarom heeft het lahar-management betrekking op het geïntegreerde beheer van water (IWRM) in een vulkanisch stroomgebied?" Voor het "hoe" gedeelte van deze vraag heeft de onderzoeker de bestaande overlap tussen IWRM en LRM in kaart gebracht. Hier wordt het VRBM-concept geïntroduceerd (vulcanic river basin management, VRBM) en wordt gepresenteerd als een geïntegreerde aanpak voor overlappende activiteiten in een vulkanisch stroomgebied. Het begint met het clusteren van IWRM-pijlers (bescherming, gebruik en risicobeheersing) in de LRM tijdschalen: pre, onset en post-uitbarsting. De clustering wordt gepresenteerd als drie fasen van VRBM, aangeduid als Normaal VRBM *(Normal VRBM)*, Rampen VRBM *(disaster VRBM)* en Normaal+ VRBM *(Normal+ VRBM)*. De Normale VRBM bestaat uit de situatie van vóór de uitbarsting waarbij in-situ waterconservering en -gebruik van toepassing zijn. De Rampen VRBM omvat in-situ risicobeheersing en ex-situ watergebruik, zonder waterconservering. De Normal+ VRBM bestaat uit alle pijlers uit de Normale VRBM maar met toevoeging van het gebruik van sediment als gevolg van modderstromen.

Binnen deze VRBM-fasen zijn het dezelfde actoren die water en modderstromen beheren. Het hoofdstuk onthult een aantal belangrijke bevindingen:

(1) Normaal en Normaal+ VRBM hebben vergelijkbare beleidsinstellingen. Beide maken gebruik van beleid voor waterbeheer en ruimtelijke ordening. Rampen VRBM daarentegen gebruikt het beleid voor rampen en vulkaanbeheer.

(2) Alle fasen prioriteren het regionale niveau. Deze voorwaarde ontstaat doordat alle managementcontexten van water, vulkaan, ramp en modderstromen zich richten en samenkomen op dit niveau. Ze verzamelen zich op regionaal niveau, ongeacht of ze stroomgebieden, de vulkaan of bestuurlijke grenzen gebruiken als de beheerseenheid. De sleutel tot de werking van de VRBM-fasen is de flexibiliteit van actoren, die verschillende rollen innemen binnen elke VRBM-fase.

(3) De interactiepogingen verschillen voor elke VRBM-fase. Tijdens Normaal en Normaal+ worden bijvoorbeeld interacties tussen de thema's water en budget gebruikt, terwijl bij Rampen alleen de interactie met het rampenthema wordt gebruikt. Dit feit suggereert ook dat flexibiliteit van het beheer nodig is om dergelijke taken uit te voeren.

(4) Het integratieniveau is het hoogst tijdens rampen-VRBM, omdat dit het hoogste integratieniveau van de risicobeheersing (IWRM) en uitbarstingsconditie (LRM) combineert bij het omgaan met de uitbarsting zelf. De Normaal VRBM staat op de tweede plaats, waarbij waterconservering en watergebruikspijlers in combinatie met de pre-uitbarstingstoestand resulteerden in samenwerking. De Normal+ VRBM heeft het laagste integratieniveau.

Hoofdstuk 8 richt zich op het beantwoorden van de laatste sub-onderzoeksvraag, die ingaat op hoe en waarom de cultureel-ecologische kennis van invloed is op het beheer van een vulkanisch stroomgebied. Het 'hoe' wordt beantwoord door de verschillende impacttypes van de CEK. Als deze bestaat en gebruikt wordt, dan is dit aangegeven met een (+), wanneer deze niet bestaat wordt dit aangegeven met (0) en wanneer deze bestaat, maar niet gebruikt wordt als (-). Het hoofdstuk heeft de invloed van CEK op volgende manier ontrafelt:

(1) de (+) CEK invloed voor Normaal VRBM volgt uit de "mainstreaming" van CEK in het beleid rondom natuurbescherming. Ondertussen komt (+) CEK invloed op Rampen VRBM doordat CEK beschouwd wordt als een essentieel onderdeel van het beleid voor rampenbeheer.

(2) de (+) invloed duidelijker is in de fasen Rampen VRBM- en Normaal VRBM dan in Normaal+ VRBM. Deze invloeden is er op regionaal en gemeentelijk niveau. De Normaal+ VRBM heeft (-) invloed, omdat er geen CEK wordt gebruikt, wat resulteert in het overexploitatie van zand in het rivier.

(3) de interactiepogingen met (+) CEK invloed zijn voornamelijk op regionaal en gemeentelijk niveau gezien, waar de onderzoeker actoren vond die onder de noemer 'culturele verbinders' *(cultural boundary spanners)* vallen. Deze actoren zijn vergelijkbaar met de actoren die uit hoofdstuk 7, ook wel *sectoral boundary spanners* genoemd.

(4) Het integratieniveau is het hoogst wanneer de meeste (+) CEK-invloed plaatsvinden. Deze voorwaarde correleert met het bestaan van *cultural boundary spanners*. Deze *boundary spanners* zijn het meest duidelijk binnen informele manieren van interactiepogingen dan formele manieren.

Het laatste hoofdstuk 9 geeft een synthese van alle resultaten uit het onderzoek en presenteert een aangepast raamwerk voor toekomstig onderzoek. De synthese presenteert de gevolgen van het samenvoegen van de voorheen gescheiden werelden van CEK en VRBM. De wereld van CEK draagt bij aan die van VRBM door de actoren eraan te herinneren hoe de natuur en de mens verbonden zijn in het ecologische systeem. Om de bijdrage van CEK mogelijk te maken, moeten de *cultural boundary organisaties* en *personen* een strategische positie innemen in de interactiepogingen en tegelijkertijd een gunstige atmosfeer creëren voor het uitvoeren van CEK in de praktijk. De onderzoeksresultaten tonen aan dat het huidige VRBM aan het begin staat van het afstemmen van deze twee. Beleidsmakers moeten de bevindingen van dit onderzoek meenemen bij de herziening van het ruimtelijk plan. Ze zouden de betekenis van het culturele landschap en het filosofische vlak (harde CEK) moeten meenemen als basis voor bescherming en beheer van stroomgebieden. De studie wijst ook opnieuw op het gebruik van zachte CEK-praktijken in interactiepogingen om het integratieniveau tussen de sectoren water, modderstromen en rampenbestrijding te verbeteren, namelijk door collectieve actiewaarden (*gotong royong*) die in elke fase van VRBM worden gevonden. De studie bewijst ook dat CEK ingrijpende gevolgen heeft voor het integratieniveau van het beheer van vulkanische stroomgebieden. Het benadrukt de rol van CEK bij het vereenvoudigen van de interactiepogingen tussen actoren binnen de *multilevel governance* van water en modderstromen. Het biedt ook de methode om een meer cultureel gevoelige en participatieve benadering van waterbeheer te creëren.

Mengelola Daerah Aliran Sungai (DAS) Vulkanik
Sebuah Penelitian Berpendekatan Budaya dalam Praktik Pengelolaan Sumber Daya Air Terkini di Sub-DAS Opak, Indonesia

Ringkasan

Di suatu hari yang indah di bulan November 2010, Gunung Api Merapi di Pulau Jawa meletus. Penduduk tidak menyadari bahwa yang terjadi kali itu bukanlah siklus letusan empat tahunan seperti biasanya. Erupsi tahun 2010 adalah siklus 100 tahunan. Kejadian tersebut menghancurkan dan melumpuhkan kawasan itu selama sebulan dan mengharuskan dilakukannya rehabilitasi dan rekonstruksi selama lima tahun. Penduduk dari daerah hulu Merapi mengungsi ke area perkotaan. Selain tempat berlindung, pasokan air bersih menjadi kebutuhan mendesak mereka. Air bersih menjadi langka, karena terjadi hujan abu, banjir lahar di sungai, dan infiltrasi belerang ke dalam air tanah. Di sinilah pengetahuan lokal digunakan. Masyarakat lokal punya cara alternatif pengelolaan air berdasarkan pengalaman sejarah, misalnya dengan mengakses aliran dasar sungai untuk air minum dibandingkan menunggu kiriman tangki air. Selain itu untuk mengetahui terjadinya infiltrasi belerang pada air sumur, mereka mencicipi rasa air daripada harus menunggu hasil uji kualitas air laboratorium. Mereka paham untuk tidak menyeberangi sungai saat hujan datang untuk menghindari bahaya lahar, serta dengan mendengarkan bunyi aliran sungai untuk mengetahui saat sebelum lahar menerjang. Selama kondisi tersebut, pengetahuan lokal lainnya turut berperan dalam membentuk reaksi orang terhadap lingkungan disekitar mereka. Fakta-fakta inilah yang memicu ketertarikan Peneliti untuk mempelajari tema pengetahuan ekologis berbasis budaya pada pengelolaan sumber daya air di kawasan bergunung berapi aktif.

Penelitian ini dimulai dengan menjelaskan konteks daerah aliran sungai (DAS) vulkanik dengan menguraikan contoh kepulauan Indonesia yang berada pada Cincin Api Pasifik. Bab ini juga mendefinisikan tujuan penelitian untuk menjawab pertanyaan penelitian utama (RQ) tentang "Bagaimana pengetahuan ekologi berbasis budaya dapat berkontribusi pada pengelolaan sumber daya air terpadu di DAS vulkanik?" Pertanyaan tersebut diikuti dengan —sub-pertanyaan penelitian lainnya (sub-RQ) tentang implementasi praktik pengelolaan saat ini untuk air, lahar, DAS vulkanik dan menyelidiki kaitannya dengan penggunaan pengetahuan ekologi berbasis budaya.

Tinjauan literatur pada bab 2 menjelaskan beberapa konsep yang digunakan untuk disertasi ini, seperti pengetahuan ekologi berbasis budaya (CEK), manajemen sumber daya air terpadu (IWRM), manajemen risiko / sumber daya lahar (LRM) terkait kerangka pengurangan risiko bencana (DRR), DAS vulkanik (VRB), tata kelola berjenjang (MLG), interaksi upaya, dan tingkat keterpaduan. Tingkat ditentukan dari rendah ke tinggi: koordinasi, kolaborasi, dan koordinasi. Kerangka kerja konseptual awal menghubungkan konsep-konsep tersebut. Kerangka ini mengelompokkan konsep menjadi (1) variabel pengaruh: CEK dan (2) variabel terpengaruh: manajemen VRB terkait IWRM, LRM, dan MLG. Kerangka kerja konseptual mengusulkan kemungkinan terjadinya hubungan (positif, negatif, atau netral) antara variabel pengaruh dengan terpengaruh.

Bab 3 menjelaskan metode pilihan yaitu kualitatif murni. Pilihan didasarkan pada sifat penelitian yang membutuhkan pengetahuan mendalam tentang budaya tertentu dibandingkan pemahaman yang luas (Yin, 2009, Flick, 2008, Kothari, 2004, Berkes, Folke, et al., 1995, Inglis , 1993, Steward, 1972). Oleh karena itu, studi kasus terkait (embedded case study) dipilih untuk membahas ruang lingkup DAS vulkanik. Desain penelitian ini relevan untuk menguji batas-batas yang tidak jelas antara fenomena yang distudi (manajemen DAS vulkanik) dan konteks penelitiannya (gunung berapi). Peneliti menggunakan data yang dikumpulkan melalui wawancara, observasi, dan kelompok fokus dari dua kali studi lapangan, dan data sekunder dari peraturan, laporan, dokumen perencanaan, ringkasan kebijakan, dan risalah rapat. Studi lapangan pertama dilakukan pada musim kemarau Agustus sampai dengan September 2016 (dua bulan), yang meliputi periode observasi dan 47 wawancara dalam sub-kasus (komunitas atas, tengah, dan hilir sungai) juga organisasi (nasional, regional, kabupaten/kota), serta para ahli. Studi lapangan kedua dilakukan pada musim penghujan, akhir Desember 2017-Januari 2018 (1 bulan), yang mencakup sepuluh wawancara mendalam untuk pemeriksaan validitas temuan riset dengan responden dari organisasi dan para ahli. Analisis menggunakan perangkat lunak Atlas.ti untuk membentuk kode aksial berdasarkan konsep teoritis. Perbandingan data secara konstan digunakan di bab 4 sampai 6, sementara analisis mendalam pada tingkat meta digunakan untuk bab 7 dan 8. Analisis ini menyajikan implementasi konsep yang dikelompokkan ke dalam tema-tema temuan. Hal ini juga menjelaskan upaya interaksi yang terjadi disetiap tema. Berdasarkan hal tersebut, tingkat keterpaduan koordinasi, kolaborasi, dan kerjasama ditentukan.

Bab 4 menyajikan jawaban dari sub-RQ: Apa saja elemen utama dari pengetahuan ekologi berbasis budaya (CEK) dalam DAS vulkanik, dan bagaimana hal ini dirumuskan? Bab ini menjelaskan lima bentuk CEK yang ada dalam konteks pengelolaan sumber daya air di DAS vulkanik. Kelima bentuk ini dikenal sebagai mekanisme transfer yaitu filosofi, internalisasi, artefak, praktik manajemen sumber daya, dan kearifan berbasis panca indera. artefak, praktik manajemen sumber daya, dan kearifan berbasis panca indera adalah CEK 'keras' yang langsung digunakan dan memiliki hasil nyata, sedangkan filosofi dan internalisasi adalah CEK 'lunak' yang tertanam dalam benak agen CEK dan tercermin dalam kegiatan atau keputusan mereka. Agen CEK adalah mereka yang mempraktikkan CEK kedalam manajemen saat ini.

Formulasi CEK didasarkan pada pengalaman historis, legitimasi, dan simbolisasi. Semakin ekstrim pengalaman historis, semakin sukses kemungkinan terbentuknya CEK. Faktor lain adalah legitimasi secara lisan oleh tokoh budaya ataupun tertulis (dalam literatur kuno atau peraturan saat ini). Dalam prosesnya, agen-agen CEK ada pada komunitas. Agen CEK ini adalah aktor penting dalam upaya interaksi pada bab-bab selanjutnya. Semakin CEK disimbolkan ke bentuk lain, semakin dalam hal tersebut tertanam di masyarakat. Contoh CEK yang signifikan adalah filosofi "*hamemayu hayuning bawono*" (memperindah keindahan dunia) yang dilambangkan sebagai poros filosofis dan diinternalisasikan dalam ritual labuhan, juga artefak sakral berupa kawasan Sungai Opak yang berhulu di Gunung Merapi dan bermuara di Pantai Parangkusumo. Proses formulasi ini digunakan sebagai landasan bagi pendekatan sensitive budaya terhadap pengelolaan DAS vulkanik.

Bab-bab berikut: 5, 6, dan 7, menjelaskan variabel terpengaruh (pengelolaan VRB). Lensa MLG digunakan untuk menguraikan batasan manajemen (IWRM dan LRM) dalam kondisi DAS vulkanik yang kompleks. Lensa ini digunakan untuk mengupas batasan yang ada, seperti yurisdiksi, tema, dan tingkatan administrasi.

Bab 5 menjawab sub-RQ: Bagaimana pendekatan pengelolaan sumber daya air terpadu (IWRM) diimplementasikan di DAS vulkanik? Bab ini menerangkan beberapa pengalaman berharga tentang penerapan pendekatan pada konteks DAS vulkanik yang implementasinya menggunakan pilar-pilar utama dalam pengelolaan sumber daya air di Indonesia, yaitu konservasi, pendayagunaan, dan pengendalian daya rusak. Pilar-pilar ini tidak ditangani oleh satu organisasi tetapi banyak aktor. Bab ini menemukan bahwa IWRM yang diterapkan pada DAS ini adalah serupa dengan lokasi non-vulkanik di Indonesia, walaupun sebenarnya DAS vulkanik memiliki perlakuan khusus dalam pengendalian bahaya karena tidak hanya mengalami banjir, kekeringan, tanah longsor, tapi juga lahar. Menggunakan konsep MLG, bab ini menjelaskan implementasi IWRM. Berikut ini adalah temuan pada tiap jenjangnya.

(1) Pengaturan kebijakan didasarkan pada pendekatan IWRM meskipun Undang-Undangnya saat ini dibatalkan, menyebabkan ketidakpastian dalam implementasinya.

(2) Konteks manajerial menggunakan wilayah sungai (WS), daerah aliran sungai (DAS), dan tingkatan pemerintahan yang ada. Bab ini juga menggunakan pilar IWRM Indonesia tentang konservasi, pendayagunaan, dan pengendalian daya rusak. Setiap sub-kasus memiliki prioritas pilar yang berbeda. Sub-kasus 1 memprioritaskan pengendalian bahaya dan konservasi, sub-kasus 2 mengutamakan pengendalian banjir, dan sub-kasus 3 mengutamakan pemanfaatan. Secara umum, implementasi IWRM yang ditemukan adalah jenis manajemen sektoral yang 'terkotak-kotak'; konservasi dilakukan oleh sektor kehutanan, pendayagunaan oleh sektor pekerjaan umum, dan pengendalian daya rusak oleh sektor bencana. Kumpulan dari manajemen 'terkotak-kotak' ini bertemu di tingkat regional. Disinilah para aktor kota, regional, nasional, WS, dan DAS berkumpul. Kumpulan ini ditemukan pada implementasi pilar pengendalian daya rusak dan pendayagunaan.

(3) Upaya interaksi dalam implementasi IWRM ini bertemakan anggaran, air, dan bencana, dimana tema anggaran dan air menjadi interaksi dominan.

(4) Tingkat keterpaduan implementasi IWRM ditentukan berdasarkan keberhasilan upaya interaksi yang ada di setiap pilar IWRM dalam setiap tingkat tata kelola. Tingkat keterpaduan beragam untuk pilar IWRM dengan melibatkan upaya interaksi yang ada. Tingkat tertinggi atau kerjasama dimiliki pilar pengendalian daya rusak yang menggunakan upaya interaksi bencana dan anggaran. Sedangkan tingkat menengah atau kolaborasi dimiliki oleh pilar pemanfaatan menggunakan upaya interaksi air dan anggaran. Jenjang terendah ditemukan pada pilar konservasi yang juga menggunakan upaya interaksi air dan anggaran.

Variasi tingkat keterpaduan disebabkan intensitas upaya interaksi yang berbeda dan kualitas aktor sebagai jembatan komunikasi. Aktor yang berkontribusi pada tingkat keterpaduan berada dalam upaya interaksi air, antara pemerintah dan masyarakat. Mereka dikenal sebagai 'pembisik'. Mereka beroperasi secara persuasif dan mendorong orang lain untuk mengikuti saran mereka. Semakin banyak pembisik ditemukan, semakin tinggi tingkat keterpaduan. Tingkat regional memiliki lebih banyak pembisik dan menghasilkan tingkat keterpaduan tertinggi. Jenjang ini diindikasikan sebagai 'lapangan bermain prioritas' untuk implementasi IWRM di DAS vulkanik.

Bab 6 menjawab sub-RQ "Apa yang dimaksud dengan pengelolaan lahar (LRM) dan bagaimana penerapannya di DAS vulkanik?" Hal Ini didasarkan pada kerangka pengurangan risiko bencana (DRR) dan dibagi dalam tiga tahapan bencana: pra-erupsi, kejadian erupsi, dan paska-erupsi. Tahapan pra-erupsi dan paska-erupsi adalah bagian dari IWRM, sedangkan tahapan erupsi murni milik DRR. Semua tahapan adalah bagian dari manajemen risiko lahar, hanya tahapan paska-erupsi yang merupakan bagian manajemen sumber daya lahar. Hal-hal berikut mencirikan implementasi LRM.

(1) Tidak adanya pengaturan kebijakan lahar langsung. Kebijakan terkait tersebar dalam pilar pengendalian daya rusak air, pengendalian lahar dalam vulkanologi, dan manajemen bencana.
(2) Manajemen lahar adalah kondisi tata kelola berjenjang didasarkan pada tingkat tata kelola administratif dengan badan penanggulangan bencana sebagai aktor utama.
(3) Upaya interaksi yang ditemukan serupa dengan yang ditemukan pada Bab 5, bertemakan air, anggaran, dan bencana.
(4) Tingkat keterpaduan ditemukan paling tinggi pada tahapan kejadian erupsi dengan menggunakan upaya interaksi bencana, karena menggabungkan cara interaksi formal dan informal, dan terletak di tingkat regional.

Bab ini juga menerangkan pergeseran peran para aktor dalam upaya interaksi yang terjadi saat tahapan kejadian erupsi. Karena lahar tidak memiliki upaya interaksi tertentu, lahar dibahas melalui tiga tema upaya interaksi yang ada: anggaran, air, dan bencana. Upaya interaksi bencana memberikan lebih banyak perhatian karena lahar lebih menjadi pusat perhatian saat terjadinya erupsi. Didalam upaya-upaya ini ditemukan jenis aktor penghubung lain yang disebut 'Contact Person/CP'. Mereka hadir saat upaya interaksi bencana tidak resmi. Keberadaan mereka lebih sering ditemukan selama tahapan pra-erupsi sebagai aktor jangka pendek. Semakin banyak cara interaksi tidak resmi dikombinasikan dengan tahapan urgensi kejadian erupsi semakin terpadu tingkat implementasi LRM. Jenjang keterpaduan LRM lebih tinggi dari implementasi IWRM, terutama pada saat kejadian erupsi. Saat pra-erupsi dan paska-erupsi tingkat keterpaduan berkurang. Tingkat keterpaduan yang berbeda ini terjadi karena ada perbedaan kuantitas dan kualitas cara interaksi tidak resmi dan CP. Mereka lebih sibuk dan dibutuhkan saat kejadian erupsi. Selain itu, lahar memiliki manajemen yang lebih fleksibel dalam hal penganggaran dan dapat menggunakan segala jenis upaya interaksi di semua tahapan.

Bab 7 menjawab sub-RQ: "Bagaimana" dan "mengapa" pengelolaan lahar terkait dengan pengelolaan sumber daya air terpadu (IWRM) di DAS vulkanik? Pada "bagaimana", Peneliti mengamati tumpang tindih yang terjadi antara implementasi IWRM dan LRM. Di sini, konsep VRBM diperkenalkan sebagai pendekatan terpadu untuk kegiatan yang tumpang tindih di DAS vulkanik. Hal ini dimulai dengan pengelompokan kegiatan berdasarkan pilar IWRM (konservasi air, pendayagunaan, dan pengendalian daya rusak) ke dalam skala temporal LRM: pra-erupsi, kejadian erupsi, dan paska-erupsi.

Pengelompokan disajikan sebagai tiga tahapan VRBM, disebut sebagai VRBM Normal, VRBM Bencana, dan VRBM Normal+. VRBM Normal terdiri dari kondisi sebelum erupsi di mana konservasi dan pemanfaatan air in-situ berjalan. VRBM Bencana mencakup pengendalian bahaya in-situ dan pendayagunaan air ek-situ, tanpa konservasi air. Normal + VRBM terdiri dari semua pilar dalam VRBM Normal yang ditambahkan dengan pemanfaatan sedimen lahar atau kegiatan penambangan pasir. Pada tahapan VRBM ini, para aktornya adalah mereka yang mengelola air dan lahar. Bab ini mengungkapkan beberapa temuan utama.

(1) Tahapan Normal dan Normal + VRBM memiliki kesamaan pengaturan kebijakan. Keduanya menggunakan kebijakan pengelolaan air dan perencanaan tata ruang. VRBM Bencana menggunakan kebijakan manajemen bencana dan gunung berapi.

(2) Semua tahapan memberikan prioritas untuk tingkat regional yang terjadi karena semua konteks manajerial air, gunung berapi, bencana, dan lahar, berfokus dan berkumpul di tingkat ini menggunakan WS, DAS, daerah tangkapan air, gunung berapi, atau batas administrasi sebagai unit manajemen. Kunci agar semua tahapan VRBM berfungsi baik adalah fleksibilitas aktor yang mengambil peran berbeda dalam setiap tahapan VRBM.

(3) Upaya interaksi berbeda untuk setiap tahapan VRBM. Misalnya selama Normal dan Normal + interaksi bertema air dan anggaran digunakan, sedangkan saat Bencana hanya interaksi bertema bencana yang digunakan. Fakta ini juga menunjukkan fleksibilitas manajemen diperlukan untuk melakukan tugas-tugas tersebut.

(4) Tingkat keterpaduan tertinggi terjadi pada VRBM Bencana karena menggabungkan tingkat keterpaduan tertinggi dari pilar pengendalian bahaya (IWRM) dan kondisi kejadian erupsi (LRM) yang melakukan kerjasama dalam mengatasi tahapan erupsi. VRBM Normal berada di peringkat kedua, saat pilar konservasi air dan pendayagunaan air dikombinasikan dengan kondisi sebelum erupsi untuk menghasilkan kegiatan kolaborasi. Normal + VRBM menduduki peringkat terendah dalam tingkat keterpaduan karena kegiatan penambangan pasir dan kondisi saat setelah paska-erupsi tidak memiliki upaya keterpaduan.

Pengelolaan lahar terkait dengan IWRM dari DAS vulkanik karena kegiatan IWRM dan LRM tumpang tindih. Bab ini mengungkapkan faktor yang tidak terdeteksi dalam kerangka kerja konseptual di bab 2. Studi ini menyebut faktor tidak terdeteksi sebagai 'penjangkau batasan sektoral (sectorial boundary spanners)' yang ada dalam upaya interaksi dan menjembatani berbagai sektor. Mereka dikenal sebagai organisasi perbatasan (boundary organization-BO) dan penjangkau batasan (boundary spanners-BS) dalam teori tata kelola. RBO menangani tumpang tindih batasan di tingkat organisasi. Di tingkat individu, banyak aktor melakukan aktivitas tumpang tindih. Aktor yang berada dalam upaya anggaran disebut 'calo (brokers)'. Mereka menjembatani tingkat interaksi pemerintah atau antar kementerian. Mereka cenderung berorientasi pada keuntungan finansial dan orangnya setiap tahun berubah. Jenis aktor lain adalah 'CP' seperti yang ditemui dalam bab 6. Mereka beroperasi sebagai pusat informasi dalam suatu bencana, sangat tulus, tetapi 'berumur pendek' hanya ada selama bencana. 'Pembisik' seperti dalam bab 5 adalah pembatas batas yang jujur dan ada dalam semua upaya interaksi. Keuntungan 'pembisik' dari upaya interaksi adalah jaringan yang berkelanjutan dengan organisasi yang ada. Tingkat keterkaitan para penghubung ini dari dangkal ke dalam adalah: broker, penghubung, dan pembisik. Fakta ini mengungkap bahwa tahapan VRBM dengan keberadaan pelaku penjangkau batasan sektoral (sectorial boundary spanners) yang paling banyak mendapatkan manfaat dari tingkat keterpaduan tertinggi dalam pengelolaan DAS vulkanik ini, yaitu VRBM Bencana.

Bab 8 berfokus pada menjawab sub-RQ terakhir yang membahas "bagaimana" dan "mengapa" pengetahuan ekologi berbasis budaya berdampak pada pengelolaan DAS vulkanik. 'Bagaimana' dijawab oleh jenis dampak CEK yang diproyeksikan ke VRBM, apabila ada dan digunakan ditandai sebagai (+), tidak ada ditandai sebagai (0), dan ketika ada tetapi tidak digunakan sebagai (-). Bab ini mengungkap dampak CEK sebagai berikut.

(1) Pada pengaturan kebijakan, dampak (+) CEK untuk Normal VRBM adalah hasil dari pengarusutamaan CEK dalam kebijakan konservasi alam. Sementara itu, (+) dampak CEK untuk VRBM Bencana disebabkan oleh CEK yang dianggap sebagai aset penting dalam kebijakan manajemen bencana. Namun, (-) dampak untuk Normal+ VRBM adalah karena manajemen penambangan pasir tidak memiliki referensi ke CEK.

(2) Akibatnya, konteks manajerial juga mengungkapkan bahwa dampak (+) lebih jelas dalam tahapan VRBM Bencana dan VRBM Normal daripada dalam Normal+ VRBM. Dampak ini terjadi di tingkat regional dan kota. Normal+ VRBM memiliki dampak (-), karena tidak menggunakan CEK apapun dalam implementasi manajemen yang mengakibatkan penambangan pasir yang berlebihan di badan sungai.

(3) Upaya interaksi dengan dampak (+) CEK sebagian besar terletak di tingkat regional dan kota saat peneliti menemukan aktor yang dikenal sebagai 'penjangkau batasan budaya (cultural boundary spanners).' Aktor ini serupa dengan yang ditemukan di Bab 7, yang dikenal sebagai 'penjangkau batasan sektoral,' tetapi di sini fungsi mereka mengantarkan CEK ke dalam upaya interaksi.

(4) Tingkat keterpaduan tertinggi terjadi ketika sebagian besar (+) dampak CEK terjadi. Kondisi ini berkorelasi dengan keberadaan penjangkau batasan budaya. Penjangkau lebih jelas terlihat pada upaya interaksi tidak resmi daripada resmi. Semakin banyak cara informal ditemukan, semakin tinggi tingkat keterpaduan yang dicapai.

Bagian terakhir dari bab 8 menjelaskan mengapa CEK berdampak pada manajemen VRB. Jawaban atas pertanyaan ini adalah keberadaan aktor 'penjangkau batasan budaya'. Aktor-aktor ini tidak terdeteksi dalam satu tahapan VRBM, tetapi berada di seluruh tahapan VRBM. Aktor-aktor yang merentang batas budaya ini 'terikat' ketika mereka menjadi bagian dari suatu organisasi atau 'bebas' ketika mereka berfungsi sebagai katalis dan tidak termasuk dalam organisasi manapun. Di tingkat regional, tipe terikat yang terdeteksi adalah pendiri Pammaskarta DIY yang bertindak sebagai pembisik dan fasilitator. Tipe kedua yang terdeteksi adalah Pangeran Kraton yang menjadi pembahas dalam pertemuan perumusan peraturan daerah tangkapan air (PerdaDAS DIY). Di tingkat kota, sebagian besar penjangkau batasan budaya adalah tipe 'terikat', dan mereka adalah milik organisasi berbasis masyarakat (Community Based Organization-CBO). Bab ini menemukan bahwa pembisik sebagai penjangkau jujur memiliki peluang lebih baik untuk menyampaikan CEK karena mereka juga beroperasi menggunakan nilai-nilai CEK.

Faktor penting lainnya adalah keberadaan atmosfer kondusif yang membuat penerapan CEK lebih mudah dalam praktik pengelolaan sumber daya air sehari-hari. Kondisi ini adalah hasil dari kegiatan BO dan BS yang memungkinkan CEK terwujud dalam VRBM. Di tingkat Nasional, cikal bakal atmosfer semacam ini terlihat pada Jambore Sungai, meskipun aktivitas tersebut bukan bagian dari periode pengamatan penelitian ini. Bagian ini hanya berfokus pada upaya informal Regional dan Kota. Komponen atmosfer yang kondusif adalah sebagai berikut. (1) BO dan BS harus hadir untuk mengatur 'panggung' penggunaan CEK. (2) Dengan adanya 'panggung', rasa takut dihilangkan saat berbicara di luar batas-batas ilmiah. Di sini mereka mencapai koneksi ke personel yang tepat dalam organisasi pemerintahan - lebih jauh lagi, realisasi pengembangan kepercayaan dalam menggunakan CEK pada praktik manajemen saat ini.

Bab terakhir merangkum jawaban untuk masing-masing sub-RQ. Penjelasan untuk setiap fungsi sub-RQ digunakan sebagai pengingat isi keseluruhan bab (4 hingga 8) untuk menjawab RQ utama: "Bagaimana pengetahuan ekologi berbasis budaya berkontribusi pada manajemen sumber daya air terpadu dari suatu DAS Vulkanik?" di akhir bab. Penelitian ini menjawab RQ dengan memberikan wawasan tentang jenis-jenis CEK lunak dan keras yang berkontribusi untuk meningkatkan keterpaduan dalam VRBM. CEK tidak melekat pada satu bentuk sumber daya. CEK melihat semua sumber daya sebagai bagian dari alam. Sifat ini membuatnya fleksibel untuk menembus segala jenis manajemen sumber daya alam yang difokuskan pada keterkaitan pengelolaan air, lahar, dan gunung berapi. CEK juga meningkatkan aspek konservasi VBRM dengan menjadi lebih bijak dalam pemanfaatan air dan sumber daya terkait serta membatasi eksploitasi untuk keberlanjutan sistem ekologi.

Bab 9 berisi sintesis dari seluruh isi penelitian dan disajikan dalam kerangka kerja konseptual yang disesuaikan untuk kepentingan penelitian masa depan. Sintesis membahas konsekuensi dari penggabungan ranah CEK dan VRBM. Ranah CEK berkontribusi pada ranah VRBM untuk mengingatkan para aktor tentang keterikatan alam dan manusia 'secara internal' dalam sistem ekologis. Agar CEK berkontribusi, BO dan BS harus mengambil posisi strategis dalam upaya interaksi sembari menciptakan suasana kondusif untuk melakukan praktik-praktik CEK. Temuan menunjukkan VRBM saat ini berada pada langkah paling awal untuk menyelaraskan keduanya. Penelitian ini memberikan cukup CEK data yang digunakan secara aktif baik dari pihak masyarakat maupun pemerintah. Data ini merupakan aset penting untuk implementasi VRBM yang lebih partisipatif, efektif, dan efisien. Para pembuat kebijakan perlu mempertimbangkan temuan penelitian ini dalam merevisi rencana tata ruang, pentingnya memasukkan makna saujana dan bidang filosofis (CEK keras) sebagai dasar untuk kawasan konservasi DAS. Studi ini juga mengingatkan penggunaan praktik CEK lunak dalam upaya interaksi untuk meningkatkan tingkat keterpaduan, yaitu nilai tindakan kolektif (gotong royong) yang ditemukan di setiap tahapan VRBM. Studi ini juga membuktikan bahwa CEK memiliki dampak mendalam pada tingkat keterpaduan pengelolaan DAS vulkanik. Studi ini menyoroti peran CEK dalam memperlancar upaya interaksi antar aktor dalam tata kelola berjenjang untuk air dan lahar. Selain itu, riset ini juga menyediakan metode untuk menciptakan pendekatan yang lebih peka budaya dan partisipatif dalam pengelolaan air. Studi ini adalah dokumen untuk generasi masa depan untuk memahami siklus erupsi 100 tahun dan mencapai tingkat keterpaduan air dan pengelolaan lahar yang lebih baik. Studi ini juga menimbulkan pertanyaan baru tentang apakah DAS vulkanik lain atau DAS rawan bencana lain dapat menggunakan pendekatan ini. Akan sangat menarik untuk membandingkan jenis CEK apa yang digunakan untuk jenis DAS rawan bencana tertentu, serta menghasilkan teori atau konsep umum yang memayungi perbedaannya.

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List of Abbreviation and Terminologies with English Translation

Abbreviations

AKSY: River Communities Association of Yogyakarta
Bappeda DIY: Yogyakarta Special Region's Development Planning Agency
Bappedakot/kab: Municipal's Development Planning Agency
Bappenas: National Development Planning Agency
BBWS SO: Serayu Opak River Basin Organization
BNPB: National Disaster Management Agency
BPBD DIY: Yogyakarta Special Region's Disaster Management Agency
BPBD Kab/Kot: Municipal Disaster Management Agency
BPDAS SOP: Catchment Management Unit of Serayu Opak Progo
BPPTKG: Volcano Center
BTNGM: National Forest Management Center
Ditjen CK: Directorate General of Human Settlements (DGHS)
Ditjen SDA: Directorate General of Water Resources (DGWR)
DSDAN: National Water Council
DSDAP: Provincial (Regional) Water Resources Council
FKWA: Winongo River Community
ForDAS: Catchment Forum
Forum PRB DIY: Yogyakarta Special Region Disaster Risk Reduction Forum
Forum SKSB: Shared Social Communication Channel Forum
GWC: Gadjah Wong River Community
JICA: Japan Indonesia Cooperation Agency
KemenESDM: Ministry of Energy and Mineral Resources
KemenLHK: Ministry of Environment and Forestry
KemenPUPR: Ministry of Public Works and Housing (MPWH)
KemenTan: Ministry of Agriculture
Musrenbangda: Regional Development Planning Participatory Budgeting
Musrenbangkab/kot: Municipal Development Planning Participatory Budgeting
Musrenbangnas: National Development Planning Participatory Budgeting
Pammaskarta DIY: Yogyakarta Special Region's Water Supply Community
PKC: Code River Community
Planas Forum PRB: National Disaster Risk Reduction Forum
Pola PSDA WS POS: Water Resources Management Framework of Progo Opak Serang River Basin Territory
PUP-ESDM DIY: Yogyakarta Special Region's Public Works Housing – Energy and Mineral Resources Agency
Rakorbangda: Regional Development Coordination Meeting
Rakorbangkab/kot: Municipal Development Coordination Meeting
Rakorbangpus: National Development Coordination Meeting
Rakornas PB: National Coordination Meeting of Disaster Management
RPDAS Opak: Opak Catchment Management Plan
RPSDA WS POS: Water Resources Management Master Plan of Progo Opak Serang River Basin Territory
RTRW DIY: Spatial Plan of Yogyakarta Special Region
Satgas Bencana: Disaster Taskforce
Satker CK-SPAM: Work Unit of Drinking Water Supply (as known in 2015)
TBC: Tambak Boyo River Community
TKPSDA: Team of River Basin Territory Water Resources Management Coordination
TP5DIY: Priority Implementation of Development Acceleration Team by Yogyakarta Special Region Government
UGM: Gadjah Mada University

VRB: Volcanic River Basin
VRBM: Volcanic River Basin Management
WS: River Basin Territory
WUA: Water User Association (also known as GP3A)

Conceptual terminologies

AKSY: River Communities Association of Yogyakarta
BLH: Environmental Agency
BO: Boundary Organization
BS: Boundary Spanner
CBO: Community Based Organization
CEK: Cultural Ecological Knowledge
DAS: Catchment
DRR: Disaster Reduction Risk
DSDAN: National Water Council
DSDAP: Provincial (Regional) Water Resources Council
FKWA: Winongo River Community
ForDAS: Catchment Forum
Forum PRB DIY: Yogyakarta Special Region Disaster Risk Reduction Forum
Forum SKSB: Shared Social Communication Channel Forum
GWC: Gadjah Wong River Community
IWRM: Integrated Water Resources Management
Komir: Irrigation Commission
KRB: Hazard Zone
LRM: Lahar Resources Management
MLG: Multilevel Governance

Javanese and Indonesian terminologies

Bawono: world
Geger Bulus: flood free zone
Hamemayu hayuning bawono: beautifying the world's beauty or living in harmony with nature
Labuhan: offering
Lampor: deity's
Merti kali: river thanksgiving (general term)
Tambak kali: river thanksgiving of Argomulyo (sub-case 1)
Wangsit: premonition

Siaga: lowest level of volcano active (1) status - alert
Waspada: mid level volcano active status (2) - standby
Awas: highest volcano active status (3) - beware

CHAPTER 1

INTRODUCTION

1 Introduction

1.0 Preamble

This research attempts to elucidate how water management works under volcanic conditions and also contends that cultural contexts have been neglected in the current practice of water management. It unfolds the story of water resources management in a volcanic river basin. Using a case study in Indonesia, which is one of the most actively volcanic archipelagos in the world, this research proposes a cultural-perspective lens to investigate current water management implementation. This investigation proceeds by ascertaining the presence of cultural ecological knowledge and how this can be used for more comprehensive management of a volcanic river basin. Therefore, this first chapter introduces the context of the volcanic river basin as the basis of the research and indicates how the research is organized. Firstly, the research context is explained. Secondly, the research problems are stated. Thirdly, the proposed research questions and aims are presented. Fourthly, the significance of the research is discussed. Lastly, the structure of the overall thesis is presented.

1.1 Background

Water is an essential component of human life. It plays an important role in the development of urban areas, industry, agriculture, and energy. In ancient developments, water resources were managed using local knowledge within a localized area with a local taskforce. Then came engineering approaches. The engineering field makes a positive contribution to controlling water, such as when and where it is needed or causes a nuisance, and therefore engineering approaches became popular. However, after some decades of intensive engineering, it has become clear that ecological damage can occur (Pahl-Wostl, Mostert, et al., 2008). This situation has supported the rise of integrated water resources management (IWRM), which is aimed at tackling problems in a more holistic way (Hofwegen and Jaspers, 1999, Biswas, 2004). The IWRM approach addresses all related resources connected in the hydrological process, such as water, evaporation, land, geology, atmosphere. Additionally, these issues are managed in such a way as to contribute to the objectives of future society while maintaining ecological, environmental, and hydrological integrity. The IWRM approach is implemented in all kinds of river basins worldwide but does not propose a specific recipe for implementation. Water resources management faces constraints within socio-technical arrangements (Hofwegen and Jaspers, 1999, Jaspers, 2003). There are many components to this new paradigm shift from a sole or primary search for new sources of supply to addressing perceived new demands (Gourbesville, 2008), with growing attention on the ecological value of water policy (Pahl-Wostl, Kabat, et al., 2008) and a conscious breaking of ties between economic growth and water use (Gleick, 2000).

Consequent to the Southeast Asian economic crises in 1997 and the Reformation era after Soeharto stepped down from his 30-year reign, Indonesia was beset by intense political and economic crises. During this time, the World Bank advised Indonesia to reform the water sector by implementing the IWRM approach through the WATSAL program (Government of Indonesia, Inter-Agency Task Force on Water Sector Policy Reform, 1999). As a developing country with 17,000 islands, Indonesia manages its water resources on the basis of 133 river basin territories decided by Presidential decree (Keppres No.12/2012, 2012). Indonesia claims to have implemented the IWRM approach through the enactment of a law (UU No.7/2004, 2004). However, the country faces threats from water-related issues such as flood, drought, erosion, environmental degradation, and pollution (Fulazzaky, 2014, Measey, 2010). Besides these issues, Indonesia has 132 active volcanoes (USGS, 2011), which are situated in most of these river basin territories. Agricultural needs still dominate water usage in Indonesia. Although water usage in agriculture is diminishing, it is still regarded as the highest priority. Public water supply ranks second, with municipalities growing and infrastructures expanding (BBWS SO, 2011). Lastly, industrial needs rank third, as urban-area livelihoods have shifted to manufacturing. The Indonesian water potential, in general, is high in quantity during the rainy season. However, during the dry season, bad land use and poor management results in water scarcity in many areas. The threats to managing each river basin vary and are specific to each location.

Another significant issue that must be stressed is the geographical location of Indonesia relative to tumultuous volcanic activity. Indonesia is located in the Ring of Fire, a term used to specify the Pacific Ocean basin where 90% of the world's earthquakes and eruptions occur (USGS, 2017). As a consequence, about 60% of Indonesia's river basin territory is located in volcanic regions (see Figure 1.1). Volcanic regions in the world always face hazards relating to the volcano eruption cycle pattern. The relationship of a volcano to the society living in the surrounding region is a much-debated argument in sociology (Chester, 1994, Lavigne, De Coster, et al., 2008, Donovan, 2010). Some inhabitants fear the effect of eruptions. Nevertheless, many inhabitants feel the urge to stay in this hazard zone because of the advantages that they derive from the environment (Donovan, 2010). These advantages include fertile soil, volcanic materials to mine, abundant freshwater, beautiful scenery, and even tourism potential. These advantages have led to agricultural land and urban areas being developed around these hazardous areas. Of the 127 active volcanoes in Indonesia (Permen ESDM No.15/2011 on Mitigation Guidelines in Volcano, Land Movement, Earthquake and Tsunami Hazards. 2011), Mt. Merapi in Yogyakarta is said to be one of the most active in the world (Thouret, Lavigne, et al., 2000). Mt. Merapi is a stratovolcano located 30 kms north of Yogyakarta and is part of a cross-island chain of four stratovolcanoes or a steep conical volcano complex with effusive lava and pyroclastic flows (USGS, 2015), comprised of Ungaran, Telemoyo, Merbabu, and Merapi. It has claimed the lives of between 3,000 and 5,000 victims since 1672 (Simkin and Siebert, 1994 in (Camus, Gourgaud, et al., 2000). People in this region have lived with Merapi's volcanic activities, as recorded in 10,000 years of history (Newhall, Bronto, et al., 2000). The volcano is known for its Merapi-type, semi-continuous outpourings of lava and actively building-up summit dome, with periodic dome collapse and total destruction (Gertisser, Charbonnier, et al., 2012). Mt. Merapi is a 'regular cougher' – once every two to four years, small eruptions happen (Lavigne and Thouret, 2003). Mt. Merapi's 10,000-year history reveals that there were major eruptions in each century (Newhall, Bronto, et al., 2000). Its eruption poses both direct and indirect hazards: firstly, the pyroclastic flow and, secondly, lahar or debris flow and earthquake consequent to the eruption (Voight, Constantine, et al., 2000). The pyroclastic flow (also known as *nuee ardantee*) is a violent hot gas (around 1000^0C) bursting from the volcano's dome (Boudon, Camus, et al., 1993) at a speed of 700km/h (Lavigne et al., 2000), whereas lava flows as a result of activities are a mixture of hot molten rock burbling out of the volcano and traveling downstream through river valleys. When it turns cold from contact with rainwater, it continues to flow and is called lahar. This composite of debris flows further into river valleys through the land at the side, at a speed of 100–200 km/h, and these sediments and boulders can be bigger than 10m in diameter (Lavigne et al., 2000). Merapi uses rivers to channel its lahar downstream; these rivers are tributaries of the Progo and Opak Rivers (volcanic river basin).

Figure 1.1 Major volcanoes of Indonesia (USGS, 2011)

Mt. Merapi is located in the Yogyakarta Special Region (DIY, Daerah Istimewa Yogyakarta) of Java Island. This special region, located directly to the south of Mt. Merapi, is inhabited by 3.5 million people. The region is made up of one river basin territory or three river basins: Progo, Opak, and Serang, with a total area of 3,133 km^2 (BBWS SO, 2011). Two of these river basins (Progo and Opak) face problems relating to volcanic eruptions, aside from other water-related problems. This issue has resulted in a very complicated situation for implementing the IWRM approach. Yogyakarta has a cultural significance as the only surviving autonomous Javanese Kingdom in Indonesia, where the Sultan rules as governor for life. The Yogyakarta Sultanate was founded on 13 February 1755 after the Treaty of Giyanti, as a result of the Dutch East Indies Company's (VOC) 'divide et impera' (divide and rule) policy to break the power of the Mataram Sultanate into Surakarta and Yogyakarta. The Sultan Hamengkubowono I governed the Kingdom, and through his bloodlines or descendants the Sultanate of Yogyakarta survived (Soeratno, 2004). The act of Sultan Hamengkubuwono IX's proclamation of his support and the immersion of his Kingdom under the Republic of Indonesia (Amanat 5 September, 1945) resulted in the region obtaining a special status as the only reigning kingdom within this Republic. Strong support from the Indonesian national government is proclaimed in Law no.13/2012(UU no. 13/2012 on Special Status of Yogyakarta Special Region, 2012), which preserves this monarchical government and Javanese culture. This enabling reason is the main driver of the preservation of the Javanese way of life in Yogyakarta (Mulder, 2005). The region's cultural significance lies in its background, comprised of local and traditional knowledge, later referred to as **cultural ecological knowledge (CEK)**, as a potential concept used in water management in the

Mt. Merapi basin. Therefore, the Mt. Merapi eruption of 2010 was chosen as the starting point of this research, as this time was a turning point because it was realized that the locals use CEK more than the scientific approach, for example, to evade the danger of eruption and to live under these conditions during and post-eruption.

1.2 Statement of Problems

Two main phenomena are addressed throughout this dissertation: first, the management of water in a volcanic river basin (VRB) and, second, cultural ecological knowledge (CEK).

The first phenomenon raises the problem of current IWRM implementation as a general approach in all kinds of river basins. Here, IWRM implementation is taken as a given context for the overall structure of water management. Consequently, there are three types of management to be examined: water, lahar, and volcanic river basin. In addressing water management in this volcanic basin, the research needs to investigate how the current approach is implemented. The IWRM approach used in this river basin is a given precondition, as Indonesia implemented this approach in all its river basins. As mentioned above, IWRM has been mainstreaming in the world and adapted to many forms and contexts. However, in reality, the approach has only sets of principles and general guidelines, which were developed over at least the last 80 years of water management (Solanes and Gonzales-Villarreal, 1999, Hofwegen and Jaspers, 1999, Snellen and Schrevel, 2004). Much research on IWRM implementation highlights the failings of this holistic approach (Biswas, 2004, Savenije and Zaag, 2008, Gourbesville, 2008). Other scholars suggest that, for IWRM to be implemented, managers need to be more adaptive (Medema, McIntosh, et al., 2008), understanding it in line with the concept of social learning (Pahl-Wostl, Kabat, et al., 2008), or addressing it instead as complex water governance (Gupta and Pahl-Wostl, 2013, Hoekstra, 2010, Moss and Newig, 2010). IWRM implementation in Indonesia has not been without challenge, but little is known about how integrated the implementation is, specifically in the case of this VRB.

The IWRM approach does not indicate how to manage water in volcanic regions. This fact presents the first problem to be addressed in this research – how the IWRM approach is implemented – as it provides a set of principles to be used but no specific guidance based on geological conditions. With the 2010 Merapi eruption on the scale of 4 VEI (volcanic eruption index), the river basins in this area suffered, and the incident claimed 400 lives (from pyroclastic flow). Additionally, the lahar or debris flows caused IDR 3.56 worth of infrastructural losses, with 140,000,000 m^3 of volcanic material deposits flowing down the rivers (Widayani, 2011). The Indonesian government, through the KemenPUPR (Ministry of Public Works and Housing) and the BNPB (National Agency of Disaster Management) tackled these issues through disaster risk reduction (DRR) efforts; using early warning systems (EWSs), hazard zone planning, and the Sabo dam system (based on hydrologic engineering calculations) to channel and filter these debris flow materials (Sumaryono, 2011). In this sense, some DRR effort has been accomplished through IWRM implementation, such as via the mechanisms of the Sabo dam and the hazard zone. Therefore, in this research, lahar management is addressed using the literature on concepts of lahar management (Rodolfo, 1991, Pierson, Wood, et al., 2014, Marso, J. N., 2013, Leung, Santos, et al., 2003), volcano management (Sigurdsson, Houghton, et al., 2015, Bignami, Bosi, et al., 2012, Dvorak and Dzurisin, 1997, Pareschi, Cavarra, et al., 2000, Van Bemmelen, 1949), and disaster management (Wisner, Blaikie, et al., 2004, Ndirangu, Kabubi, et al., 2009, Birkmann and von Teichman, 2010). It is hoped that an understanding of what is involved in lahar management will clarify its relation to water management. Thus, this elucidation will add to the understanding of volcanic river basin management (VRBM) in general.

The second problem is lahar management. As lahar is partly formed by water, it is considered to be a water-related hazard and therefore is controlled and managed through the KemenPUPR. This ministry is also the primary stakeholder in managing water resources in general. However, the implemented lahar management approaches were insufficient, as the 2010 eruption still resulted in a significant number of victims and the loss of many of the main infrastructures in Yogyakarta. This condition presents the second problem of this research about the nature of the implemented lahar management. The reason behind these losses was the lack of comprehension of local livelihood conditions, which are based mainly on agricultural activities and the cultural values of the people in the region (Donovan, 2010). Here, cultural beliefs hold a strong place. These beliefs have shaped the people's perception of Merapi as their protector, in opposition to the technocratic approach by the government, which told them that the volcano was a threat (Chester, 1994, Cashman and Giordano, 2008, Gaillard and Dibben, 2008, Sigurdsson, Houghton, et al., 2015). Lahar management is constructed in this case study from experiences, using the concepts and theories explained earlier.

The next problem is how to integrate water and lahar management within a volcanic river basin. This problem is more challenging, as the literature is limited and focuses mainly on geological research perspectives (Delcamp, Roberti, et al., 2016, Dimitrov, 2002, Dorava and Meyer, 1994, Dvorak and Dzurisin, 1997, Iles and Hegerl, 2015, Major, Pierson, et al., 2000, Manga, 1997, Parisi, Paternoster, et al., 2011, Rodolfo, 1991, Van Bemmelen, 1949) and not on the management or governance point of view. This problem needs to be addressed before delving into the main problem of this research on the cultural approach. In the literature above, most research relates to disaster management, volcanology, or geography, with very few studies on lahar and water management in volcanic regions. These facts spark interest in current management practices in the volcanic river basin, where interrelations between water, lahar, and volcano management have to be understood.

The second phenomenon is the existence of CEK in this case study. Using earlier studies on traditional ecological knowledge (Berkes, 1993), indigenous knowledge (Agrawal, 1995, Pert, Ens, et al., 2015, Nikolakis, Grafton, et al., 2015), indigenous technical knowledge (Howes and Chambers, 1980), and local knowledge (Corburn, 2003, Geertz, 2000, Stabinsky and Brush, 1996), the elements of CEK are defined. These are the foundations used to investigate the case study. However, this raises the fourth research problem, as not all of these earlier studies relate directly to water management or the context of volcanic river basins. Other studies that have focused on the use of this non-scientific knowledge for understanding sustainable water development (Miller, 1966, Nikolakis, Grafton, et al., 2015, Robinson, Bark, et al., 2015, Gartin, Crona, et al., 2010) are used as examples of how to frame CEK in this case study. A prominent theory on cultural ecology argues that culture is shaped as a product of the environment or ecological conditions (Steward, 1972). These theories, along with the previously mentioned studies, are applied to explain the connection between Javanese culture and its embodiment in CEK for this case study. This problem is answered by linking the existence of CEK to the management realm.

The last problem is the unclear relation (in general and also in the Indonesian context) between CEK and the management of water in a volcanic river basin. Each of the earlier problems has to be addressed first to understand the link. Even if the IWRM is a holistic approach, it seems to lack the component of implementation know-how, as each place and country contains a different type of society and culture (Matz, 2008, Pahl-Wostl, 2006). This IWRM is not a ready-made solution; it must be tailored to fit each condition (Gourbesville, 2008); it needs to be adapted. IWRM is also problematic for cultural implementation. With water acting as the supplier of needs, but also becoming a threat if not managed correctly, global problems have arisen as a result. These are complex problems as they are multi-oriented, multidisciplinary, and link to multi-stakeholders within many levels of governance systems (Moss and Newig, 2010, Youngblood, 2007). As an integrated approach, IWRM must integrate environmental and social conditions and economic benefits. However, in managing any river basin, multi-stakeholders(Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Termeer, Dewulf, et al., 2010) and conflicts of interest(Jaspers, 2003, Biswas, 2004) are common conditions where disparate views are represented. Oversimplifications of this IWRM concept and narrowed translations are expressed as justifications for technical or engineering development (Pahl-Wostl, 2006) and zoning formulation (Barrow, 1998), as is also the case in Indonesia. These approaches also have less focus on wise environmental management, with specific discipline views on the problem depending on the main focus of the various organizations. These standard approaches (IWRM and lahar management) at the different management levels react differently to pressing hazard challenges.

Indonesia is a land with many cultural identities, but the influence of CEK in the water resources management sector has rarely been explored. At least 300 tribes from the country's total 250 million inhabitants reside in this archipelago (Badan Pusat Statistik, 2015). The Javanese make up almost 40% of the total population (Koentjaraningrat, 1985). Nevertheless, Yogyakarta, the Javanese cultural 'heart' has not explicitly recognized the relation of the IWRM concept to its cultural setting. This condition calls for an assessment of the sociocultural condition concerning water resources in society. Despite the importance of the cultural context for water, empirical studies from all over the world have suggested that culture has not been significantly considered in IWRM (Pahl-Wostl, 2006, Flanagan and Laituri, 2004, Ross and Pickering, 2002, Wisner, 2010). Each society has a different culture-based perception of water. The cultural values of water need to be prioritized, for indigenous communities (Matz, 2008) to implement IWRM in a specific cultural setting. This is where CEK functions as the bridge between the humans–nature relationship (Berkes, Colding, et al., 2000). CEK has promising potential, but its role and how it should be deployed in the management of a volcanic river basin have to be discovered.

1.3 Research Aim and Research Question

As proposed in the problem statement, this research aims to investigate the contribution of CEK to current IWRM in a VRB. This aim was chosen as an opportunity to provide a way forward in creating a culture-sensitive IWRM implementation for any cultural context. This culture-sensitive approach uses the cultural context as the lens to understand the existence of CEK in water management practices. This existence can be factual or directly used CEK (hard), but also background CEK (soft) in the practice of management. The specific location and culture may contribute to the different type of knowledge being used. This inquiry supports mutual learning and deliberation on the use of local knowledge in the current scientific approach to water management (Raymond, Fazey, et al., 2010, Agrawal, 1995).

The main research question is formulated to achieve these objectives: How does cultural ecological knowledge contribute to the integrated water resources management of a volcanic river basin?

It is assumed that currently there is no direct relation between CEK and IWRM in a VRB. Therefore, to assist in answering this main question, the five sub-questions listed below have to be answered. Each of the sub-questions is answered in a chapter.

(1) What are the main elements of cultural ecological knowledge in a volcanic river basin, and how is it formulated?
In this sub-question, the definition of CEK and its characteristics is the starting point of the research. This step helps to create the lens to find the form of CEK in current society, and policies also set the indicators of CEK practiced by the local communities. It is the basis of the research into rediscovering the application of CEK.

(2) How is the integrated water resources management (IWRM) approach implemented in a volcanic river basin?
This sub-question addresses the current concepts and policies being implemented, what they entail, and whether they are congruent with the IWRM concept in general. It is an essential sub-question as it deals with how IWRM is implemented in a VRB.

(3) What constitutes lahar management (LRM), and how is it implemented in a volcanic river basin?
This sub-question addresses the nature of lahar management and the concepts and implementation of lahar management in the case study, and it forms the basis for answering the next sub-question.

(4) How and why does lahar management relate to integrated water resources management in a volcanic river basin?
Here the relation between the LRM and IWRM concepts are explained and described. This sub-question also investigates the imperfections and complementing factors of each concept, which can be used in managing the river basin. This step is set as the preparation to address the next question, which

deals more with the relations between IWRM and LRM. This sub-question is also where the emergence of the term volcanic river basin management is located to merge the interrelation of water–lahar–volcano management.

(5) How and why does cultural ecological knowledge impact the management of a volcanic river basin?
This sub-question addresses whether the current policies have already embedded CEK, what forms it takes, and also what impact or non-impact it might have. If it has not yet been incorporated, this sub-question examines where the gap exists. It also addresses why CEK can have impacts in current management practices; this is answered by looking into the governance settings.

1.4 Significance of the Study

This research is used to gain a deeper understanding of the imperfections of current water management (Teisman and Edelenbos, 2011, Pahl-Wostl, Kabat, et al., 2008, Fulazzaky, 2014, Savenije and Zaag, 2008, Graefe, 2011, Global Water Partnership, 2000) and lahar risk management approaches (Wisner, Blaikie, et al., 2004, United Nations, 2015, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003, Marso, J. N., 2013, Rodolfo, 1991) in the reality of a complex river basin condition (Brown, Harris, et al., 2010), such as in a volcanic area. In defining lahar management, this research learned from other countries, such as the Philippines, USA, New Zealand, Peru, Vanuatu, and Japan (Keys and Green, 2008, Pierson and Scott, 1985, Rodolfo, 1991, Scrivenor, 1929, Thouret, Enjolras, et al., 2013, Wood and Soulard, 2009, Pierson, Wood, et al., 2014). However, the difference between the lahar sediment in any of those locations and that from Mt. Merapi is that the latter is considered as a resource, as the sand and rocks can be mined (Ikhsan, Fujita, et al., 2009) because the sediment is of the best quality and can be used for construction. Additionally, studies performed on lahar after the 2010 Mt. Merapi eruption focused more on the disaster management angle – the vulnerability, the hazards, and the risks (De Bélizal, Lavigne, et al., 2013, Widayani, 2011, Pallister, Schneider, et al., 2013, Marso, 2013).

The findings of this study help to rediscover the CEK in the region (Berkes, Colding, et al., 2000). This finding will benefit people in conserving intangible heritage in a structured way, by defining it, categorizing its forms, and how to operate it within the IWRM approach (Matz, 2008, Biswas, 2004, Jaspers, 2003). By using the case of this VRB in Yogyakarta, this study reveals the existing knowledge of the people in managing water resources (Flanagan and Laituri, 2004, Corburn, 2003), while facing the risks of an eruption. Earlier works on the Merapi volcano are not directly related to the aims of this research to integrate CEK into IWRM. They discuss mainly the existence of local knowledge in facing volcano eruption, such as perceptions about the volcanic eruption (Dove, 2008) and perceptions about local knowledge and adaptation on Mt. Merapi (Dove, 2007). Other researchers have focused more on cultural vulnerability in this volcano (Donovan, Suryanto, et al., 2012) and cultural responses to its hazards (Donovan, 2010). Aside from that, there are those who focus on the 2010 evacuation experiences (Mei, Lavigne, et al., 2013) and the behaviors of communities in facing volcanic hazards (Lavigne, De Coster, et al., 2008).

Therefore, the study aims to tackle two theoretical gaps. (1) How to operate IWRM under different cultural conditions (Matz, 2008, Pahl-Wostl, 2006). The findings may also be used to enrich the current approaches with cultural context, as most current solutions are still engineering based. (2) How to connect lahar and water management as holistic management in a VRB context. Finally, in this research, culture is seen as an asset and not as a hindrance to the IWRM approach. From these observations, the study proposes a culture-sensitive IWRM approach based on a cultural context, especially for those in volcanic regions.

1.5 Structure of the Thesis

This thesis is arranged in nine chapters. The first three chapters are the foundation of the research, whereas Chapters 4 to 8 are empirical chapters, where each chapter answers a sub-question. Chapter 9, the conclusion, summarizes the findings of this thesis. The thesis structure is defined as follows:

Part I, consisting of the first three chapters, gives the context of the research, the grounding within the field of study, and the methods employed.

Chapter 1: The introduction addresses the background to this research and states the research problems, research aim, and research question, and also discusses the significance of this research.

Chapter 2: The literature review presents the broad concepts and theories used in this thesis. It unpacks the concept of CEK, IWRM, lahar risk/resource management (LRM), and VRB. It also explains how the interrelations are seen through the governance lens using the concept of multilevel governance (MLG) and boundary spanning activities. The chapter concludes with the overarching conceptual framework for the thesis.

Chapter 3: The methodology chapter explains how the research was conducted, using a case study research design and qualitative methodologies. It starts with the case study selection, the location, the post-eruption timeframe between 2010 and 2018, and the methods used, and end with the operationalization of variables and indicators, translated into analytical frameworks.

Part II consists of the empirical chapters, where discussions of findings are presented, that is, Chapters 4, 5, and 6. Each empirical chapter addresses one of the sub-research questions presented in Chapter 1.

Chapter 4: This chapter identifies the main elements of CEK in a VRB. It answers the first sub-question: What are the main elements of cultural ecological knowledge in a volcanic river basin, and how is it formulated? The chapter is divided into two main parts of CEK: the main elements (historical experience and transfer mechanisms) and the formulation patterns (cultural institutionalization and processes).

Chapter 5: This chapter discusses the management of water resources in a VRB. It addresses the second sub-question: How is the integrated water resources management (IWRM) approach implemented in a volcanic river basin? Using an MLG lens, this chapter focuses on IWRM implementation. The chapter is arranged in four parts: (1) the current condition of policy settings, (2) managerial contexts (national, regional, municipal), (3) analysis of interaction attempts, resulting in (4) the integration level. The chapter shows through the MGL lens that the IWRM approach is translated into pillars of implementation, presented as water conservation, water utilization, and water-related hazard control.

Chapter 6: This chapter deals with LRM. It analyses the third sub-question: What constitutes lahar management, and how is it being implemented in a volcanic river basin? A similar structure to that found in Chapter 5 is used (four parts: policy setting, managerial context, interaction attempts, and integration level). However, it has a different arrangement as lahar management highlights the importance of temporal dimensions, complicating the multilevel arrangement with pre-, onset, and post-eruption stages.

Part III presents the analytical chapters, which result from constant comparisons and iterative processes within the results, with each chapter also answering a sub-research question.
Chapter 7: This chapter deals with VRBM: the interrelation of lahar management and IWRM. Answering the fourth sub-question: How and why does lahar management relate to integrated water resources management in a volcanic river basin? This chapter introduces the VRBM concept, where there is a multilevel overlap (boundaries). It adopts the MLG structure as in the two earlier chapters. The VRBM concept answers the how, as it divides the interrelations of water and lahar management into Normal, Disaster, and Normal+ VRBM phases. The chapter also pays more in-depth attention to why water and lahar management interrelates, which is answered through the actors or agents within existing interaction attempts. The types of actors' characteristics identified are related to the concept of boundary spanning activities, boundary organizations, and boundary spanners.
Chapter 8: This chapter focuses on impacts of CEK in a VRB. It addresses the last sub-question: How and why does cultural ecological knowledge impact the management of water and lahar in a volcanic river basin? It is divided into two main parts on the 'how' and the 'why'. The impact patterns are used in answering how CEK impacted the multilevel arrangements, and it is concluded that the impact patterns of CEK in each VRBM phase (as introduced in Chapter 7) result in different integration levels. The highest integration level is found where more boundary activities are present. Thus, this part answers the 'why' aspect of the research question: boundary activities are explained as the cause of why certain CEK made or did not make impacts on the management of the VRB. Further analysis of boundary organizations and boundary spanners presents their locations and identity within the interaction attempts, clustering the boundary spanners into different types based on sectorial interaction attempts and affiliations. Additionally, for CEK to actively impact the management of the VRB, it needs a conducive atmosphere, the characteristics of which are explained in this chapter.

The last part, **Part IV**, the conclusion, is presented in Chapter 9.
Chapter 9: This is the concluding chapter. It reprises and summarizes the answers to each of the sub-questions and shows how the earlier chapters build up to answer the main research question.

CHAPTER 2

LITERATURE REVIEW

2 Literature Review

2.0 Introduction

This chapter presents a general overview of the three concepts used in this research, which will be explored and relate to one another. Firstly, this chapter develops a working definition of cultural ecological knowledge (CEK) to frame the research context. It then clarifies two other concepts used in the management of a river basin in a volcanic area, called a volcanic river basin (VRB). These are the more general concept of integrated water resources management (IWRM) and lahar risk/resources management (LRM), which also entails disaster risks reduction (DRR). Both of these concepts need to be interrelated to address the problems of volcanic river basin management (VRBM). This chapter also explains how CEK may be interrelated with IWRM and LRM from the literature point of view. Thus, a conceptual framework is built based on these three concepts, using theoretical findings from this field of study.

2.1 Cultural Ecological Knowledge

This section explains the CEK concept, which stems from earlier works that explain similar concepts of local, indigenous, traditional ecological knowledge. CEK is used to summarize these earlier works. This section also explains how this concept came to be central in this thesis, as a result of the emerging of interest in CEK and also the divide between knowledge and science, as there is proven merit in understanding how local knowledge can benefit science.

2.1.1 Development of Cultural Ecological Knowledge

To understand CEK, the term culture is firstly addressed in the context of its primary function as people's customs and their perception of the environment. However, in this respect, the term culture is more related to Steward's (1972) concept of cultural ecology. His definition shares the idea that cultural ecology's main function is to enable people to grasp their natural surroundings, adapt to changes in their environment, and give meaning to their place. In short, cultural ecology studies human adaptation to the social and physical environment (Steward, 1972). This adaptation may change or reorient the products of a culture so that humans can survive in their surroundings.

Therefore, knowledge is an essential aspect of cultural ecology, where all understanding related to a group of people through generations is assembled. This production of knowledge by humans to manage their ecology thus links to the development of cultural ecology. Steward (1972) also argues that each culture has a base core, which usually takes form in a belief system or a concept. This culture core informs how each culture develops or lives with the environment as a structured dynamic on the interaction of man and environment, where man is also a part of nature (Sutton and Anderson, 2010, Steward, 1972).

The development of CEK is referred to in earlier studies with terms, such as local knowledge, indigenous knowledge, indigenous technical knowledge (ITK), and traditional ecological knowledge (TEK). First, how people deal culturally with their environment is sometimes called local knowledge. This term is defined as knowledge with practical, collective, and strong roots to a particular place that forms an organized knowledge based on experiences (Geertz, 2000). Geertz also suggests that local knowledge can be described as simply knowing a city by knowing its streets.

A term that fits more closely with CEK is TEK. This knowledge represents experience acquired over thousands of years of direct human contact with the environment (Inglis, 1993). It is defined as intuitive wisdom characterized by traditional or non-literate cultures that have a developed and refined awareness of the environmental condition (Inglis, 1993, Capra, 1982). Another definition of TEK as a cumulative body of knowledge and beliefs transferred through generations about the relationships of living things with each other and their surrounding (Berkes, 1993). The term also explains the continuity of the historical dimension of resources practices by societies, especially those that are less advanced.

Some Javanese cultural knowledge is documented in the literature, songs, poetry, and also part of daily activities (Mulder, 2005, Geertz, 1976). The expression 'cultural knowledge' is used in anthropology, examining the culture-specific body of knowledge (Stabinsky and Brush, 1996). A branch of this is ecological knowledge. It is defined as a pure awareness toward the environment in the form of wisdom representing empirical experiences of human–nature relations (Berkes, 1993). This form of knowledge can be derived from the perspective of a distinct cosmology or worldview, a conceptualization of the environment of which ecology is a part.

CEK takes shape in the holistic understanding of the adaptation and outlook of nature. This knowledge is built by pieces of smaller knowledge using experimentations and shared through practical experiences (Inglis, 1993), documented in letters or books (Daldjoeni, 1984) or transmitted orally (Berkes, 1993).

CEK is founded on the relationship between humans and nature or the socio-ecological system (SES), which can be classified into three categories; first, generations of experience in managing resources; second, the collection of resources using indigenous informants; and, third, the conservation of resources (Brush, 1993). Both managing and collection can be summarized as utilization. Water resources have a hazard-related dimension that requires an avoidance relationship and adaptation to evolving environmental conditions, as explained in cultural ecology (Steward, 1972).

Therefore, for clarity in this research, it is more appropriate to use the broader term of cultural ecological knowledge, the working definition of which is summarized as follows: ***CEK is the collective body of knowledge and beliefs passed through generations that explain human–nature relationships, transmitted orally or in writing.***

2.1.2 The Interest in Gaps between Knowledge and Science

The choice of CEK as the focus of this research is based on the growing interest in the gaps between knowledge and science. The elements of CEK are borrowed from local knowledge, ITK, and TEK. It is necessary here to distinguish between Western science and local knowledge. However, the most exciting part of the distinction is that local knowledge completes the unknown factors within scientific findings (Agrawal, 1995). The author divided the dichotomies between Western and local knowledge into three major themes: (1) substantive – where local knowledge is more connected than Western knowledge to local livelihoods (as the way of solving problems), (2) methodological – how the two possess different methods and worldviews in implementation, where Western science is open, systematic, objective, analytical, whereas local knowledge is closed, non-systematic, non-objective, non-analytical, (3) contextual – where the local counterpart is embedded more in its context. These three themes are the main elements of local knowledge and are used to cluster the findings about CEK.

This local knowledge cannot be seen as a generalized idea, from a methodology point of view. Other literature suggests that there is a method in local knowledge, as it based on the intuition of the senses to arrive at ITK (Howes and Chambers, 1980). Howes and Chambers summarized two main differences between ITK – which is similar to ecological knowledge – and the scientific model. The first difference is the way a phenomenon is observed and ordered: science breaks down data presented to the senses and reassembles it, whereas ITK is more concrete, relying on institutions and the evidence of the senses. The second difference is the way practitioners are engaged: science is an open system with alternative perspectives, whereas ITK is a closed system and lacks other ways of looking at the world (Howes and Chambers, 1980). CEK must also be identified through the use of human senses by observing a phenomenon, by observing practitioners as they engage with the knowledge. As it is a closed system, understanding why certain senses belong to a phenomenon helps to explain the logic behind them.

Both approaches highlight two critical points in understanding the contrast between CEK and science: context enrichment of a place, culture, or identity group; know-how belonging to these connections of human and nature in a specific place, and closed method. These points need to be addressed to ascertain whether they are still the same in current society.

Several IWRM studies, including those listed hereunder, try to relate CEK to IWRM. These studies do not always suggest a holistic relation between CEK and the dimensions of water management. Therefore, the knowledge gathered is scattered.

(1) The incorporation of local knowledge in water management policy in the face of climate change challenges, case study: Murray-Darling Basin. Many studies have been performed on this case study, and the government does justice to local knowledge by incorporating indigenous knowledge in water management policy for the basin. A water management plan was enacted in 2012, and progressive results have been found over time (Hart, 2015, Nikolakis, Grafton, et al., 2015, Robinson, Bark, et al., 2015).

(2) Cultural knowledge was used in an environmental assessment in the Wind River Indian Reservation (Flanagan and Laituri, 2004), comparing water management using the scientific method with ecological knowledge from the Euro-American cultural perspective implemented through rules for water management derived from the local indigenous ecological and cultural knowledge of Native American cultures.

This approach resulted in some reframing of water-use priorities, purposes of stream preservation, and in-stream flows.

(3) Herds use local knowledge in resource rotation and alteration of grazing areas in the African Sahel (Niamir-Fuller, 1998); this relates to water conservation areas.

(4) The use of seasonal pattern calendars based on Javanese culture for the agricultural planting season (Daldjoeni, 1984, Retnowati, Anantasari, et al., 2014) and determining a dam operation rule curve (Ariyanti, Wicaksono, et al., , 2016); this relates to the hydrological cycle.

None of the attempts discussed above were applied specifically in a VRB. Therefore, the results of this research may contribute to the literature in this respect. However, in the LRM area, there are some studies dealing with risk perceptions toward volcanoes and their activities, including the following:

(1) The utilization of local myth and legends as an educational tool for community preparedness in risk perception of volcanic eruptions (Cashman and Cronin, 2008) in New Zealand and the US.

(2) A community hazard risk assessment (Cronin, Gaylord, et al., 2004) in Vanuatu, which incorporates traditional knowledge with scientific ideas in building awareness and develops participatory volcanic risk management strategies and emergency plans.

These studies focus only on disaster management strategies and do not necessarily explain how to manage water during eruption and lahar flow.

Additionally, not much attention has been paid to seeking knowledge on interrelations in VRBs. Knowledge gaps exist between the cultural (CEK) and the scientific (IWRM, LRM) fields, and also between the management of hydro-geomorphology (IWRM) and volcanology (volcano management). These gaps are addressed throughout this research.

2.1.3 Characteristics of CEK

CEK conceptualizes the environment differently from Western science, in that ecology is part of the community (Berkes, 1993, Agrawal, 1995). The relationships between community and ecology are based on reciprocity and obligations toward community members, other beings, and communal resources management institutions based on shared knowledge and meaning (Berkes and Folke, 1998). As CEK is the collective body of all kinds of local knowledge, the following common characteristics are found in TEK, ITK, local knowledge, and indigenous knowledge:

(1) They are based on historical experiences,

(2) They have forms or mechanisms of transfer, and

(3) They use five senses wisdom as a direct indicator of the ecological condition.

Therefore, to learn about the existence of CEK, one should be sensitive to these characteristics.

Historical Experiences

The first characteristic, historical experiences, is the basis for the generation or production of the knowledge. This definition is based on other work by Berkes, studying the socio-ecological practices and mechanisms in traditional knowledge and practice from all over the world (Berkes, Colding, et al., 2000). This knowledge can be categorized into management practices and the social mechanism behind them. It also influences the categorization of environmental management practices to be studied under CEK. It sorts the socio-ecological management practices into three types (conventional, abandoned, and managing complex system), as supported by other similar works on local knowledge, ITK, and indigenous knowledge.

These clusters of practices are rearranged based on the types of historical experiences, starting with the generation of knowledge where the reinterpretation of these signs, as the entry point, may be explained by the five senses wisdom (third characteristic of CEK). Berkes explained in a later study (2012) that local ecological knowledge is generated by reinterpreting physical-environmental signs and the revival of local knowledge from folklore, as also supported by others (Daldjoeni, 1984, Agrawal, 1995, Inglis, 1993, Howes and Chambers, 1980, Geertz, 2000, Retnowati, Anantasari, et al., 2014).

The next step is the practices for responding to change in the environment. This comes under the conventional type of TEK (Berkes, Colding, et al., 2000) in monitoring resource abundance and change (Gunderson, Holling, et al., 1995); protection of certain species, vulnerable life (Ross and Pickering, 2002, Gadgil, Berkes, et al., 1993), specific habitats, sacred locations (Berkes, 2012), or sources of materials; and temporal harvesting restrictions (Daldjoeni, 1984, Brush, 1993, Naylor, Battisti, et al., 2007). However, practices in responding to extreme change, especially for a VRB, means the response to a volcano's eruption hazards (Corburn, 2003, M. Dove, 2007, Donovan, 2010, Schlehe, 2010); this functions as a turning point for both social and ecological parameters.

Experiences relating to protection or conservation of resources are used to protect vulnerable life (Brush, 1993), sources of materials (Ross and Pickering, 2002), and sacred locations (Berkes, 2012). These conservation measures take the form of taboos, regulations, myth, and folklore, and are supported by rituals performed (Geertz, 2000); this is discussed later and referred to in the section on mechanisms of transfer. The sacred locations are usually connected with the source of materials, such as rivers and mountains, but can also be delineated to protect vulnerable life, such as endangered flora or fauna, or even indigenous people (Berkes, 2012). These sacred locations also relate to indigenous people's worldview, encompassing the origin of life and the magical or spiritual worlds (Geertz, 1973). Conservation is one of the commonest acts in the practice of CEK, especially when the local people are still superstitious. Furthermore, these sacred locations for water resources are usually connected with conservation areas.

Temporal experiences can take the form of harvesting restrictions, whereby resource rotation is based on the seasonal calendar (Brush, 1993, Naylor, Battisti, et al., 2007, Daldjoeni, 1984) and the cycle of nature (Berkes and Folke, 1998), which can range through seasons, cyclones, and volcano eruptions. The seasonal calendar is commonly followed by indigenous groups, for whom it is part of their cultural knowledge, whether it is formally known or, as in most cases, orally transmitted. The seasonal calendar indicates the right season for agricultural activities (Daldjoeni, 1984), and usually it is more detailed than the conventional division of wet/dry season (Retnowati, 2014, Brush, 1993, Nikolakis, Grafton, et al., 2015, Gadgil, Berkes, et al., 1993, Howes and Chambers, 1980). Phenomenology is the method used in such calendars, whereby indigenous people have observed the changes in seasons with compatible physical, biological, or ecological indicators concerning human senses (Retnowati, 2014). The precision of such tools is challenged by climate change (Nikolakis, Grafton, et al., 2015), as seasons have shifted and temporal experiences use human senses as indicators to inform them about seasonal conditions (Agrawal, 1995), i.e., the five senses wisdom.

There are some notable examples of experience in managing dynamics of complex systems in the landscape or watershed (Nikolakis, Grafton, et al., 2015, Robinson, Bark, et al., 2015, Flanagan and Laituri, 2004) or ecological processes at multiple scales (Brush, 1993, Daldjoeni, 1984, Steward, 1972, Capra, 1996) and responding to environmental disturbances (Schlehe, 2010, Denevan, 1983). Experiences in watershed management using CEK range from water quality (Gartin, Crona, et al., 2010), fairness and justice in access (Nikolakis and Grafton, 2014), water allocations (Flanagan and Laituri, 2004), to water market (Wutich, York, et al., 2012), among others. This experience of managing water resources using CEK and cultural values is known as ethnohydrology (Back, 1981, Sangkhamanee, 2007, Gartin, Crona, et al., 2010), which stresses the importance of water function as a cultural flow, which is different from environmental flow (Nikolakis and Grafton, 2014). This is because water as a cultural flow is described as having spiritual and cultural values defined "as a large and encompassing flood event that replenishes, reconnects, and sustains the ecological and cultural integrity of the forest" (Robinson, Bark, et al., 2015, Nikolakis, Grafton, et al., 2015, Hart, 2015).

Mechanisms of Transfer

The second common characteristic is the mechanisms of transfer or the forms of CEK, defined as a social mechanism underlying management practices (Berkes, Colding, et al., 2000). Similar works on local knowledge support this argument where the mechanisms of transfers can be clustered as follows:

(1) Structures of cultural institutions through stewards/wise people or local task groups (Berkes, Colding, et al., 2000),
(2) Dynamics of cultural institutions through the integration of knowledge and social/religious sanctions (Inglis, 1993),
(3) Cultural internalization (Berkes, Folke, et al., 1995, Inglis, 1993) through rituals, cultural frameworks, folklore or myths, and regulations or taboos (Mulder, 2005),
(4) Physical artifacts (Dradjat, 2009, Berkes, Colding, et al., 2000, Inglis, 1993),
(5) Worldview or cosmology (Geertz, 2000, Mulder, 2005, McArthur and Baron, 1983), and
(6) Cultural values such as ethics or reciprocity toward the community (Geertz, 1973, Retnowati, Anantasari, et al., 2014).

The structure of cultural institutions is more about the actors, whereas the dynamics are about the activities. In the structure of a cultural institution, the role of stewards or wise people is to be the 'go-to person' in sharing their knowledge (Berkes, Colding, et al., 2000). However, the wise person role is also related to specialized tasks. For water management in Java and Bali, local task groups usually consist of such persons, whose roles include determining water allocation, for example (Christie, 2007). The dynamics of this group are what is considered as the group's activities in performing its tasks. This description of dynamics suggests social dynamics, and these are not without conflict, but there is a solution and balance must be maintained (Wutich, York, et al., 2012).

Cultural internalization implies that knowledge is presented as part of daily activities. The forms of ritual for water depend on the cultural values of water (Back, 1981). All over the world, indigenous people perceive water as a holy matter, thus it purifies other substances (Berkes, 2012, Degroot, 2009). Therefore, water is part of rituals.

For example, the Thais in Mekong perform various festivities concerning the origin of water in the rivers or mountains as the source of the river (Sangkhamanee, 2007). The cultural frameworks in the same literature explain about the three layers of the world; this relates to their worldview, where water is of significance in the world (Sangkhamanee, 2007). This knowledge is non-objective as explained earlier in the methodological theme of local knowledge, as it is not based on personal feeling, but rather socially constructed by common terms in social institutions.

Folklore and myths are used as a way to transfer knowledge, either orally or in writing (Agrawal, 2014). These are explained as important stories about a society's history, and at times of extreme change, the 'timestamp' is known. Aside from that, there are regulations and taboos, which are known by the community as a way to establish ethics toward the environment (Berkes, 2012). Concerning the knowledge, physical artifacts are present to signify or mark these unique places or regions as results of that knowledge (Inglis, 1993, Berkes, Colding, et al., 2000). However, the most overwhelming concept of a given society is its worldview, which relates deeply to culture and is embedded in the way indigenous people see their surroundings, whether in the realm of the seen or the unseen (Geertz, 1973, Geertz, 2000, Stabinsky and Brush, 1996, Agrawal, 2014).

Five Senses Wisdom

The third characteristic is the utilization of humans' five senses as direct indicators, as mentioned earlier as the substance and methods of how the knowledge absorbs the input of ecological conditions. This characteristic is supported by the ideas of the senses as substantively relating to a context, a territory, a place, or geographically specific (Geertz, 2000, Capra, 1996, Berkes, 1993) and methodologically through the intuitions based on the senses (Howes and Chambers, 1980, Agrawal, 1995, Berkes, Colding, et al., 2000).

The five senses are: sight (visual sense), touch, taste, smell, and hearing. Use of the visual sense can help people to see the biophysical indicators of ecological change. Touch relates to differences in surfaces, humidity, and temperature, and other similar characteristics. The taste buds in the tongue can help in determining whether the right kinds of ingredients exist in water or land, for example, in water quality. The smell of things, such as the air, water, soil, plants, helps to create awareness of these dimensions of the environment. Hearing is used to detect changes in sounds, such as flooding, rain, and eruption. The use of sensory organs as direct indicators to determine changes in the surroundings is based on historical experiences and contextualized within geographically specific conditions.

2.1.4 Summary of CEK

A working definition of CEK describes the concept as: *CEK is the collective body of knowledge and beliefs passed through generations that explain human–nature relationships, transmitted orally or in writing*. In line with these earlier works, CEK as a body of knowledge can be recognized through three main characteristics:

(1) Historical experiences in the generation of knowledge, utilizing indicators in response adaptation, conservation, or protection, temporal experiences, and managing complex nature dynamics (Berkes, Colding, et al., 2000). These indicators are used to obtain a more in-depth understanding of empirical experiences through history in managing ecology based on the cultural point of view

(2) The mechanisms of transfer are the form of CEK in current society (Berkes, Colding, et al., 2000). These mechanisms are the second part of the assessment to seek the forms of CEK in current society. There are several possible forms, such as the institutionalized structures and dynamics of the community; cultural internalization: myth, rituals, worldview, philosophies, resources management practices; and cultural values: taboos, regulations, and ethics.

(3) The five senses wisdom in the human–nature relationship is divided into substantive and methodological sub-features using the five senses indicators for humans (sight, touch, taste, smell, hearing) (Berkes, Colding, et al., 2000, Agrawal, 1995, Howes and Chambers, 1980, Capra, 1996). Wisdom is using these indicators to explain the condition of nature and how humans should react to this condition.

Using these as a lens helps to focus on what to seek in the field and to understand the essence of CEK. The relationships of the CEK characteristics are hypothetically arranged as follows: they start with historical experiences, are developed into the mechanisms of transfer, and are refined into the five senses wisdom. In this research context, these CEK characteristics are used as indicators to uncover its existence in the current society in a VRB. These characteristics are presented in more detail in Table 2.1.

Table 2.1 Characteristics of CEK

Characteristics of CEK	Sub-feature	Definitions	Literature Source
Historical experiences (Berkes, Colding, et al., 2000).	Generation/production of knowledge	Reinterpreting physical-environmental signs The revival of local knowledge	(Daldjoeni, 1984, Berkes, Colding, et al., 2000)
	Responding to environmental conditions	Monitoring change Resource abundance Managing ecological disturbances (hazards)	(Schlehe, 2010, Berkes, Colding, et al., 2000, Steward, 1972, Gunderson, Holling, et al., 1995, Denevan, 1983)
	Protection or conservation of resources	Vulnerable life Sources of materials Sacred locations	(Brush, 1993, Berkes, Colding, et al., 2000, Gadgil, Berkes, et al., 1993, Ross and Pickering, 2002, Berkes, 2012)

	Temporal	Harvesting restrictions Resource rotation The cycle of nature	(Daldjoeni, 1984, Berkes and Folke, 1998, Naylor, Battisti, et al., 2007, Brush, 1993)
	Managing dynamics of complex system	Watershed Collection of resources The ecological process at multiple levels	(Brush, 1993, Berkes, Colding, et al., 2000, Steward, 1972, Capra, 1996, Daldjoeni, 1984, Flanagan and Laituri, 2004)
Mechanisms of transfer (Berkes, Colding, et al., 2000)	Structures of cultural institutions	Stewards/wise people Local task groups	(Berkes, Colding, et al., 2000)
	Dynamics of cultural institutions	Integration of knowledge Social/religious sanctions	(Inglis, 1993, Berkes, Colding, et al., 2000)
	Cultural internalization	Rituals (ceremonies, traditions) Cultural frameworks Folklore or myths Regulations/taboos	(Berkes, Colding, et al., 2000, Inglis, 1993, Berkes, Folke, et al., 1995, Mulder, 2005)
	Worldview	Symbol/physical artifacts Cosmology	(Geertz, 1973, Dradjat, 2009, McArthur and Baron, 1983, Mulder, 2005)
	Cultural values	Ethics Reciprocity toward the community	(Endraswara, 2013, Geertz, 1973, Geertz, 1976)
Five senses wisdom (Berkes, Folke, et al., 1995, Geertz, 2000)	Substantive	Context, territoriality, place meaning, and geographically specific	(Berkes, 1993, Capra, 1996, Geertz, 2000)
	Methodological	Process of relying on intuition evidence to the senses	(Berkes, Colding, et al., 2000, Agrawal, 1995, Howes and Chambers, 1980)

In order to conduct research on CEK, it is necessary to locate the communities in the case study that still practice the knowledge. In the context of this research, this refers to knowledge relating to water management and also involves victims of lahar.

Firstly, it is essential to detect those stewards or wise people, usually elders, but sometimes the position can be passed to the newer generation. These people are characterized as accepted as a spiritual leader to perform rituals, someone who understands the local knowledge and is respected in the community through this knowledge, or someone who is asked to give advice in regard to cultural beliefs and the 'old ways' (Berkes, Colding, et al., 2000)

Secondly, it is essential to detect the local task groups that deal with everyday activities (Berkes, Colding, et al., 2000) to manage water resources, but also who understand lahar. In some cases, these can be farmers' associations, women's associations, youth groups, or disaster response groups, or even anything in between. These task groups can provide potential participants of all ages in the community who understand the knowledge and may still practice it.

2.2 Integrated Water Resources Management (IWRM)

In this section, the development of the IWRM approach is discussed, followed by a review of its current approach, and its four dimensions: natural, spatial, temporal, and human. In the summary, the concept is contextualized for this research.

2.2.1 Development of IWRM

The IWRM approach was initiated to answer problems faced by managers and stakeholders. The issues faced in water management are categorized into six groups (Thomasa J. and Durham, B., 2003, Biswas, 2004, Jaspers, 2003, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009): (1) quantity and quality: supply and demand, wastewater collection, pollution control; (2) timing: present versus future generations, the timing of releases; (3) types of water utilization and water projects: reservoir, weir, dam, flood control, coastal development, and protection; (4) forms of water resources: surface water: rivers, lakes, glaciers, and groundwater: water table, underground stream; (5) multi-scales problems: multi-objectives of water values (economic, environmental, social), policy implications for all social groups and stakeholders, legal and regulatory frameworks, water stakeholders' variations in interests, boundary issues in river basins; and (6) conflict at multi-levels: urban and rural issues, upstream–downstream conflicts of interest, bottom-up and top-down approach, government levels and governance hierarchy, and issues of decentralization versus centralization.

These issues are answered differently regarding the development of science in water management. The evolution of concepts in water resources management may be summarized as follows:

(1) The 1960–1970s saw mostly an engineering approach to water resources (Savenije and Zaag, 2008). This approach, however, led to a very technocratic way of thinking in dealing with water. It lacks the whole picture of water as essential support for ecology and cultural understanding.
(2) The 1980–1990s saw water resources being managed through regional and national planning. Thus, there was more awareness of ecological problems after overexploitation of water during the previous era. The IWRM concept (the IWRM approach was born in 1992) is an internationally acclaimed concept, as it has replaced earlier forms of water resources management (Savenije and Zaag, 2008, Solanes and Gonzales-Villarreal, 1999, ICWE, 1992).
(3) In the 2000s, water management developed into water governance, with multi-sectorial facets and stakeholders, and now addresses issues of socio-economic development, physical planning, environmental protection, public participation, and sustainability (Edelenbos, Bressers, et al., 2013, Savenije and Zaag, 2008). This period calls for social learning (Pahl-Wostl, Mostert, et al., 2008, Pahl-Wostl, 2006), including a cultural understanding of water.

However, a lag in IWRM research has accentuated the problems of implementing IWRM in real-life conditions (Pahl-Wostl, Mostert, et al., 2008). Many water management institutions in the world claimed the IWRM label, while only fostering technical solutions, and then later considered the social aspects (Pahl-Wostl, Mostert, et al., 2008). This tendency for IWRM to adopt a social research point of view has made it part of governance and policy studies (Molle, 2009b, Lubell, 2013, Hoekstra, 2010, Teisman and Edelenbos, 2011).

2.2.2 Review of Current IWRM Approach

Under the IWRM approach, there are three criteria for good water management: social equity, economic efficiency, and environmental-ecological sustainability (Solanes and Gonzales-Villarreal, 1999). Additionally, Jaspers (2003) describes IWRM as the management of water, whether located on the surface or subsurface in multi-disciplinary and participative approach based on its quality, quantity, and environmental sense. To achieve this condition, IWRM recognizes the complementary elements of an effective water resources management system. This condition must be developed and strengthened concurrently. Therefore, IWRM positions the efforts of water governance through policy, stakeholder roles, and management instruments.

The IWRM concept bases its premise on water as a shared resource that should be managed jointly in an equitable manner for the social and economic good, while at the same time protecting the ecosystem. The premise is built on the four Dublin principles (Savenije and Zaag, 2008, ICWE, 1992, Solanes and Gonzales-Villarreal, 1999): (1) fresh water is a finite and vulnerable resource, essential to sustain life, development, and environment, (2) water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels, (3) women play a central part in the provision, management, and safeguarding of water, (4) water has an economic value in all its competing uses and should be recognized as an economic good.

IWRM also has a long-term ambition to form an equitable way for the common good. The World Bank and Global Water Partnership advocated this central concept as an international remedy for water governance, making this concept very famous (Savenije and Zaag, 2008, Gourbesville, 2008). However, IWRM implementation focuses more on water needs and societal requirements regarding present and future water conditions (Jaspers, 2003).

IWRM is described by the origin of etymology per word (Cardwell, Cole, et al., 2006) as follows:

> Integrated (verb): To have made whole by bringing all parts together; unified, or as a noun: Integrity – completeness, unity. Water (noun; adjective): A liquid essential for most life and a widely used solvent; a body of water including a sea, lake, river or stream. Resources (noun): Something that can be looked to for support; and available supply; means that can be used to advantage or profitably; assets. Management (noun): The act, manner, or practice of managing, handling, or controlling something. Synonym: control, handling, or as a verb: To manage. To contrive or arrange; succeed in doing or accomplishing something (objectives/goals implied).

In this regard, IWRM is defined as a coordinated, goal-directed process for controlling the development and use of rivers, lakes, oceans, wetlands, and other water assets.

The Global Water Partnership adopts another definition of IWRM internationally, in which IWRM is recognized as a process that promotes the coordinated development and management of water, land, and related resources (Solanes and Gonzales-Villarreal, 1999, Snellen and Schrevel, 2004). In this definition, the integrated manner of water resources management can be divided into three types of integration: (1) integration of related resources and (2) functional and (3) social scales.

The current specialized and fragmented governance system has made IWRM implementation much more difficult. Typically, joint responsibility, cooperation facilitation, and integration are ideal in this context (Teisman and Edelenbos, 2011), particularly as interdependence is created between organizations as a result of the water cycle process and environmental and economic issues (Jaspers, 2003). Furthermore, this specialized governance system is often disconnected from the public. Therefore, the premise on which the IWRM concept was built has not been entirely achieved. Consequently, this condition calls for constant pressure to bring these fragmented pieces together in a more holistic approach.

It is also understandable that it is doubtful that this broad concept will be implemented equally with the same success rate, as no country adopts IWRM in the same way (Biswas, 2004, Gourbesville, 2008, Mitchell, 2005). Therefore, water resources management needs to be framed in each country in each specific condition to guarantee its success. In the VRB context, an IWRM approach must also consider the interrelation of water and volcano as the frame for any policies.

2.2.3 Dimensions of IWRM

According to (Savenije and Zaag, 2008), the IWRM approach has to consider the following four dimensions of water management: natural, spatial, temporal, and human, as its main building blocks. Their work explained the importance of a comprehensive IWRM to make appropriate decisions and arrangements by considering these dimensions.

The Natural Dimension: Water and its Natural Forms

This dimension suggests that the entire hydrological natural process must be taken into account (Graefe, 2011), including quantity and quality, also distinguishing each form of water in its cycle. In the water cycle of VRBs, the water resources relate to three other resources (Gleick, 2003, Marso, J. N., 2013): (1) atmospheric conditions (precipitation and evaporation), (2) water flows (river, lake, base flow, groundwater, sea), and (3) land (types of geological condition and soil materials: sand, boulders, tuff).

In this interrelation, natural processes occur between the resources. Hydro-meteorological processes are precipitation and evaporation as a function of nature interlinking atmosphere to water flows; hydro-geological processes describe surface and groundwater, including geological processes. In the context of this research, the geological activity is defined as volcanic activity.

Another type of interrelation also exists in the geomorphological conditions of water resources. Each river has a relation with physical circumstances, for example, the situation of upstream–downstream floods control (Nikolakis, Grafton, et al., 2015). The correlation between surface and groundwater in the same river basin usually corresponds to a pattern where the hydrological process and geomorphological boundaries are at times cross- or inter-basin and non-coterminous (Molle and Wester, 2009). Each basin is unique, although some of the hydro-geomorphological characteristics are common (White, 1963). These specific conditions belong to these attributes.

Therefore, the interrelations of natural dimensions in IWRM, in many definitions, can be variable. However, this research is focused on the interrelations located in the types of resources (atmosphere-water flows-land) and related processes (hydro-meteorology-geological), and also the hydro-geomorphological characteristics: upstream–downstream.

The Spatial Dimension: The Spatial Unit of Management for Water Resources

That water resources management uses hydrological boundaries is not a new fact; it has existed since ancient times and came more into focus when serious water competition started to occur. Environmental integrity and preserved environmental flows offer a new direction. It is almost impossible to organize water resources management without integration on the hydrological base (Jaspers, 2003).

How water is used and its available resources are variable. The distribution of water resources and uses among users, watershed, catchment, up–downstream, and the existence or non-existence of delineated management boundaries illustrate this point. However, the spatial management focus is not on the basin but on the river itself and various types of use allowed by technology, and on issues of adaptation of river strength, up–downstream interactions, or connectivity of river systems (Molle, 2009b). When a basin is too big for planning and management, sub-divisions of this spatial scale are defined, either by characteristics (upper-middle-lower basin) or sub-basins by tributaries (Biswas, 2004). None of these boundaries uses a stable physical line, and there is seldom a gap between adjacent basins. This condition sometimes neglects the fact that many inter-basin water transfers may have occurred in the past. Even so, the river basin is a clear-cut concept of physical delineation of the watershed, a natural unit of planning and management of water resources. A river basin is also a bio-geophysical unit, with a high degree of integrity and relatively homogenous systems, where human and environmental conditions differ according to each situation (Zalewski, 2013).

The ecosystems in a river basin can have many functions, uses, and attributes that make a valuable contribution to the quality and availability of water resources for human life and socio-economic development. Various ecosystem functions associated with the river basin are considered to be of value to human life. Conventionally, efforts have been made to control and manage resources by targeting water bodies themselves, such as structural flood control measures and reducing the direct discharge of industrial pollution (Graefe, 2011, Barrow, 1998).

Moreover, the river basin as a sub-division in the natural environmental process still needs to be considered, as each river basin has its own specific geomorphological and hydrological characteristics. Most planning policies regarding water management have substantial spatial dimensions. In favor of this idea, a river basin territory suits well in the context of existing river basin transfers and infrastructures. Therefore, land use as a spatial planning tool remains the leading component amongst other dimensions.

Although various international institutions have chosen the river basin as the unit for IWRM, there is, of course, the question of the neglected inter-basin and cross-basin water development. This question is answered by the existence of the alternative river basin territory concept, in which river basins are no longer managed under the natural or evident delineation but also include high complexity because of the inter-basin issue and because in large parts of the world water is not managed at the catchment area level (Molle, 2009a).

The issue of 'river basin fetishism' is also questioned, where a particular scale is favored and is misleading for finding solutions to problems in accessing water – a bit naïve and neglecting the socio-political factor of IWRM in its technical or hydrological nature (Graefe, 2011). Taking the river basin as the management unit is supposed to strip administrative boundaries (Graefe, 2011). It then depends again on how management needs to deal with each river basin case and relations with neighboring basins.

The operational definition of a VRB in this research is derived from the geomorphological and hydrological definition (Graefe, 2011, Molle, 2009a), which describes basins as those water catchments with a direct origin at a volcano, with the sea as its terminal. However, it is also important to consider political, administrative boundaries as a driving factor in water governance.
Therefore, the interlinking of the spatial dimension consists of (Savenije and Zaag, 2008):

(1) The interlinking of spatial scales: watershed, river basin, inter-basin
(2) The interrelation of functions: land use, administrative boundaries
(3) The interconnectedness of hydro-geomorphological conditions: upstream (mountainous areas) and downstream (low land and terminal), also the spatial type of rivers.

The Temporal Dimension: Management of Water Cycles
Timing variations in water demand and availability calculates the actual water amount to even out fluctuations and ensure a fair water balance. In IWRM, this temporal scale varies according to the annual natural water balance, which depends on the seasonal pattern and the timing specified within a specific basin (Savenije and Zaag, 2008). The water balance concept consists of a river's inflows and outflows, divided into a supply and demand function of water quantity to time in the relevant river basin. However, in a VRB, a distinctive characteristic is added to the water life cycle as it also includes the volcanic activity cycle. Therefore, on the natural side, the annual seasonal pattern based on hydro-meteorological data needs to be considered. These data are required to ascertain the times of the year in which extreme drought and flood may be experienced and also what the desired condition is thought to be.

Meanwhile, on the social side, this water balance depends on the continuous process interlinking with the decision processes of many alternative uses of water. The term 'water balance' is closely linked to the supply and demand function of water through the course of a year. Often, this water balance is expressed in a term plan with a given time horizon (i.e., 20 years or 30 years, multi-year plan) and repeatable in periods (Jaspers, 2003).

Therefore, a holistic temporal dimension in a VRB will include these two sides as the natural rhythm, based on nature's processes – for example, the temporal dimension of the annual hydro-meteorological cycle and the seasonal pattern. The social aspect must also be considered, based on human prerequisites, such as the water balance and term planning.

The Human Dimension: Actors and Their Activities in Water Management

The human dimension includes all water users with their economic interests and the organizational relationship of stakeholders in varieties of forms of river basin organizations. Water resources management at the river basin level requires corporate management. IWRM at the river-basin level anchors the mainstream water policies of today. Various models of river basin organizations (RBOs) reinforced by international organizations and motivated by good examples from the Western world have made it an essential item in any country.

Various scholars have emphasized the use of IWRM in the river-basin context. Makin et al. (2004) and Radosevich and Olson (1999) also state that integrated river basin management (IRBM) is the most appropriate tool to deliver IWRM at a basin scale. Therefore, RBOs are increasingly being promoted as the vehicle by which this tool should be deployed. Moreover, RBOs have become a central component of the framework defining the strategy implemented for water management (Huitema and Meijerink, 2014). However, this coordination happens in an inappropriate institution of turbulent and messy types of conditions, which are becoming increasingly common in many parts of the world. These arguments promulgate the idea that IRBM is currently founded on a myth of inter-organizational coordination (Watson, 2004). In other words, it is widely assumed the institutional obstacles to IRBM can be overcome by improving coordination among the various agencies with shared responsibilities for the management of land and water resources.

The human dimension also explains the increasing trend of the multilevel governance (MLG) of water (Moss and Newig, 2010, Hoekstra, 2010). This concept is used to understand the complexities of the multiple scales, multiple stakeholders, multilayered governance, across sectors or domains, and so forth, which are always encountered in studies on water. The context of multilevel is a global phenomenon (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Lubell, 2013, Termeer, Dewulf, et al., 2010). The lens of connective capacity is essential for understanding the mechanisms used for water governance.

In this regard, the crucial issues are stakeholder involvement, where the decision-making process could founder (Jaspers, 2003), and measures can only be applied when stakeholders have the same vision. Coordination certainly can help to overcome problems of administrative fragmentation, but it does not provide the necessary institutional capacity to deal with land and water management problems characterized by complexity, change, uncertainty, and conflict (Watson, 2004). In contrast to coordination, inter-organizational collaboration provides a dynamic, open-ended, and interactive approach to IRBM; so collaborative works and connective capacity are more natural between related stakeholders (Edelenbos, Bressers, et al., 2013).

To answer these problems, organizations' arrangements on water resources should promote adaptive management approaches (Pahl-Wostl, Kabat, et al., 2008) with a focus on connective capacity (Edelenbos, Bressers, et al., 2013). This changing form of water governance is an asset for creating better understanding between stakeholders. The components of connective capacity (Edelenbos and Lubbel, 2013), which need to be considered in an IWRM network, should consist of expanding boundary judgments: (1) multi-actors networking, (2) openness to new actors, (3) openness to new ideas. Therefore, it is crucial to link political, economic, and social forces with coordination processes and institutional arrangements in water management to a concise decision-making policy.

The main characteristics of the ideal interrelation of water stakeholders are: a leader/leading sector, a person or an organization/agency (Benson, Gain, et al., 2015, Lubell, 2013); a shared vision of integrated socio-economy-ecology benefits, i.e., an RBO (Jaspers, 2003, Medema, McIntosh, et al., 2008); and the norms of interrelation based on connective capacity (interconnection capacity): openness to new actors and ideas, stakeholder cooperation, and inter-organizational collaboration (Edelenbos, Bressers, et al., 2013, Pahl-Wostl, Kabat, et al., 2008, Edelenbos and Lubbel, 2013)

2.2.4 Summary of IWRM

IWRM is perceived as a learning process (Edelenbos and Lubbel, 2013) for a coordinated, goal-directed method for controlling the development and use of water through its four dimensions: natural, spatial, temporal, and human (Savenije and Zaag, 2008). VRBs are water catchments following the geomorphological and hydrological definition (Graefe, 2011, Molle, 2009a), with a direct origin at a volcano and the sea as the terminal.

In implementing IWRM, each country has unique experiences about ways in which water organization is carried out (Jaspers, 2003). There is no universal recipe for the perfect fit; it must be defined by the existing conditions of these dimensions in water management. Therefore, IWRM in the VRB context can be described as the process of managing water and its four related dimensions under volcanic conditions.

Thus, what works in the Western world may not function in the Indonesian context. More specifically, these paradigms are applied in a specific administrative region of Yogyakarta with its Javanese cultural values. This formulation will be a part of the knowledge to be obtained through the course of this research. Therefore, a working definition of IWRM in the context of this research is the integration of water resources and its interrelated dimensions – natural, spatial, temporal, and human – as a process to promote sustainability in the ecology, economy, and social conditions. To summarize, the four dimensions managed by IWRM are pictured in Figure 2.1.

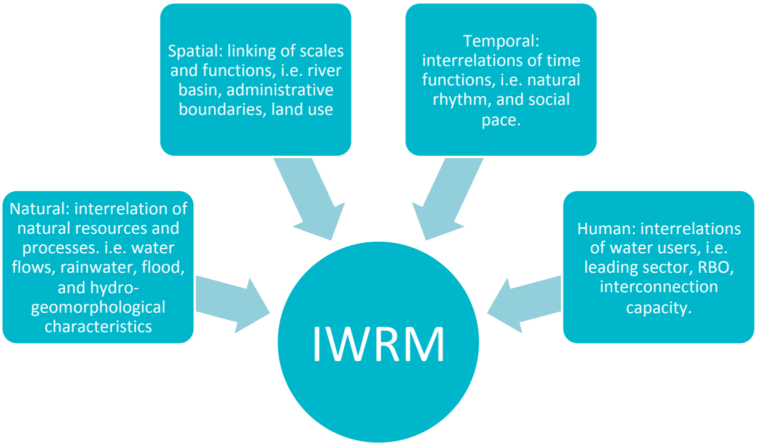


Figure 2.1 The four dimensions of integrated water resources management

In this respect, IWRM as a process is summed-up as covering the dimensions detailed in Table 2.2, derived from the literature review in this section.

Table 2.2 Details of IWRM dimensions

IWRM Dimensions	Definitions	Sub-dimensions	Literature Sources
Natural dimension	Interrelated different types of resources and processes in water resources	The interrelatedness of resources: • Atmospheric conditions • Water flows • Land	(Graefe, 2011, Savenije and Zaag, 2008, Gleick, 2003, Marso, J. N., 2013, Lavigne, Thouret, et al., 2000, Jaspers, 2003)
		The interrelation of natural processes: • Hydro-meteorological: atmosphere–water flows • Hydro-geological: water flows–land	
		Linking of hydro-geomorphological characteristics: • Upstream • Downstream	
Spatial dimension	Linking of different scales, functions, and interconnection of hydro-geomorphological conditions	Linking of scales: • Watershed • River basin • Inter-basin	(Molle, 2009b, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003)
		Linking of functions: • Land use • Administrative delineation	
Temporal dimension	Holistic interrelation of time-related functions of water resources	The interrelation of natural rhythms: • Annual hydrological cycle • Seasonal pattern	(Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009)
		The interrelation to social pace: • Water balance: supply-demand • Term plan	

Human dimension	Interrelatedness of all water users with their economic interests and organizational relationship	The interrelatedness of leader: • Person/organization/agency • Integrating socio-economy-ecology benefits (multi-oriented)	(Jaspers, 2003, Medema, McIntosh, et al., 2008)
		The interrelatedness of norm (connective capacity): • Analysis of decision making • Fostering cooperation • Inter-organizational collaboration	

2.3 Lahar Management (LRM)

In this section, VRBs are discussed, in the context of lahar. It is essential to understand lahar characteristics to understand lahar risk management by using the guiding principle of DRR frameworks and the relationships between IWRM and LRM. An active volcano has eruption cycles, which form strong characteristics for a river basin and may pose hazards for humans. Lahar hazard in particular is explained, and other volcanic hazards are described briefly. The main focus of the section is to describe the characteristics of lahar.

In the next section, the DRR framework and related terminologies are explained. This section also clarifies the components of DRR used in lahar risk management. These terminologies will specifically highlight the components of lahar hazard, lahar vulnerability, and risk. Furthermore, this section describes lahar as a water-related disaster. Therefore, lahar management also fits within the IWRM dimensions, although additional components concerning volcanic activities need to be considered.

2.3.1 Lahar Definitions

The most pressing threats in the relation between water and volcanic activity are lahar hazards or volcanic debris flows (Marso, J. N., 2013, Rodolfo, 1991). Hazards do not always occur as extreme natural phenomena; however, when they occur in the vicinity of human habitation, they threaten life, infrastructure, and property. Hazards in themselves do not constitute disasters.

A volcano has an immediate hazard – the pyroclastic flow – and non-immediate hazards –earthquakes and lahar. Pyroclastic flow, most dangerous hazard, is a fast flow (up to 700 km/h) of hot gas (1,000^{0}C) and molten rock or tephra (Lavigne et al., 2000). Earthquakes arise when a volcanic eruption blows this tephra, and during the process of an eruption a low tremor movement occurs. Lahar, which develops when a volcanic-material build-up on the flank of a volcano after eruption comes into contact with heavy rainwater, is a debris flow with a speed up to 100 km/h and a volume up to an unlimited amount depending on the scale of eruption (Lavigne and Thouret, 2003, Marso, J. N., 2013, Rodolfo, 1991).

The term 'lahar' has been used internationally since 1929 to describe mudflow from the deposits of volcanic activity (Scrivenor, 1929). However, this definition is too narrow, as it does not explain the composition of water and volcanic materials. Also, it refers mainly to sand and clay, whereas in reality it also contains rocks, pebbles, and even boulders. Another definition explains the character of lahar as a mudflow that contains volcanic materials transported by water, including volcanic materials in the form of debris and angular blocks (Bemmelen, R. W. v., 1956). This looser definition fits better with the lahar concept used in this research.

The generation of rain lahar can be seen as an iterative process of mixing water and volcanic materials (Pierson and Scott, 1985). Differences in the percentage of composition cannot be measured in detail as lahar continuously changes its composition throughout its flow downstream. The formation phase is visualized in Figure 2.2 (Rodolfo, 1991). In each phase, rain lahars may form differently in each condition as they also vary depending on the condition of sediments and the geomorphology of the volcano slopes. Figure 2.2 shows the process of lahar formation as partly water induced.

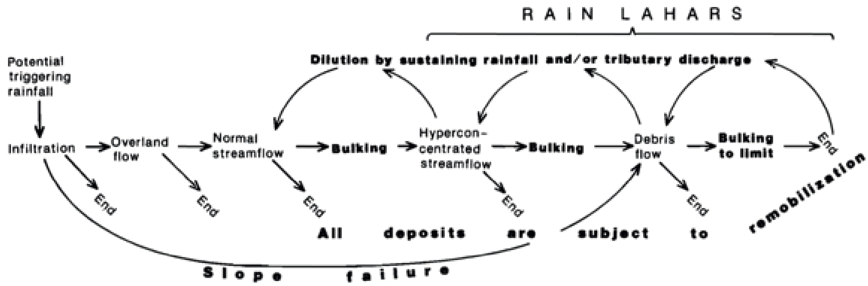


Figure 2.2 Lahar formation (Rodolfo, 1991)

2.3.2 Disaster Risks Reduction Frameworks in LRM

The DRR framework aims to reduce statistically expected loss from a particular type of risk, by means of reducing the likelihood of hazards, reducing the expected loss, or both, with prerequisites of clear understanding of the cultural and organizational character of society and the active involvement of NGOs and local communities (Ingleton, 1999 in (Wisner, Blaikie, et al., 2004). The risk mitigation of water-related disaster is one among many of the challenges of water resources management. The nature of rain lahar makes this hazard similar to flash flooding, i.e., a tendency toward a high volume in a short period, flowing from up to downstream, and high magnitudes of force, which may destroy anything in its path.

Attempts to reduce the risks of natural disasters should give more attention to social than to physical approaches, they should be more proactive than reactive, and they must focus more on the reduction of vulnerability, as part of on-going policies and programs (Weichselgartner, 2001). Natural disasters belong more to hard science, in disciplines such as geology, hydrology, and volcanology. However, to mitigate risks, soft science is more needed, such as psychology, cultural studies, and sociology. The latter type of science is more important in assessing prevention and preparedness strategies.

In natural sciences, the first step of the disaster management cycle is a natural hazard analysis (Weichselgartner, 2001). The objectives of this phase are the identification, recording, and assessment of all the natural events in a given area that can potentially damage human life and property. Other relevant physical processes are studied, based on which a natural hazard map is created. This map indicates hazards, quantitatively and qualitatively, for physical processes and characteristics or the likelihood of an occurrence and its intensity.

The UN Sendai Framework for DRR 2015–2030 aims to guide multi-hazard DRR management at all levels across all sectors, by means of priorities for action: (1) understanding risks, (2) strengthening disaster risks governance, (3) investing in DRR for resilience, and (4) enhancing preparedness to build back better (United Nations, 2015). In the discussions to develop this framework, community leaders need to be involved in order to ensure that cultural knowledge is included in all varieties of DRR strategies. In addition, the sharing of experiences requires someone to assume the role of a steward or wise person with knowledge, skills, and wisdom as assets, and it requires a cultural heritage as the driver of resilience and local commitment.

Furthermore, given the ineffectiveness of natural hazards mitigation using high technology-based strategies, there is a need for a systematic classification of how the mitigation system works, because sometimes the system reduces the effectiveness of the mitigation (Day and Fearnley, 2013). Even though technology provides aid tools, the knowledge gap between the user and the scientist needs to be simpler to be grasped. Here is where the role of local knowledge positions itself as the bridge between the scientist and the common people.

The DRR framework is based on risk relations as a function of hazard and vulnerability (Wisner, Blaikie, et al., 2004, Cardona, Aalst van, et al., 2012). Regarding DRR, several terminologies need to be explained, as outlined in Table 2.3.

Table 2.3 Terminology in DRR framework

No.	Terminology	Definition	Sources
1	Disaster	Disaster is characterized by sudden extreme changes in conditions as a result of either natural hazard or human actions, resulting in loss of life, damage to infrastructure, illness. Disasters are caused by the interaction of humans with their environment. A disaster is a function of the risk process.	(Kaplan and Garrick, 1981)
		Disaster is the result of the combination of the occurrence of hazards, conditions of vulnerability, and insufficient capacity to reduce the potential negative consequences of risk.	(UNISDR, 2004)
		Disasters are a multifaceted blend of natural hazards and human action, and it is helpful to understand this fact to prevent or mitigate them.	(Wisner, Blaikie, et al., 2004)
2	Risk	Risk is the possibility of loss or injury, also the degree of probability of such loss.	(Kaplan and Garrick, 1981)
		Perception of risk is multidimensional and personal, where different hazards mean different things and contexts to people; therefore, risk is socially constructed.	(Wisner, Blaikie, et al., 2004)
2	Vulnerability	Vulnerability is mainly a characteristic of the exposed element of society and its ability to respond to a hazard or stressor.	(Cardona, 2004)
		Progression of vulnerability includes root causes, dynamic pressures, and unsafe conditions.	(Wisner, Blaikie, et al., 2004)

3	Hazard	Hazard is a source of disaster.	(Kaplan and Garrick, 1981)
		Disaster risks reduction (DRR) distinguishes hazards as extreme events into (1) sudden-onset hazards, (2) climate increase exposure related, (3) result of climate change.	(Birkmann, Tetzlaff, et al., 2009)
		Natural hazards are classified into (1) hydro-meteorological disasters: landslide, droughts, extreme temperatures, floods, storms, insect infestation, storm surges and (2) geophysical disasters: earthquakes, volcanoes, and tsunamis.	(Ndirangu, Kabubi, et al., 2009).

In lahar management, these terminologies need to be related directly to the lahar event. Specific characteristics of lahar attract special attention to components of these terminologies. Lahar is perceived as a hazard; lahar vulnerability and risks are further explained in the next sections.

Lahar Risk Management

LRM based on the DRR framework aims to minimize risks from lahar by lessening vulnerability. Evaluating risk using risk assessment as a tool is usually begun at the project planning stage; experts ensure that they use the best existing methods. The approach to mitigating lahar risks can be generalized in four categories (Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003, Chanson, 2004):

(1) Hazard avoidance using land-use plan and zonation
(2) Hazard modification with engineering solutions (bypass channel, sediment check-dams/Sabo dams, deflection berm, sediment retention dam, sand pocket, and do on)
(3) Hazard warning with the help of information technologies and remote sensing
(4) Hazard response and recovery for long-term impacts of lahar.

Lahar risks relate to the character of lahar hazard, as a hybrid fluid mix of volcanic materials and rainwater. It characteristically flows to land located at the foot of the volcano and thus poses risks to aspects of life. Depending on its composition, it entails three types of risks (Pierson, Wood, et al., 2014, Rodolfo, 1991, Lavigne and Thouret, 2003):

(1) Debris flow (DF) with boulders and bigger stone compositions of greater than 60% of debris, which are the result of the tumbling of an earlier eruption flank, easily buries or encases buildings and lands
(2) Hyper-concentrated stream flow (HSF) about 20–60% composition of volcanic material to water, many meters deep fluid, with the appearance of quicksand, may last for weeks, complicating search and rescue efforts
(3) Normal stream flow (SF) with up to 20% composition of volcanic materials to water, slower velocity, much like mud-rock slurries, may dry like concrete.

Therefore, based on this description, the risks concerning lahar are comprised of, but not limited to (Pierson, Wood, et al., 2014, Marso, J. N., 2013):

(1) Human-related: loss of life, loss of livelihood, health impacts, psychological impacts
(2) Physical infrastructure destruction: damage to structures, buried houses and buildings

(3) Environmental disruptions: damage to land, less bio-diversity, river-channel sedimentation
(4) Economic losses: ruined agricultural produce, severed transportation lines, infrastructural loss
(5) Loss of cultural heritage: buried monuments.

The methods to characterize lahar risk vary depending on the specific issues to be addressed (Cardona, 2004, Wisner, Blaikie, et al., 2004, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003). However, for this research to have a meaningful result, a limitation must be placed on the risks that are considered. Thus, in this research, the risks that are addressed have a direct relation to water resources management: water infrastructure damages, river sedimentation, land damage, and loss of human life (Pierson, Wood, et al., 2014).

Vulnerability to Lahar

The vulnerability concept can provide a means to reduce losses due to natural hazards. It addresses issues of sustainability and quality of life, and it also enables a common theoretical framework for all kinds of disasters, be they humanmade or natural.

It focuses on three stages of progression (Wisner, Blaikie, et al., 2004):
(1) Root causes (limited access and ideologies); mostly based on the condition of beliefs (Chester, Duncan, et al., 2008, Donovan, 2010, Dibben and Chester, 1999), sociopolitical aspects, and historical context of social development (Gaillard and Dibben, 2008)
(2) Dynamic pressure from lack of means, be they social (Cronin, Petterson, et al., 2004), economic (Leung, Santos, et al., 2003), or educational (Gregg, Houghton, et al., 2008, Paton, Smith, et al., 2008); also the macro forces behind the pressures, such as political conditions (Lane, Tobin, et al., 2003)
(3) Unsafe conditions created by physical environment (Pareschi, Cavarra, et al., 2000), local economy (Donovan, 2010, Lane, Tobin, et al., 2003), vulnerable society, and public actions (Cronin, Petterson, et al., 2004), which affect preparedness and response (Wood and Soulard, 2009).

This research focuses more on vulnerability, as it stands as a pivotal point determining whether risks can be lessened (Wisner, Blaikie, et al., 2004). Relating to the dimensions of IWRM in the previous section, the progression stages are explained as follows:
(1) Human dimension: support local livelihoods, address vulnerable society/group, support public actions
(2) Temporal and spatial dimension: improve physical environmental safety conditions.

2.3.3 Dimensions of Lahar Management

In addressing lahar not as risk, but as a resource, an attempt is made in this research to use the IWRM dimensions as the starting point. After the lahar flows, time is needed for the lahar to slow down and start the process of sedimentation in river channels; then it starts to be characterized as a resource.

Natural Dimension: Lahar Hazard

Depending on its formation, lahar can be categorized as lahar related to crater lakes, caused by melting ice and snow, derived from rainwater after an eruption, or derived from debris avalanches (Jakob, Hungr, et al., 2005). In this study, lahar is formed mainly from rainwater mixed with volcanic materials, and it may result in lahar flow. Furthermore, it can be triggered by slope and channel gradient (more than 3%), deposit thickness in centimeters and volume based on the magnitude of the eruption in millions of cubic meters, pyroclastic characters, permeability, pore and grain size, and the existence of vegetation cover (Lavigne and Thouret, 2003). Depending on the lahar's characteristics – its speed, reach, and composition – the destruction level may differ (Marso, J. N., 2013, Lavigne and Thouret, 2003, Rodolfo, 1991). Lahar characteristics are described hereunder:

(1) Speed: starting with a velocity of 20 m/s at the origin of the volcano flank, it can still maintain its speed at 10m/s up to 50 km away, especially if it stays in narrow channels (Pierson, Wood, et al., 2014, Marso, J. N., 2013). In the Merapi case, the lahar's velocity is up to 100 km/h (Lavigne, Thouret, et al., 2000)

(2) Reach: lahar delivery systems take the following forms (Jakob, Hungr, et al., 2005, Rodolfo, 1991):

    b) Summit ravines (deep trenches of volcano slope, as a result of pyroclastic flows)

    c) Pyroclastic fans (pyroclastic flows leave a fan-shaped build-up on the volcano flank)

    d) Lahar channels (remnants of pre-eruption channels and gullies, which mostly correspond to rivers).

    The lahar in this way flows downstream and ravines are formed downstream in a fan-shaped lahar pattern. The lahar flows through forcibly widened rivers and tributaries (Marso, J. N., 2013, Pierson, Wood, et al., 2014).

(3) Composition: the water percentage in lahar may vary during its trip from upper flank to downstream, as it is in a different phase of the iterative process of lahar composition, as explained above as DF, HSF, and SF (Pierson, 2005, Rodolfo, 1991, Lavigne and Thouret, 2003).

In IWRM, lahar hazards are seen as part of the natural dimension, which is the most influential dimension for inducing a disaster (M. R. Dove, 2008, Wisner, Blaikie, et al., 2004, Weichselgartner, 2001). The management aspects of nature refer to the monitoring stage. The planning and implementation stages mean human meddling in the natural dimension, which is not possible; for example, the human cannot plan or induce/implement an eruption; this is a natural process.

Rain lahar flows are the primary focus of this research's hazards study, which aims to understand its characterizations and behaviors from volcanology concepts. In this respect, the aspects of lahar in the natural dimension that can be monitored are (Chester, 1994, Lavigne and Thouret, 2003, Pierson, Wood, et al., 2014):

(1) The magnitude of volcanic eruption (based on the volcanic explosivity index): volcanic activities include the normal volcano processes during its short eruption cycle that result in the volcanic deposit (Leung, Santos, et al., 2003). Hazard occurrences are the result of a greater magnitude of natural processes that are part of a volcano's long-term life cycle.

(2) Hydro-meteorological processes: predominantly annual patterns of precipitation, surface water such as rivers and lakes, and evaporation. Causes of lahar, as discussed above, are induced by the rainwater magnitude, often during a high intensity rainfall of 40mm in two hours (Lavigne and Thouret, 2003).
(3) The characteristics of lahar as explained above: speed, reach (Rodolfo, 1991), and composition: DF, HSF, SF (Pierson, 2005, Rodolfo, 1991, Lavigne and Thouret, 2003).
(4) The geomorphology condition of the volcano (Rodolfo, 1991), which includes topography, river channels, and a pyroclastic fan in which lahar may deliver the sedimentation volume, and which may influence its direction.

Lahar hazard occurs mostly in river channels, and it threatens the condition of water resources infrastructures. Water, as the trigger of lahar, may transmit its character to the composition of lahar. This, combined with slope and channel gradient and geomorphological condition, will spread through its delivery system. This spreading speed is the result of a combination of water composition and the geomorphological condition.

Therefore, water resources management should play a role in lahar risk management, as most engineering structures are based on river channels (Pahl-Wostl, 2006) and the zonation policy of the conservation area of water sources (Savenije and Zaag, 2008) on the flank of the volcano corresponds to the LRM protection area (Lavigne et al., 2000).

Spatial Dimension: Lahar's Spatial Reach

This dimension includes geographical attributes of a hazard zone map (Sumaryono, 2011), such as position, river basin boundaries, and location of lahar deposit. Most importantly, the spatial dimension should record the earlier experience of lahar distributions and their direction. It needs to be possible to predict the direction and the magnitude of a future lahar in the course of channels/rivers (Lavigne and Thouret, 2003, Pierson, Wood, et al., 2014), as eruption impacts are likely to happen. In this regard, the spatial scale is related to the planning and implementation stage. It also may have a monitoring aspect to it (over time as conditions change). Hazard map and future eruption prediction areas might intrude on current activities and functions in a location. Therefore, a synchronization process is needed. The LRM spatial dimension is then categorized into:

(1) Historical hazard record map (Newhall, Bronto, et al., 2000)
In recorded history archives of the volcano eruption, data on lahar hazards are mostly in the geologists' domain. However, this type of map provides significant knowledge about past experiences and lahar behavior in the region that will elucidate lahar characteristics.
(2) Future hazard map (Pierson, Wood, et al., 2014)
Using the historical hazard map, geologists may be able to predict the directions, magnitude, and reach of lahar in future occurrences. In the prediction, natural dimensions of lahar will also be calculated.

Temporal Dimension: Volcano and Lahar Cycle

In this dimension, time management of the lahar hazard is redefined in terms of the volcanic eruption periodic cycle (Lavigne and Thouret, 2003) and seasonal patterns with their variations (Case, Ardiansyah, et al., 2007). The volcanic eruption cycle is important in defining the magnitude of the eruption, and the seasonal pattern determines the quantity of rainwater, which will form lahar faster under the influence of an extreme rain event. In this dimension, farmers' activities connected to seasonal activities (Daldjoeni, 1984, Hamada, Yamanaka, et al., 2002) also contribute to the risk level. The more activities relate to tending agricultural land during the rainy season, the higher the risks. Therefore, in LRM, two central time natural functions can be monitored:

(1) Volcanic periodic cycle (Gaillard, 2008, Lavigne, De Coster, et al., 2008, Chester, 1994, Lavigne, Thouret, et al., 2000, Gertisser and Keller, 2003): explaining normal and major eruption events and activities through time, either annually or in the longer term. In this regard, major eruptions, which mostly take place in the longer term, should be anticipated through the historical record of activity on the mountain.

(2) Hydro-meteorological annual and periodic cycle (Ndirangu, Kabubi, et al., 2009, Viviroli, Archer, et al., 2011, Zalewski, 2013): describing the annual history and change trends in the water cycle, especially on precipitation as a trigger of lahar and surface water as a form of river. Accounts of the flooding season in local history should probably also be taken into account in relation to lahar hazard. The changing seasonal pattern should be anticipated also in light of climate change.

In relation to humans, time can be planned, implemented, and monitored from the human perspective. In the context of a volcano, humans may have some control over time management with the help of geo-information systems. However, humans cannot control all aspects of lahar time. Hence, the manifestations of the human–nature relation temporal dimensions are:

(1) Before the hazards:

   a. Mitigation plan (Leung, Santos, et al., 2003, Weichselgartner, 2001, Paton, Smith, et al., 2008, Keys and Green, 2008): a plan for the community and institutions to prepare for a hazard. In the case of lahar, these mitigation plans may include technical and non-technical solutions. On the technical side, the objective is to lessen the hazard magnitude, whereas on the non-technical side, the aim is to educate the community to evacuate and train to be prepared for signs and to notice warning signs.

   b. Early warning (Gaillard, 2008, Mei, Lavigne, et al., 2013, Lavigne, Thouret, et al., 2000): a short-term estimate of hazard occurrence based on volcanic activity signals. This warning is published a month to two weeks before the actual eruption happens. It signals an appropriate evacuation of nearby residents.

(2) During the hazards:

   a. Evacuation plans (Jousset, Pallister, et al., 2012, Mei, Lavigne, et al., 2013) work as a way to clear or leave the location of hazard as the occurrence is happening. This plan requires a map of the evacuation route, safe meeting points, and training.

b. Emergency response (Mei, Lavigne, et al., 2013). This response is the most crucial activity, as information and data are used as a basis for decision making during the hazard occurrence.

(3) After the hazards:

a. Long-term projection (Lavigne, De Coster, et al., 2008, Boudon, Camus, et al., 1993, Gertisser, Charbonnier, et al., 2012, Newhall, Bronto, et al., 2000): based on the history of major eruption cycles. This projection is useful as a prognosis for future preparation in terms of when an actual volcano will erupt and when the lahar will be formed.

b. Sediment management (Lavigne and Thouret, 2003, Ikhsan, Fujita, et al., 2010) needs to be introduced as part of lahar risks management. As the lahar settles, it forms sedimentation on the riverbed and may lessen the river's water flowing capacity. Thus, sediment dredging can be introduced as a way to make room for the water. In some cases, this dredging can be someone's livelihood. Therefore, it can become a sand-mining industry and needs to be managed regarding environmental balance.

It is therefore argued that water resources management in VRBs should address lahar vulnerability. Both water resources management and LRM have common components as building blocks of vulnerability. Therefore, what creates vulnerability in water resources management leads to the same condition in lahar management, as both have fluidity characteristics. However, the degree of vulnerability may vary depending upon the severity of conditions.

Human Dimension: Actors and Their Activities in Lahar Management

The human dimension refers to the organizations affiliated to different institutions (Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004). This dimension has two main characteristics: the relationship of the organization and the type of stakeholders, which may be able to be monitored if already known, or may need to be identified. The organization managing the disaster has the following attributes (Birkmann and von Teichman, 2010):

(1) Norm and rules: each institution should follow its guidelines in managing disaster

(2) Rights: authority stated by law regarding where each institution is positioned in relation to the others

(3) Distribution of responsibilities: obligation and tasks of each institution during a disaster.

A mismatch in these relationship components may result in a failure to face a disaster (Day and Fearnley, 2013). A functional scale will become effective if the perception of disaster risks can be synchronized at the same level of awareness. However, under the current DRR framework, most action plans are still in a segregated format (Djalante, 2012, Renaud, Birkmann, et al., 2010). LRM consequently involves multiple stakeholders. A stakeholder analysis needs to be performed to find the relevant stakeholders. Interrelations of multilayer, multi-oriented, and multidiscipline stakeholders are at issue here (Djalante, 2012, Renaud, Birkmann, et al., 2010). Hence, the main types of stakeholders are (Cardona, 2004, Wisner, Blaikie, et al., 2004):

(1) Agencies: all organizations related to volcanic hazards, especially lahar, based on the institutions that contribute their financial, human, and time resources to action planning in preparation for, and management of, hazard.

(2) Communities: everybody, either as actors or victims of volcanic hazards, especially those who have experienced the occurrence of a hazard.

2.3.4 Summary of Lahar Management

LRM follows the DRR framework, but with specific characteristics of hybrid hazard. A similar approach to that used to reduce risks from general hazards can be used. DRR also works on four dimensions of management: spatial, temporal, functional, and natural. As the characteristics of lahar depend on two types of hazard, there is a need to understand the nature of both volcanic and water-related hazards. Table 2.4 presents a summary of lahar management.

Table 2.4 Lahar management dimensions

Dimensions	Definitions	Sub-dimensions	Literature Sources
Natural	Interrelation of ecological change, which may induce lahar (M. R. Dove, 2008, Wisner, Blaikie, et al., 2004)	Volcanic activities	(Chester, 1994, Lavigne and Thouret, 2003, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003)
		Geomorphological characteristics in relation to lahar	(Rodolfo, 1991, Lavigne and Thouret, 2003)
		Lahar characteristics: speed, reach, composition (DF, HSF, SF)	(Lavigne and Thouret, 2003, Marso, J. N., 2013, Rodolfo, 1991)
Spatial	Interrelation of geographical attributes of dimensions in lahar hazard zone map (Pierson, Wood, et al., 2014, Sumaryono, 2011)	Historical hazard record map	(Newhall, et. al., 2000, Newhall, Bronto, et al., 2000 Voight, Constantine, et al., 2000)
		Future hazard map	(Pierson, Wood, et al., 2014, Sumaryono, 2011)
Temporal	Interrelation of periodic cycle of volcanic activity (Lavigne and Thouret, 2003) and change in seasonal patterns (Case, Ardiansyah, et al., 2007)	Natural time functions: Volcanic periodic cycle	(Gaillard, 2008, Lavigne, De Coster, et al., 2008, Chester, 1994, Lavigne, Thouret, et al., 2000, Gertisser and Keller, 2003, Voight, Constantine, et al., 2000)
		Hydro-meteorological annual and periodic cycle	(Ndirangu, Kabubi, et al., 2009, Viviroli, Archer, et al., 2011, Zalewski, 2013)
		Human–nature relation time dimensions: Before: mitigation plans, early warning system During: evacuation plans, emergency response After: long-term projections, sediment management	(Leung, Santos, et al., 2003, Weichselgartner, 2001, Paton, Smith, et al., 2008, Keys and Green, 2008) (Gaillard, 2008, Mei, Lavigne, et al., 2013, Lavigne, Thouret, et al., 2000) (Jousset, Pallister, et al., 2012, Mei, Lavigne, et al., 2013, Mei, Lavigne, et al., 2013) (Lavigne, De Coster, et al., 2008, Boudon, Camus, et al., 1993, Gertisser, Charbonnier, et al., 2012, Newhall, Bronto, et al., 2000)
Human	Interrelationship of people affiliated to different institutions in managing lahar (Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004)	Components of relationships in organization: Norm and rules Rights Responsibilities	(Birkmann and von Teichman, 2010)
		Types of stakeholders: Agencies Communities	(Cardona, 2004, Wisner, Blaikie, et al., 2004)

2.4 Relation between Lahar Risk Management and Integrated Water Resources Management

According to the extensive review of water and lahar management above, these relations are present in the VRB and lahar is part of the water-related hazards condition. However, deeper interrelations are located in the dimensions of management and the actors dealing with them. This section explains how the two lenses (water and lahar management) see the possible interrelations.

2.4.1 Volcanic River Basin

The condition of river basins having an active volcano in the region is a common natural condition for young tectonic plates in the world. Of the 1500 active volcanoes in the world, about 500 record eruption activities (Sigurdsson, Houghton, et al., 2015). Some of these are located in the vicinity of river basins. The term ‘volcanic river basin’, which combines the definition of volcanic basin and river basin, is used to describe this condition in this research.

Volcanic basin is a term in geological science, derived from the condition of the volcanic region, which has remnants of volcanic rocks (McQuarrie and Rodgers, 1998). It experiences volcanic activities, such as pyroclastic flow (Sigurdsson, Houghton, et al., 2015), lahar (Pierson, Wood, et al., 2014), hydrothermal (Svensen, Planke, et al., 2004), magmatic, lava, or volcanic mud production (Cas and Wright, 2012), or is located on the flank of a volcano (Dorava and Meyer, 1994). This is different from the term ‘volcanic province’, which indicates several volcanoes within a region (Arndt, Chauvel, et al., 1998).

The river basin borrows its geographical definition from Buache’s 1752 theory as, “the set of all the slopes on which fall the waters that converge to a same river or creek” (Molle, 2009a), which is later used in IWRM as the unit of management (Burton, 1995, Jaspers, 2003), although, in reality, the interpretation of a river basin is still flexible, depending on the actors who define it. This term is becoming a contested unit of management for water resources (Barrow, 1998, Graefe, 2011, Downs, Gregory, et al., 1991).

The groundwater also interrelates with the volcano, as it functions as storage and drainage (Delcamp, Roberti, et al., 2016). Water can also be the cause of the pyroclastic flow, heightening its activity. Thanks to water, the pyroclastic flow can travel faster and further down. Indeed, the rich groundwater circumstance explains why the eruption is explosive. The steam from the water causes this to happen. The volcano’s water plays a vital role in the volcano’s stability and instability; the illustration in Figure 2.3 shows a simplified model.

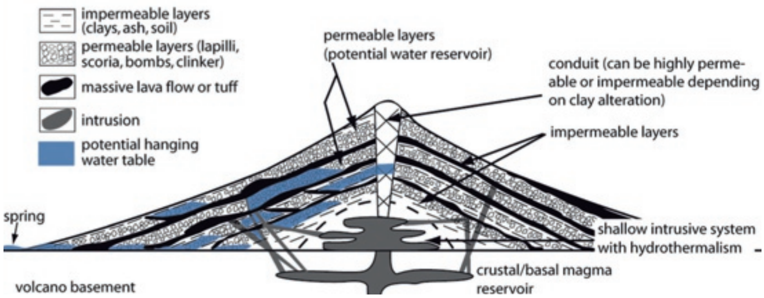


Figure 2.3 Simplified interrelation of water in a volcano system (Delcamp, Roberti, et al., 2016)

Therefore, the definition of a volcanic river basin is a river basin with a direct relation with an active volcano (usually as the upstream areas or origin of the river). Geographically and geologically, this condition offers a natural setting for good groundwater infiltration. However, as explained in the lahar definition, it also means regular lahar flows within the river channels. The VRB is usually also fertile as regards its soil condition. These are just illustrations of the benefits and challenges relating to water resources within a VRB. This term is used in explaining the case study, where a volcano is situated upstream in a sub-basin.

2.4.2 Lahar as Water-Related Hazard

There are not many studies on water and lahar hazard in water management issues (Jakob, Hungr, et al., 2005). Those studies that do address lahar are in the field of geology or volcanology. Most literature on water management addresses water-related hazards as related to climate change (Parry, Canziani, et al., 2007). Therefore, to pinpoint this issue, the connection must be recognized, as lahar has characteristics of fluidity because it is partly composed of rainwater (Rodolfo, 1991). The starting point is to see lahar as rain derived, as this therefore creates the link to water management in general. Lahar may be directly related to volcanic eruption, but in the Merapi case, it more related to high precipitation after eruption, which can continue for several years after the actual eruption happens (Lavigne and Thouret, 2003, Lavigne et al., 2000, Pallister, Schneider, et al., 2013). This kind of lahar is known as rain lahar (Rodolfo, 1991).

In this regard, lahar hazards are mostly dealt with through common water infrastructures (Marso, 2013), such as retention dams and check dams (Pierson, Wood, et al., 2014). Indonesia has adopted the Japanese Sabo dam system since the 1970s (Chanson, 2004). Under this arrangement, water resources managers are amongst the most influential stakeholders in lahar mitigation (Lavigne et al., 2000). To analyze lahar hazard, a hazard map is usually produced (Jakob, Hungr, et al., 2005). This indicates peak flow, sediment concentration, sizes of rocks, depth of flow, movement directions, speed, distribution, frequency, duration, destructive magnitude, and predictability. This map can used to analyze the possibilities of merging the cultural approach with water resources management and hazard mitigation.

Lahar, as part of a water-related disaster, is treated as a form of flood in reality. The engineering approach to lahar risk mitigation is to utilize sediment check dams or retention dams. Lahar is tackled as floodwater in river valleys, but this is not necessarily enough, as the magnitude of water plus debris could easily destroy these dam structures (Chanson, 2004).

As one of the focuses of water resources management is to mitigate water-related hazards, it would be more economical and less costly to focus on preparedness than to rely on emergency responses. The new implementation proposed in the DRR framework represents an opportunity to broaden the range of stakeholders involved. Water-related hazard risks need to be addressed in operational plans, such as the water resources management plan (Ndirangu, Kabubi, et al., 2009, Renaud, Sudmeier-Rieux, et al., 2013).

Also, as lahar in this study refers to rain lahar, the concept of lahar as a water-related disaster should form the basis of IWRM and be included as part of the problem (Pierson and Scott, 1985). IWRM, in general, highlights floods, droughts, and landslides as water-related disasters, yet there is not much mention in the literature about managing lahar as part of IWRM. Rain lahars are the most common types of lahar in the world, as 46% of active volcanoes (about 400) are located in a tropical region. However, they are poorly documented, as most occur in developing countries where there are not many trained scientists (Rodolfo, 1991). Lahar is formed explicitly in VRBs as part of indirect eruption cycle activities and therefore should be addressed as one of the main challenges in managing water resources in a volcanic area. The DRR framework for lahar hazards should incorporate and include lahar management in IWRM.

2.4.3 The Relationships between Dimensions of IWRM and LRM

Currently, there is still minimal literature explaining the relationship between IWRM and LRM in a VRB. As the dimensions (natural, spatial, temporal, and human) of management overlap in both cases, they seem to be connected in some ways. However, the forms of these interrelations are not yet precise. It is then assumed that, in each of the dimensions, relations do exist. It is the task of this research to discover these relationships and how they correlate to one another. It is also possible to have interrelations between inter-dimensions as, in reality, the condition of the context encapsulates one entity.

Therefore, to study the relationships between these dimensions of IWRM and LRM, this research uses a general relationship perspective. Both concepts are based on four common dimensions, but each dimension’s components are not the same. There is scant literature explaining this relationship. The majority of concepts are probably neither purely isolated nor purely interrelated. Therefore, the dimensions’ different aspects on degrees of interrelations will be studied regarding the possible types of relationships at the philosophical level as follows (Goldstone, 1996):

(1) Isolated: not related to any aspects or dimensions
(2) Coherent: consistent in forming the same aim
(3) Juxtaposed: two things seen or placed close together with contrasting effect
(4) Parallel: two things side by side always touching, although never converging
(5) Overlapping: extending over to cover partly.

These details of typical dimensions are shown in Table 2.5. Although the possibility of relations is expressed in terms of dimension, further investigation is needed to determine what their relationships are and whether they correspond to one another.

Table 2.5 IWRM and LRM dimensions

Dimensions	IWRM	LRM
Natural	• The interrelatedness of resources: atmosphere, water flows, land • The interrelation of processes: hydrometeorology and hydrogeology	• Volcanic activities • Lahar characteristics: speed, reach, composition • Geomorphological characteristics (Chester, 1994, Lavigne and Thouret, 2003, Pierson, Wood, et al., 2014)
Spatial	• Linking of scales: watershed, river basin, inter-basin • Linking of functions: land use, administrative delineation • Linking of hydro-geomorphological characteristics: up–down stream, spatial type of rivers (Molle, 2009, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003)	• Historical hazard record map • Future hazard map (Molle, 2009b, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003, Marso, 2013, Newhall, Bronto, et al., 2000, Rodolfo, 1991, Lavigne and Thouret, 2003, Pierson, 2005, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003)
Temporal	• The interrelation of natural rhythms: annual hydrological cycle, seasonal pattern • The interrelation to social pace: water balance and term plan (Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009)	Natural time functions: • Volcanic periodic cycle • Hydro-meteorological annual and periodic cycle Human–nature relation time dimensions: • Before • During • After (Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009, Lavigne et al., 2000, Gaillard, 2008, Chester, 1994)
Human	• The interrelatedness of leader: A person/organization/agency, integrating socio-economy-ecology benefits (multi-oriented) • The interrelatedness of norm (connective capacity): analysis of decision making, fostering cooperation, inter-organizational collaboration (Jaspers, 2003)	Components of relationship in organization: • Norm and rules • Rights • Responsibilities Types of stakeholders: • Agencies • Communities (Jaspers, 2003, Medema, McIntosh, et al., 2008)

With these comparisons between the two concepts, it can be summarized that parts of the LRM approach need to be investigated in IWRM. However, to further develop the approach, empirical work is needed attesting the current synchronized dimensions of IWRM in the VRB. As the conceptual literature points out, the interrelation of IWRM and DRR concepts are closely related in managing VRBs. Both IWRM and LRM operate in the four dimensions of management. However, how the interrelation takes shape is not yet clear. This needs further investigation in the context of this research.

Using IWRM as a way to deliver LRM in the case of a VRB with existing approaches would mean scrutinizing the mitigation and adaptation strategies, and also the type of resilience existing in the community toward lahar hazard. Each DRR strategy can be used through managing the four IWRM dimensions: natural, spatial, temporal, and human. Moreover, regarding DRR, as described in the Sendai Framework, the need to further understand the use of cultural knowledge in coordination with science has been acknowledged: cross-validation.

2.4.4 The Actors in IWRM and LRM

This section explains the type of actors included in the research, which are not only objects of this research, but also subjects of management. There are mainly two types of actors under investigation in this research: organizations and local communities (Flanagan and Laituri, 2004, Inglis, 1993, Matz, 2008, Savenije and Zaag, 2008). The following section explains what these actors are and where they are located.

Government Organizations/Agencies

Managers direct, and invest funds in, resources management. They are professionally trained and work in an agency or organization whose main responsibilities are to maintain nature, but also to provide services for people (Savenije and Zaag, 2008, Jaspers, 2014). Here, the types of investment involved are not only funds, but also personnel, materials, and time. These managers are directly involved in guiding regulations or rules. They aim to implement the IWRM approach according to the requirements of their main sectors. IWRM needs interrelations between organizations that provide services in relation to water.

Local Communities

The locals live in the location, still practice CEK, and are 'managed' by managers in terms of water resources usage. This group can also be named users; however, to continue the terminology used in the CEK definition, they are referred to here as locals (Flanagan and Laituri, 2004, Geertz, 2000, Inglis, 1993). These are people with direct contact with water and its related resources (including the volcano and land). They are also directly impacted by hazards when the volcano erupts. These locals belong to a community that has lived through generations in the location. They experience the eruptions throughout their lives and keep alive the wisdom of human–nature relations.

2.4.5 Multilevel Governance as Relations of Water and Lahar Management

This section explains the intricate MLG conditions (see Figure 2.4). With water and lahar related in the VRB context, this research is bound to meet the complexities within the governance perspective. Of the different kinds of MLG presented here, the existing condition will be analyzed to understand the construction of VRB governance. The MLG actors and their interrelations are later explained in the section on interaction attempts. As already mentioned regarding lahar management, the actors in this research context are multilayered. In this light, to anticipate the complexities, the MLG concept (Hooghe and Marks, 2003) was adopted. The levels are located within the boundaries of jurisdictions, with coordination between different actors within and across the boundaries. There are two main forms of this concept: federalism and flexible (Termeer, Dewulf, et al., 2010, Hooghe and Marks, 2003).

Type 1: Federalism
Federalism consists of boundary limits, where coordination between jurisdictions is designed with procedures and non-intersecting membership, and it is systematic and durable (Hooghe and Marks, 2003). This is what takes place in the federation state system of governance, where jurisdiction is allocated within administrative boundaries.
Type 2: Flexible
The flexible type does not place limits on the number of jurisdictions/boundaries, intersecting membership, and flexible design, which is addressed by adaptive governance. Scholars adopting this concept argue that this condition is supported by the dispersion of monopoly, preference, jurisdiction, and heterogeneity (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Hooghe and Marks, 2003, Termeer, Dewulf, et al., 2010).

In dealings about water, the actions of the various actors result in variations in policies for different water issues, within different governance levels. The direction in these multilevel issues has to be addressed and coordinated within and between various layers of government (Edelenbos, Bressers, et al., 2013). The levels range from global, transnational, national, to local (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Termeer, Dewulf, et al., 2010). Although the global level influences the lower levels, this research focuses more on the national and the local level, as it is analyzing a river basin. A river basin as a scale also has to be placed within the existing MLG.

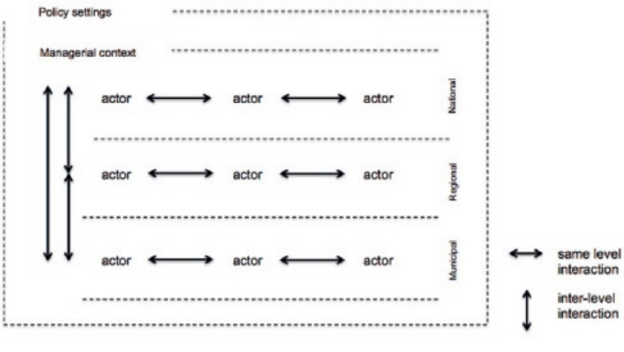


Figure 2.4 Multilevel governance visualized

Note that the arrangement in Figure 2.4 combines the two possible types of MLG discussed earlier, but tailored to address the national and local levels. As explained in relation to water and lahar management, the human dimension creates the management links. This MLG concept is used to explain the complexities taking place within the links of water and lahar management in a VRB.

2.5 Interaction Attempts and Integration Level

The interaction attempts and integration level are used to answer the 'how' questions for implementation of IWRM in Chapter 5, LRM in Chapter 6, the interrelations of IWRM and LRM in Chapter 7, and CEK impact on management of a VRB in Chapter 8. With the existence of the MLG construct, there are bound to be spillovers or overlaps of jurisdictions (Hooghe and Marks, 2003). The overlap is further explained in interactions, where actors across levels and sectors congregate to discuss problems and negotiate. An interaction is "a mutually influencing relation between two or more entities" (Kooiman, 1999). These interactions are termed in this study as interaction attempts because they are not always successful. Three kinds of possible interactions are defined: interferences, interplay, and interventions. The first kind is spontaneous; the second is more organized; and the last is formalized (Kooiman, 1999). The interaction attempts found in MLG are characterized in this study as based on these possible kinds.

Interaction attempts are the basis for determining the management integration level in any river basin, be it volcanic or other; this is located in the human dimension. In order to implement the IWRM approach, close coordination, collaboration, and cooperation are needed (Biswas, 2004). According to the governance literature, the types of integration are also divided into the same three: coordination, collaboration, and cooperation.

Coordination is defined as the synchronization of activities among organizations (Hall, Clark, et al., 1977) or mutual adjustments between actors to provide positive results and avoid negative ones (Bouckaert, Peters, et al., 2016). This coordination is divided into three types: hierarchy-type mechanisms (HTM), market-type mechanisms (MTM), and network-type mechanisms (NTM) (Bouckaert, Peters, et al., 2016). The first, HTM, requires authority and power (use of the law, budgets, and coercion) as resources for coordination with lines on control. The second, MTM, aims for incentives to enhance the performance of public actors by mobilization of bargaining and information as resources. The third, NTM, searches for common knowledge, values, and strategies between partners. However, this research will not focus on these different types of mechanisms, but rather give an overview of whether coordination happened in interaction attempts. The characteristic of coordination is that information is shared and synchronized.

Many scholars argue that collaboration is the way forward in MLG for managing natural resources, particularly water (Folke, Hahn, et al., 2005, Pahl-Wostl, Kabat, et al., 2008, Lubell, 2013). This research espouses the definition of collaboration as "the processes and structures of public policy decision making and management that engage people ... across the boundaries of public agencies, levels of government, and the public, private, and civic spheres to carry out a public purpose that could not otherwise be accomplished" (Emerson and Nabatchi, 2015). Often, mutual interdependencies are used as the basis for collaboration to happen (Kooiman, 2003). Therefore, collaboration is based on shared information and aim.

Cooperation depends on the voluntary association of both government and non-government actors in a defined boundary (geographic area) to regulate and perform services in this territory (Norris, 2001). It may work in two or more ways between the actors. Ostrom and Ostrom's (1999: 96 in (Hooghe and Marks, 2001) definition presents it as cooperative arrangements that highlight the presence of multiple collective assumptions and productions, where "overlapping units of government, conflicts among governments at any one level may be resolved by recourse to the decision-making arrangements existing at a higher level of government." This definition is in line with the concept of cooperation as a leveling in MLG's interaction attempts.

Moreover, cooperation means supposedly sharing a set of common values (Valentinov, 2004), which can also mean a shared entity in developing something together. In this research, the shared entities are information, aims, and resources.

The three concepts are intermingled and interchangeable. To different authors, they mean different things, but, for the sake of this research, the three concepts are used as indicating the level of integration. Some governance scholars may not agree with this categorization, as coordination, collaboration, and cooperation in governance are sometimes reversed in terms of activities and elements. However, this research agrees with Kooiman, as he contended that collaboration represents something looser in terms of working together, whereas cooperation has more enduring patterns of working together (Kooiman, 2003, 1999).

This research resolved the integration level issue as follows. First, coordination is ranked as the lowest level of integration as it requires minimal alignments; this is what scholars call information sharing (Hall, Clark, et al., 1977, Bouckaert, Peters, et al., 2016). The second level is collaboration, with most scholars agreeing that it requires extra synchronization and harmonization of aims, not merely information sharing (Emerson and Nabatchi, 2015, Kooiman, 2003). The highest level is cooperation, which is based on voluntary 'spirits,' thus aligning information, aims, and resources (budget, personnel, other) into one action (Norris, 2001, Hooghe and Marks, 2001, Valentinov, 2004). Thus, interaction level is determined by the conditions prevailing in interaction attempts.

2.6 CEK Influence Pattern in a VRB

This influence pattern is used to answer the fifth sub-question: How and why does cultural ecological knowledge impact the management of a volcanic river basin? - The theme of Chapter 8. By definition, influence is the action or process of producing effects on the actions, behavior, and opinions of others (Partridge, 2006). In general, influence's role of intention is to affect a relationship between one concept and another concept. This role of intention can be assumed to be neutral, positive, or negative (March, 1957). The interrelation between concepts and theories conjugate into a form of new theory that can be framed as follows: (1) the conceptual structure of a science can be treated as a language and (2) the relations of the concepts in these languages to empirical phenomena and to one another can be determined using the methodological tools afforded by logic (Nersessian, 2010).

The interest in influence stems, in turn, from its conception as the fundamental intervening variable for the analysis of decision making. Influence is to the study of decision making what force is to the study of motion – a generic explanation for the basic observable phenomena.

The patterns of relationships explained in this section are based on how CEK may relate to IWRM and not the other way around. This is determined by the limitation imposed by the scope of this research, which is trying to ascertain the influence of CEK on IWRM. However, in reality, there might be feedback from IWRM to CEK, through the integration process proposed.

Using the theory of influence to look at the possibilities in this regard can be exhaustive, comprising power relation theories, social learning, social influence, and so forth. Therefore, for the purposes of this study, the influence investigated is limited to process-based influence (Kirkhart, 2000, March, 1957) where the integration process is used. Under this definition, there are three dimensions: cognitive, affective, and political. This study is interested in the cognitive and political dimensions, as it seeks to investigate current policies and knowledge.

The context of this study is an evaluation of the current implementation of IWRM policy in the study area. Therefore, Kirkhart's idea on influence can be adopted. Her idea of influence is based on three-dimensional incorporation: source, intention, and time. Source refers to the origin of influence as active agent of change, whether it aims for influence as a process or a result. The possible forms of intention are intentional and unintentional. On the timeframe, influence can be distinguished as immediate, end-of-life, or long term.

In the case of CEK influence on IWRM, not all knowledge is positive, as we are reminded by the literature (Flanagan and Laituri, 2004, Inglis, 1993, Berkes, Colding, et al., 2000). However, to decide what has what kind of influence, one must look into the current condition of known and practiced CEK in relation to current IWRM policies. This pattern of influence can be assessed as follows, on the assumption that the process-based influence on policy (March, 1957, Kirkhart, 2000) can be positive, negative, and neutral.

(1) Positive. This type suggests a supportive relationship or a 'for' (+). It proposes CEK with a supporting quality, which may be of use in enhancing or complementing the current IWRM approach. Under this form of influence, the relationship would be either persuasion (intentional) or inducement (unintentional). The influence of CEK can be judged as positive, as it may add value to the current IWRM approach.

(2) Negative. This influence proposes a hindering relationship or against (-) position to the current approach. A hindering may suggest slowing a process or partly not agreeing, and against means absolutely not agreeing. Under this form of influence, the relationship would be either activation of commitment (intentional) or deterrence or avoidance (unintentional). The influence of CEK can be judged as negative, as it is not used in the current IWRM approach.

(3) Neutral. Under this type, there is an assumption that sub-characteristics of CEK may neither support nor contradict IWRM, or zero influence (0). This type of influence suggests that there is no relevant or no direct interconnection. This type of influence may suggest that CEK exists parallel to IWRM. This would be the case in some of the CEK discerned in the empirical parts of the study, which would need to be categorized to filter them.

These simple categorizations are based on pre-fieldwork assumptions; therefore, more sub-categories may arise in the course of the study. From the above, the CEK pattern is defined for the interaction attempts in the management of a volcanic basin, based on the presence or non-presence of CEK.

2.7 Conceptual Framework

In this research context, the CEK characteristics are used to discover whether it exists in current society and policies in the integrated water management of a VRB. The IWRM and DRR concepts correlate through the dimensions of IWRM and LRM. As the aim of this research is to investigate the contribution of CEK to IWRM in a VRB, it gives special attention to combining water and lahar management as a type of hybrid approach. In this framework, CEK is the starting point of the research. This CEK concept is addressed by rediscovering and defining CEK for the case study. To do so, it is proposed to start with historical experiences recorded or part of people's observed everyday life. It should be noted that it would probably be wise to start at the hamlet scale, as experience from earlier investigations of rural Merapi areas has shown (Donovan, 2010, Dove, 2007, Mei, Lavigne, et al., 2013). This level is where the strong power relation of CEK is based in this administrative structure. Later on, the mechanisms of transfer will be identified using its features.

The research will be conducted on two different units of analysis in the region: the locals (groups) and the managers (organizations). Each group, as actors, has its own opinion and expertise. The research starts at the source of influence (Kirkhart, 2000) with the locals, by attempting to rediscover their CEK understanding (Inglis, 1993, Flanagan and Laituri, 2004). It will provide a strong basis to answer the first sub-question: What are the main elements of cultural ecological knowledge in a volcanic river basin and how is it formulated? All the characteristics of CEK will be ascertained using an ethnographic approach among the representatives of communities affected by the 2010 Merapi eruption. Each aspect of CEK will be rediscovered to compile the existing known cultural knowledge in the location of study. This list of sub-characteristics of CEK is based on literature on traditional ecological knowledge, local knowledge, and cultural knowledge (Berkes, Colding, et al., 2000, Geertz, 2000, Corburn, 2003, Raymond, Fazey, et al., 2010).

The second aspect will focus on organizations in order to assess current IWRM policies. This will address the second sub-question: How is the IWRM approach being implemented in a volcanic river basin?, which deals with a group of organizations (Jaspers, 2014, Savenije and Zaag, 2008) that have capacity and resources, usually a governmental body appointed to manage the river basin and its related resources (Huitema and Meijerink, 2014).

The third aspect addresses the sub-question: What constitutes lahar management and how is it being implemented in a volcanic river basin? Lahar management itself is not something new; there have been studies on experiences in controlling lahar hazards in different parts of the world. However, these studies have been conducted from a hard science perspective, such as geology and volcanology (Sigurdsson, Houghton, et al., 2015, Marso, 2013, Rodolfo, 1991, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003, Keys and Green, 2008, Pareschi, Cavarra, et al., 2000, Dimitrov, 2002, Federico, Aiuppa, et al., 2002, Cuoco, Tedesco, et al., 2013, Dorava and Meyer, 1994). However, the type of lahar also determines the kind of lahar management methods used. Therefore, this research will investigate the implemented lahar management and its elements, also from a governance viewpoint.

The fourth aspect addresses the sub-question: How and why does lahar management relate to integrated water resources management in a volcanic river basin? As not much has been published on this issue, this sub-question addresses the critical point of how relations are really handled using the current policies, who is managing what, and what characteristics of lahar can be attributed to water-related disasters, also when precisely lahar occurs in the water cycle. This is investigated using interrelation possibilities (Goldstone, 1996) existing in the VRB, between water management and lahar management. Each interrelation aspect of management is considered from the standpoint of the literature findings. The results of in-depth analysis are explained in Chapter 7. The 'why' question is answered by the overlapping activities, which are theoretically explained there and not in this chapter.

The next aspect is the influences relationship referring to the next sub-question: How and why does cultural ecological knowledge impact the management of a volcanic river basin? In this research, the influences investigated come in two options: the ways and the pattern of influence (Kirkhart, 2000, March, 1957). The answers will reveal whether CEK and IWRM can work together in the same location under different approaches. The types of influence will explain whether CEK has a positive, negative, or neutral influence on IWRM. Thus, the sub-question about whether CEK can influence the IWRM approach will be answered by describing which of the CEK characteristics has influence on the IWRM dimensions. It is important to note that the relationship functions relate indirectly through the screening of sub-components of the concept. Therefore, for clarity, each of the indicators will need to be explained, to pinpoint the relevant influence. In each of the sub-concepts, the interrelations are found based on the literature reviews. This helps to identify alternative influences that may affect the IWRM dimensions. The influences assumption has been described earlier in a two-fold manner, that is, patterns of influence and ways. The extent to which influence is investigated has to be limited in order to answer the stated questions. The more intricate interrelations between components of CEK and IWRM are assumed to take form in the ways that are possible in the integration process. These interrelations are still open to other ways that may be found during the course of the research. Note that, within the VRB, the research will investigate the existing interaction attempts and integration level of IWRM, LRM, and the overall VRB, before determining whether or not CEK has an impact in these governance settings. The conceptual framework derived from this synthesis and depicted in Figure 2.5 is used to specifically address the issues faced in this research.

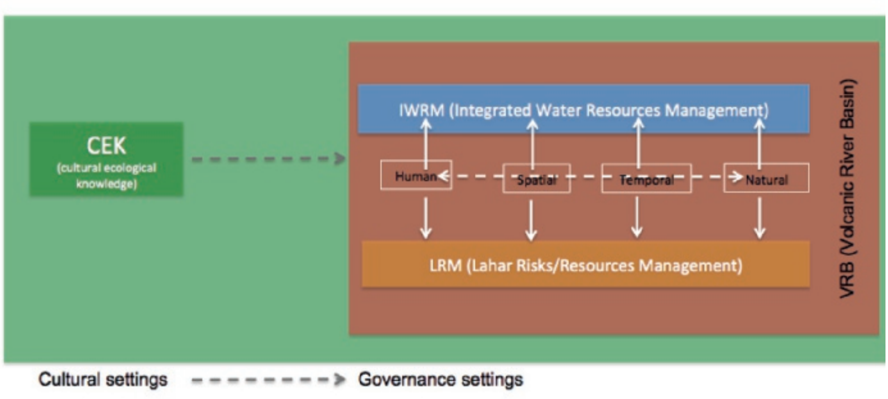
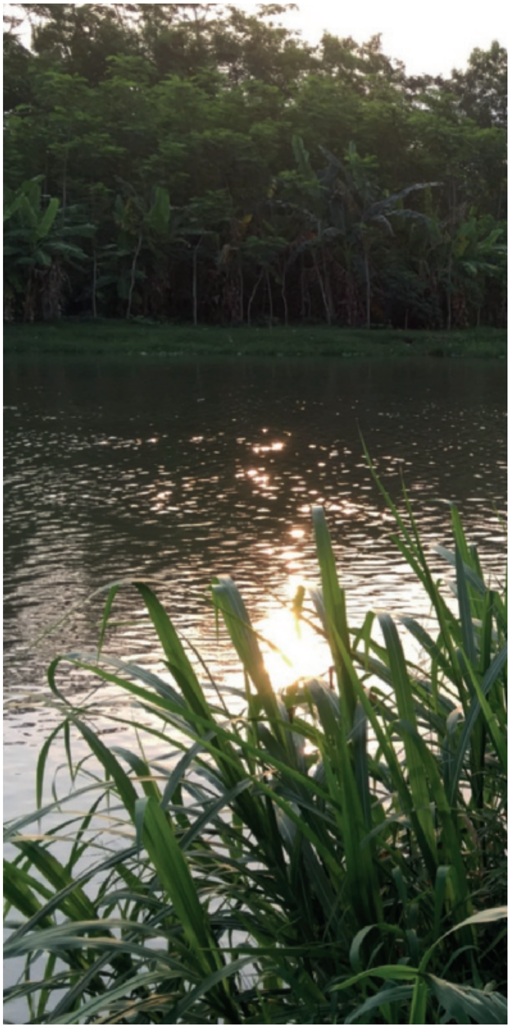


Figure 2.5 Conceptual framework of CEK influence in a volcanic river basin



CHAPTER 3

METHODOLOGY

3 Methodology

3.0 Introduction

This chapter explains all the methods and analytical frameworks used in this research. It starts with the research design: an embedded case study. It continues with the selection of the case study and its sub-cases, based on the representation of the volcanic river basin (VRB). Next, it explains the location of the case study. The timeframe of this study extends from Mt. Merapi's 2010 post-eruption to the beginning of 2018. The units of analysis are determined as organization and community. The methods are based on pure qualitative approaches. In the last section, the chapter presents the operationalization and analytical frameworks for the dependent and independent variables, and the relationship between the two.

3.1 Case Study Research Design

As this study requires in-depth understanding rather than breadth of comparisons in different locations, the case study research design has been chosen (Yin, 2009, Flick, 2008, Marvasti, 2003). Moreover, many scholars who have researched subjects similar to cultural ecological knowledge (CEK) suggest that the understanding of knowledge in general is best found *in situ* and in one cultural context by using a case study approach (Agrawal, 2014, Berkes, Colding, et al., 2000, Howes and Chambers, 1980). This approach was used to relate this methodology back to the literature review and earlier studies on CEK in water management (Flanagan and Laituri, 2004, Robinson, Bark, et al., 2015, Retnowati, 2014, Nikolakis, Grafton, et al., 2015, Pert, Ens, et al., 2015, Ross and Pickering, 2002, Gartin, Crona, et al., 2010, Back, 1981, Sangkhamanee, 2007) or disaster management (Corburn, 2003, Berkes, Colding, et al., 2000, Inglis, 1993), especially for volcanic regions in the world (Bachri, Stötter, et al., , 2013, Corburn, 2003, Chester, 2005, Cashman and Cronin, 2008, Cronin, Gaylord, et al., 2004, Dibben and Chester, 1999, Gaillard, 2008, Gregg, Houghton, et al., 2008). The approach is also relevant because of the context of culture and its relationship to specific geographical conditions. In this research, this refers to the water resources in the VRB studied; as such resources may differ greatly across different locations.

Therefore, these experiences of earlier scholars led to the choice of an embedded case study for a researchable context. With the embedded case study option, a case study is thoroughly examined, where triangulation is key to verifying the understanding of a phenomenon in a particular context (Verschuren, Doorewaard, et al., 2010, Yin, 2009, Kothari, 2004). In this research, the context is culture and its relation to the management of water in a VRB. Furthermore, the whole basin is chosen as the case study. However, to gather more detailed information at community level, sub-cases were chosen to represent the variety of conditions in the VRB studied. These sub-cases are distinguished by function in terms of water resources and characteristics, geographical location, and the impact of volcanic activities, especially lahar.

3.2 Selection of Case Study Opak Sub-Basins in Yogyakarta Special Region

As the embedded case study selection for this research has to represent an active VRB located in a highly populated area, impacted by lahar as a water-volcano-related hazard (and where a traditional culture still exists), these criteria limited the selection of the case. Of 1500 volcanoes in the world, only 500 have a history of eruptions (USGS, 2018). Furthermore, only around 10 major volcanoes are located within a 10–80km radius of highly populated areas of 1 million inhabitants or more (ESRI, 2018). One of these 10 – Mount Merapi (2010) – erupted recently with a high volcanic explosivity index (VEI) of 4 (De Bélizal, Lavigne, et al., 2013, Jousset, Pallister, et al., 2012, Pallister, Schneider, et al., 2013). Therefore, the Opak-Sub Basin was chosen as the case study for this research, because:

(1) It is an active volcanic basin with Mt. Merapi in its upstream area and has an eruption cycle of once every four years (Newhall, et. al., 2000, Lavigne et. al., 2000),
(2) It is located in a highly populated area of the Yogyakarta Special Region, with around 3.5 million inhabitants (BPS Provinsi D.I. Yogyakarta, 2018),
(3) It is the exemplary location for a particular type of lahar risk mitigation infrastructure in Indonesia, known as the Sabo dam system, which has been implemented since the 1970s (Sumaryono, 2011, JICA, 1980), and
(4) The traditional culture is conserved through the region's special status, which is a Sultanate (Geertz, 1976, Koentjaraningrat, 1985, Mulder, 2005, Purwadi, 2010, Purwani, 2014, Irawanto, Ramsey, et al., 2011).

Lahar is a product of an extreme water-related disaster (Marso, 2013, Rodolfo, 1991, Pierson, Wood, et al., 2014, Lavigne and Thouret, 2003, De Bélizal, Lavigne, et al., 2013), managed under the integrated water resources management (IWRM) approach by the Indonesian Ministry of Public Works and Housing (BBWS SO, 2014, JICA, 1980, PPK PLG Merapi, 2015, Sumaryono, 2011, BBWS SO, 2011). This therefore presents a unique case of water management, which is the interest of this research.

These two interrelated themes of water and lahar management and the existence of the Sultanate offer the opportunity to research the potential influence of CEK on water management practices. Yet, there seems to be a lack of interest in investigating whether CEK influences IWRM in a VRB. Any research proposed in the Merapi area represents one step in the attempt to integrate local knowledge into current modern approaches to managing the environment. Therefore, this research aims to take that one step with the aim of contributing to this field of study.

Other research that inspired this study was the work on local ethics or local knowledge in natural resources management and human–nature relations in the Yogyakarta Special Region. These include research on environmental ethics as reflected in the seasonal traditional calendar *PranotoMongso* – referred to with a different spelling in this thesis as *Pranata Mangsa* (Retnowati, Anantasari, et al., 2014) – and earlier research on the place of the calendar in rural life, which explained the use of bio-climatological and sociocultural functions (Daldjoeni, 1984), and also on Javanese culture (Koentjaraningrat, 1985), its religion (Geertz, 1976), and the mysticism surrounding it (Mulder, 2005, Zoetmulder, 1991). Other works include the local knowledge applied to manage risks in water and land management (Retnowati, 2014) – although these are located in karst areas in the Oyo Basin, the fork of the Opak Sub-Basin before it meets the South Java Sea – and urban spatial planning in the Mataram Sultanate (Dradjat, 2009, De Giosa, 2011).

These contexts positioned the research in relation to the literature review and empirical studies on the concepts relating to CEK, IWRM, and lahar risk/resources management (LRM). With these conditions in Yogyakarta, its unique cultural context, Mt. Merapi, and the existence of water/lahar management organizations form a complete establishment. Therefore, it is the perfect case study to perform research that investigates the potential of CEK integration into IWRM in a VRB.

3.3 Location

The division of river basin territory (WS) in Indonesia is determined by President's Decree No.2 of 2012 (Keputusan Presiden No.12 Tahun 2012) in line with management requirements. The reason for dividing these territories is the geographical conditions and existing water infrastructures, which in many cases crisscross different river basins. The main idea behind this inter-river basin transfer is proper management and prosperity, to ensure equilibrium in water distribution. However, many of these territories still suffer from annual flood and drought, not due to the division, but mostly to the lack of understanding about proper IWRM (Maryono, 2005).

The WS Progo Opak Serang (POS) is comprised of three river basins: Progo, Opak, and Serang. Each basin is characterized by different attributes. The Progo River Basin accounts for the largest area of about 40% of the whole POS River Basin. Its location benefits from a hilly steep terrain with the Mt. Merapi volcano situated in its upper stream and from its geological conditions with latosol, sandstone, sand, and breccia rocks, which make its basin rich in groundwater supply (BBWS, 2011). The Opak River Basin, on the other hand, has a rather specific character. Half of this basin is located downstream of Merapi, and the other half in the east and south of Yogyakarta is the karst area in the Oyo tributary basin. The Opak River Basin accounts for 30% of the POS River Basin (BBWS SO, 3011) and contains most of the downtown urban area of Yogyakarta. It is also the most populated riverside area in Yogyakarta. Water resources developments in these areas are limited to non-karst areas, in the forms of weirs and irrigation systems.

The case study is geographically delineated (see Figure 3.1-1) in the Opak sub-basin, which was impacted directly by the 2010 Mt. Merapi lahar flow (Jousset, Pallister, et al., 2012). Along the main Progo and Opak channels, a series of Sabo dam systems were built as lahar mitigation infrastructure. This is a main part of the current IWRM approach for these two river basins, which is also in line with lahar management. However, empirical data from previous research on lahar in Mt. Merapi revealed that the most impacted areas in the Yogyakarta Special Region are located in the Opak sub-basin (Newhall, et. al., 2000, Lavigne et. al., 2000, Jousset, Pallister, et al., 2012). As explained earlier, not all of the Opak basin is directly connected to Merapi. Half of it originates in the karst area of Gunung Sewu in Gunungkidul Regency, namely, the Oyo sub-basin (BBWS SO, 2011). This research therefore focuses only on the part of the Opak basin connected to Mt. Merapi, namely, the Opak sub-basin.

Figure 3.1 Map of study area. Note: The red border indicates Opak sub-basin and the dots are three sub-cases: (1) Argomulyo, (2) Gowongan, and (3) Kebongagung, with author's elaboration (BBWS SO, 2011)

This research location also corresponds with the culturally established Yogyakarta Special Region. Importantly, the Kingdom of Ngayogyakarta Hadiningrat offers an encapsulated cultural heritage region embodying Javanese values and traits (Mulder, 2005, Purwani, 2014, Koentjaraningrat, 1985). This is a key aspect to consider, as it is essential to have enough evidence to enable the rediscovery of CEK in the region. Javanese culture is still widely practiced in daily life in Yogyakarta, even as it embraces modern life. Under the kingdom rules and the law for the region's special status, Yogyakarta has succeeded in conserving a lot of its Javanese cultural heritage in different aspects of life, both physical and non-physical (Soeratno, 2004, Undang-undang Republik Indonesia No.13 Tahun 2012 tentang Keistimewaan Daerah Istimewa Yogyakarta, 2012).

Under the administrative delineation of the Opak sub-basin, the research study area is divided into three municipalities: Regency of Sleman (upstream), City of Yogyakarta (downstream-middle area), and Regency of Bantul (downstream-terminal). These administrative areas are three of five municipalities in the Special Region, so they comprise almost 50% of the Yogyakarta Special Region. However, the characteristics of the municipalities are the main criteria for selecting the research study area, which is located in the upstream, midstream, and downstream area of Merapi's lahar-prone zone (Lavigne et. al., 2000).

The three villages selected as representatives for the case study have experienced the worst lahar impact according to reports by the disaster management agency (BPBD DIY, 2012) and the river basin organization (BBWS SO-JICA report 2011):

(1) Upstream at Sleman Regency: Argomulyo Village, District Cangkringan – Opak and Gendol tributary
(2) Midstream at Yogyakarta city: Gowongan Sub-district, District of Jetis – Opak Tributary – Code River
(3) Downstream at Bantul Regency: Kebonagung village, District of Imogiri, as the terminal of Opak sub-basin before it joins the Oyo tributary.

3.4 Timeframe

The research on IWRM use is limited to the time after the 2010 Merapi eruption. This baseline timing was chosen for IWRM and LRM in this VRB, because the year 2010 represents the 100-year cycle of Merapi eruptions (Jousset, Pallister, et al., 2012) and the most recent eruption with a high VEI. The research started with the policies and experiences in 2010 and ran to early 2018, after the second fieldwork was conducted. The policy documents consulted in this research are the regulations and master plans dating from after the 2010 eruption, most of which are valid for 20 to 30 years. This timeframe is proposed to provide a review of current policy on water/lahar management as a preparation for future major eruptions.

However, although the timeframe for the IWRM research starts in 2010, CEK is the product of previous generations, as one of the characteristics of CEK is its transfer inter-generationally. Consequently, CEK and historical experiences of Mt. Merapi eruptions and water and lahar management are considered and not only limited to the 2010 eruption onwards. This CEK is found in written Javanese literature such as Serrat (poems or songs) and Babad (history record) and also transmitted orally as the whole body of knowledge. Thus, it is still used in current society but stems from earlier generations.

These two timeframes are taken as applicable to this study to follow the logic of two concepts: (1) the post-eruption time limitation and (2) the inter-generation knowledge transfer.

3.5 Unit of Analysis

In this research, the unit of analysis is the whole river basin, based on groups and organizations. To select the first unit, the researcher borrowed some selection criteria from earlier CEK-related studies, especially those on water management (Flanagan and Laituri, 2004, Berkes, Colding, et al., 2000, Retnowati, 2014, Inglis, 1993), but also on volcano and lahar management (Donovan, 2010, Gunardo, 2015, Widayani, 2011). The criteria were that communities must still practice local and cultural knowledge, possess culture-based institutions, have an interest in conserving cultural values, honor the human–nature relationship, and demonstrate proof of inter-generation knowledge transfer. Groups were chosen as the unit of analysis as this research aims to gather opinions from the local Merapi communities in order to explain the current conditions of CEK wisdom, mechanisms, and experiences. To select the groups, the following additional criteria were applied in the context of this research: the groups had to be (1) located in the research area (see Figure 3.1-2), with equal numbers of up-, mid-, and downstream villages, (2) affected by 2010 and future Merapi eruptions (based on BPBD map 2011), and (3) accessible and consent to participating in this research. The groups chosen are local communities related to the study site. The common qualities of these groups are that they have Javanese ethnicity and have been impacted directly by Merapi lahar. Representatives of the groups were selected based mostly on location. Details of the selected locations are provided in later discussions.

The second unit is the organization or the managers. Selection of the managers from the IWRM perspective was guided by five criteria. Potential organizations in the research location had to be involved in the following functions (Jaspers, 2003):

(1) Plan: develop a Water Resources Management Plan (WRMP), i.e., river basin plan, protection plan, strategic plan, and so forth
(2) Implement and monitor: water extraction and drainage allocation, permits, pollution control, and so forth
(3) Collect water charges, levies, and funding
(4) Responsible for sub-basin coordination, creation of awareness, and capacity building
(5) Responsible for conflict resolution: legal and appeal function for permits and against defaulters.

LRM was another perspective that had to be included in these selection criteria. Under this concept, the managers in this field are those in charge of the following functions for managing lahar disasters (Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, Aalst van, et al., 2012):

(1) Providing norm and rules
(2) Having authority
(3) Having the main responsibilities: obligations and tasks.

As a start, the research examined the current list of organizations under the main IWRM policies and found the coordination team for water resources management (TKPSDA) for POS river basin territory. This type of team is formed in each river basin territory in Indonesia, endorsed and facilitated by the Ministry of Public Works and Housing. The members of TKPSDA POS, appointed by the Ministry of Public Works decree No.358/KPTS/M/2014, are working in two provinces: Central Java and the Yogyakarta Special Region, from 7 July 2015 to 2019. TKPSDA has 62 member organizations, 31 governmental and 31 non-governmental (the private sector and the community or NGOs). Thus, there is a balance of opinion. TKPSDA functions as a vessel for solving problems that arise in the POS river basin territory. From 2009 to date, the TKPSDA meetings have been held as an assembly during which participants discuss agendas under a meeting ordinance. The first TKPSDA meeting created this ordinance. This team must hold a minimum of three meetings each year, where the team discusses emerging issues related to managing water resources in the area.

The Indonesian version of IWRM is implemented by river basin organizations (RBOs) called the Balai (Besar) Wilayah Sungai or B(B)WS for short (Global Water Partnership, 2000, Government of Indonesia, Inter-Agency Task Force on Water Sector Policy

Reform, 1999, UU No.7/2004, 2004). These river basin organizations are formed under the Ministry of Public Works and Housing, General Directorate of Water Resources. Their vision in managing water resources is the realization of water resources management and beneficial optimal sustainable functioning for the benefit of the entire community. On the basis of these criteria, several organizations can be considered as the main manager of IWRM and LRM. The main organization is BBWS SO: Serayu-Opak River Basins Organization. BBWS SO is seen as the most important organization in the research area because of its function as endorser of TKPSDA and its main function in managing all infrastructure and the organizational IWRM and DRR framework for the POS river basin territory. It is the branch office of the Indonesian Ministry of Public Works and Housing, and it finalized the WRM for Pola RPSDA WS POS (POS river basin territory management framework) in 2010 and RPSDA WS POS (WRMP for POS river basin territory) in 2015. Meanwhile, as partner organizations of BBWS SO, two other organizations hold a provincial mandate in terms of IWRM and LRM:

(1) PU-P ESDM: Public Works, Housing, Energy, and Mineral Resources Agency (IWRM). This agency is located at local, provincial level government. Its organizational vision aims at the realization of public works infrastructure service quality and adequate housing, an increase in the number of habitable homes, and the management of energy and mineral resources in an environmentally friendly way. In providing water resources infrastructure, this agency works collaboratively with BBWS SO. However, as the main responsibility for all rivers is under the authority of the national level, most funding schemes are worked through BBWS SO. PU-P ESDM also provides monitoring data on all water stations in the region, which are used by BBWS SO as base case data in deciding water usage and designing water infrastructures. One of the most important planning products of PU-P ESDM is the RTRW or the region's spatial and regional plan. It sets the local development policies.

(2) BPBD DIY: Local Disaster Management Agency (LRM)
This agency is the local front-line commander during disaster occurrences. The current approach used in this agency is the DRR framework. Its vision is to promote the people of the Yogyakarta Special Region as sensitive, responsive, and resilient to disaster toward a new civilization. The tasks under this agency are:
   a. Formulate fast, accurate, effective, and efficient policy disaster management for the area
   b. Coordinate and implement disaster management operations in the area in a planned, integrated, and comprehensive way
   c. Implement the management of disaster management activities.

However, although the abovementioned organizations have a strong relation to IWRM and LRM, there is still a need to assess whether they have a direct relation to CEK. Other related organizations were found in the fieldwork.

3.6 Methods

Several methods were employed in this research:

(1) Research strategy
(2) Data collection methods
(3) Sample size and selection
(4) Validity and reliability

(5) Data analysis methods.

3.6.1 **Research Strategy**

In this research, the explanatory strategy is used to collect sufficient data by composing 'how' and 'why' questions in relation to the study's objectives. This design uses sequential timing, starting in the first phase by prioritizing primary and secondary data collection directly in the field. Concurrently, the findings from primary and secondary data are analyzed, while secondary data is still being collecting through e-mails, returning to the field for validation, and finally writing a report. These findings are used to build the second phase of research to validate the initial findings. Later on, it is used for further analytical interpretation.

This research does not define in fixed terms how the concepts are hierarchically related to one another. Rather, it tries to find a causality relationship and proposes a cyclical relationship between the concepts. The explanatory nature of the research facilitates the investigation of the meaning of CEK as a starting point however; this does not necessarily suggest that it cannot be affected by the other two concepts, IWRM and LRM. The relationships between these concepts (IWRM–LRM) in a VRB also ultimately reveals the CEK contribution to the VRB as examined here.

3.6.2 **Data Collection Methods**

In order to answer the main Research Question: How does cultural ecological knowledge contribute to the integrated water resources management of a volcanic river basin? some sub-questions needed to be answered. Table 3.1 lists the sub-questions and their data collection methods.

Table 3.1 Data collection methods

No.	Sub-Questions	Type of Data	Data Collection Methods
1	What are the main elements of cultural ecological knowledge in a volcanic river basin and how it is formulated?	Primary data	Semi-structured interviews, observations, focus group
		Secondary data	Regulations, archives, or literature on the Yogyakarta and the Mataram Sultanates
2	How is the integrated water resources management approach implemented in a volcanic river basin?	Primary data	Semi-structured interviews
		Secondary data	Data archive Regulations, MoM, planning documents, policy documents
3	What constitutes lahar management, and how is it being implemented in a volcanic river basin?	Primary data	Semi-structured interviews
		Secondary data	Data archive Regulations, MoM, planning documents, policy documents
4	How and why does lahar management relate to integrated water resources management in a volcanic river basin?	Primary data	Semi-structured interviews
		Secondary data	Data archive Regulations, MoM, planning documents, policy documents

5	How and why does cultural ecological knowledge impact the management of a volcanic river basin?	Primary data	Semi-structured interviews, observations, focus group
		Secondary data	Data archive Regulations, MoM, planning documents, policy documents

Note: MoM – Minutes of Meeting, IWRM – integrated water resources management.

This research utilizes qualitative data collection for its primary source of data (as shown in Table 3.1). Inspired by the ethnographic approach, some methods are used here in the form of observation; semi-structured interviews are used for data acquisition, along with focus group discussion (FGD) (Crang and Cook, 2007, Emerson, Fretz, et al., 2011, Angrosino, 2007, Fetterman, 2010). However, to understand volcanic activities and hydro-meteorological conditions, secondary data are needed. These secondary data are used to support primary, qualitative data (Hox and Boeije, 2005, Flick, 2008). The data support one another in the triangulation process.

Primary Data Collection

The primary data were collected using the tools of an ethnographic approach, in either the local groups or the manager groups. This conforms with the idea of assessing the groups and organizations as a unit of analysis in their natural settings to compile rich data on daily life. Three tools – observation, interviews, and focus groups – were used to verify by triangulation the primary data compilation. These tools create a deep understanding of relevant information needed for this research. Each of these tools is used to provide a complete description of the research participants (Angrosino, 2007).

Ethical matters for ethnographic research have been derived from several understandings of the term 'ethics' (Madison, 2011), at least two of which are used by the American Anthropology Association:

(1) Kant included at least three moral principles:
   a. Human beings as ends and not means: treat the participants as a person not as mere informants regarding the research, personal relations need to be kept well, even after the research is completed
   b. The categorical imperative: appropriate understanding on the subject of research to embody empathy
   c. The moral imagination: sets of appropriate conducts and morale in the community being set as good.

(2) Rousseau and Hume explain the ethic of ethnography as consisting of influences between culture and human behavior. A positivistic lens is used in approaching humans as subjects of research, presuming that humans are innately good and their emotions are beyond logic.

A code of ethics was developed and approved in 2012 as follows (Statement on Ethics: Principles of Professional Responsibilities, 2012):

(1) Avoid harm or wrong
(2) Respect the well-being of humans and non-human primates
(3) Obtain informed consent and necessary permissions
(4) Weigh competing ethical obligations due to collaborators and affected parties

(5) Make your results accessible
(6) Protect and preserve your records
(7) Maintain respectful and ethical professional relationships.

The 'kit' for doing the fieldwork (Emerson, Fretz, et al., 2011, Crang and Cook, 2007) is based on personal choices; however, it relates to the forms of data that are needed from the field. In this research, the samples of forms of data are:

(1) Hours of observation – field notes
(2) Locations – description of scenes in field notes
(3) Minutes voice recording
(4) Minutes on video
(5) Photographs.

The ethnographic approach used in this research was informed by the following pointers:

> As ethnographers, when we travel to other worlds, we open ourselves to the greatest possibility of loving perception and dialogical performance, because (a) we witness and engage cultural aspects of the Other's world; (b) we witness and engage with Others' sense of self in their own world; (c) we experience how we are perceived through Others' eyes; (d) we are now bodies that must touch, see, and listen to each other because we are inhabiting a space in their world where distance cannot separate you; (e) we witness and engage the Other as a subject even as he or she may be subjugated, and, as a result, meanings of power and positionality begin to arise between us; (f) we are dependent on each other for the possibility of being understood. (Madison, 2011: 289-290)

All respondents' consent in this research was given either orally or in writing. The Institute of Housing and Urban Development Studies under the Graduate School of Social Sciences and Humanities at Erasmus University Rotterdam gave approval for the fieldwork conducted by providing a letter of intent for the researcher in summer 2016. Most respondents from the community gave their consent to use their real name in this research. Anonymity was promised to those who asked for their identity to be protected. The same also applies to the government organization respondents, although most were willing for their name to be used; however, anonymity was applied to sensitive quotes to protect the respondents' identity.

Semi-structured interviews

This method was chosen as it fits the nature of an exploratory research project, where informants are selected for confirmation of acquired data. However, to focus, the overall main idea of the information needed from each informant has to be outlined. The advantage of this type of open-ended interview is that it uncovers the rich information behind the layer of consciousness (Marvasti, 2003); this helps to elucidate cultural experience and perceptions and to explore the context from an ordinary viewpoint (Gubrium and Holstein, 2002). For this method, voice and video recorders were used; photographs were also taken, if participants gave their consent.

Using interviews to acquire primary data is a good way to complement the unclear relations of behaviors, scenes, or interactions observed during fieldwork. It explains participants' lives from their own perspective (Kvale, 2008). This method is used to acquire data from key informants, if deemed necessary after the observation stage. The function of this method is to confirm and detail the findings from observation (Angrosino, 2007).

The following interview stages were used in this research (Kvale, 2008):

1. Thematizing. This stage is a starting point of the research and was conducted in the proposal literature review and in conceptualizing the frameworks to be used.
2. Designing. The researcher listed the knowledge intended to be acquired in each stage while at the same time following the abovementioned code of ethics.
3. Interviewing. Using a guideline in interviewing helps to focus the questions on the research objectives.
4. Transcribing. Transcription – a written version of interview results – is needed as material in content analysis.
5. Analyzing. The type of analysis for the interview material is decided beforehand to serve the purpose of the research.
6. Verifying. This ascertains the validity, reliability, and generalizability of the interview findings. Reliability refers to how consistent the results are, and validity means whether an interview study investigates what is intend to be investigated.
7. Reporting. The findings of the study and the methods applied must be communicated in a form that meets scientific criteria, takes the ethical aspects of the investigation into consideration, and results in a readable product.

Inspired by the ethnographical approach to interviewing, the semi-structured interview becomes a part of growing knowledge based on observation. The interview is a two-way communication; therefore, interviews, especially the semi- or non-structured types, flow fluently and with reciprocity (Cassell and Symon, 2004). Even if an interview guideline is used, anecdotes help the researcher to understand a context, as they enrich the quality of knowledge (Flick, 2008). The participants in this research explained their world in their own words in interviews conducted in one of two ways: either observation (site visit) or focus groups.

Observation

The observation method is adopted in the group participants' natural surroundings (site visit). For the community, this is their villages, and for organizations, this is their office. This method has the advantage of capturing subjects in their natural setting. As this research needs to redefine and rediscover how the concepts are used and implemented, this can only be done through finding pieces of information and working inductively to arrive at a complete representation (Ritzer, 1975). The shadowing method is an effective way of observing. The researcher picked samples of the population using purposive sampling, on the criterion that the respondents had a high level of understanding of CEK, water and lahar management, and volcano management.

In observation, the researcher has four possible standpoints (Burges, 1984 in Cassell and Symon, 2004): complete participant, participant as observer, observer as participant, and complete observer. For this research, the standpoint of participant as observer was chosen where the researcher was an insider of the manager group, especially in BBWS SO, whereas, for the local group, the standpoint of observer as participant was chosen, as the researcher did not naturally belong to this group. The tools used for this observation were mainly field notes and voice and video recordings of important events. Further information on the observation method is provided in the operationalization section.

The main aim of conducting an observation is to collect details, thereby giving 'color' to the context of study (Ladner, 2014). This is obtained through the main medium of record, which is field notes. In fieldnotes, several points need to be recorded with video or photographs. The following were used in this research (Emerson, Fretz, et al., 2011):

(1) Fragments of actions and talks in scenes, events, and interviews
(2) Scenes without characterization or opinionated
(3) Concrete everyday life, which 'shows' rather than 'tells' of behavior.

To ensure that the observation is run effectively, several fieldwork aspects have to be included as points of observation (Emerson, Fretz, et al., 2011, Crang and Cook, 2007, Falzon, 2012, Chambers, 1994):

(1) Behavior: talk, activities, and expressions (collected for all respondents) documented in video and audio recordings
(2) Details of scenes: sensory aspects relating on the setting (see, feel, moods) in all sub-cases and the organizations' offices (photographed)
(3) Transect walk: a systematic walk accompanied by community members as guides and showing important locations for water and lahar management as a defined path, observing the conditions, combined with observations recorded on video and in photographs.

These observations were obtained during the fieldwork and interviews and proved to give additional information, often hidden, which was needed to uncover realities as seen or heard by the respondents. The observations were also used as part of data triangulation.

Focus Groups

Focus groups were conducted with the community in each of the sub-cases, in which the researcher guided the focus group and created an enabling condition for participants to share their points of view (Cassell and Symon, 2004). This method increases the validity of evaluation findings. Another aim of the focus groups was to triangulate the findings from individual interviews and observations in each sub-case. For this method, a group of participants was selected from the in-depth-interview respondents or the respondents invited other people related to them and able to address the research questions. Video and audio recordings were made of these groups. The discussions lasted about two to three hours, during which participatory exercises were conducted, although not aimed at modifying attitudes, behaviors, and mindsets. The purpose of these exercises was to gather data using visualization tools to capture participants' perceptions. Aiding tools were used to visualize the dimensions of IWRM and LRM insofar as they related to CEK. In line with the participatory approach, the particular tools used were chosen on the basis of each participant's message. Although not applied as a main research method, providing visual aids enhanced the quality of the discussion. This approach is inspired by PRA (participatory rural appraisal), as the research part of rediscovering CEK among rural communities. The approach, as applied anthropology, is based on experiences with techniques for obtaining data in rural areas in regard to volcanic eruptions (Vrolijks, 1998, Cronin and Kaloumaira, 2000, Mosse, 1994, Howes and Chambers, 1980, Chambers, 1994). The visualization tools include:

(1) Community timeline (historical events in a community)
(2) Storytelling (pre- and post-disaster condition)
(3) Community mapping and diagram-drawing exercise.

Therefore, during the focus groups, the activities were:

(1) Photographic presentations: resulting from observation, conveying the condition of a place, description of issues, using the photo to start storytelling, and reality perception check
(2) Map drawing: helping to visualize spatial surroundings and relation of locations to one another
(3) Timeline or cycle diagram: aiding in corroborating a timescale in the research, seasonal calendar, activity calendar, eruption calendar, and so on
(4) Stakeholder mapping using diagram: helping to identify the relations and structures among different organizations and the communities.

A focus group discussion was performed once in each village. During the discussion, the questions were repeated and answers were observed, to check for consistency. Each focus group was accompanied with notes, video-audio recordings, and photo documentation. The method used in these discussions was observation and a participatory exercise. As part of the research strategy, focus groups were used to check the validity of the knowledge acquired in the earlier part of the research (Flick, 2008). The number of participants engaged in this method was between 6 and 12 per session (Crang and Cook, 2007); this number was decided on the basis of the number of representatives from the community involved. Sub-case 1 had six participants, sub-case 2 had eight participants, and sub-case 3 had seven participants. Most of the participants were respondents for the in-depth interview, except for sub-case 2, as the interview respondents were not comfortable about telling their stories in a group session. Therefore, sub-case 2 had focus group participants, who represented the sub-kampong level (RW), but not the same persons as the in-depth interview participants. This functioned also as a validity and reliability check for the preliminary findings based on the round of interviews.

The overall primary data collection method is summarized in Figure 3.2, which explains that, in each community group and organization, the amount of time spent was three weeks, with the third week as the validity check. For each community group, a similar timeline was used with a separate focus group for each village. However, with one main IWRM and LRM organization, BBWS SO, deeper investigation was conducted. However, with the partner organizations, a series of interviews and participatory exercises were conducted. In this regard, the focus groups involved different organization representatives. Therefore, three focus groups were conducted for each of the sub-cases or villages. The second fieldwork was carried out in early 2018 to validate the findings of the analysis based on the 2016 fieldwork by ten more in-depth interviews.

Flow of work during fieldworks

2016 -1st fieldwork

Community/ organization Individuals 47 interviews

Point of view	Method	Length	No. Site visits
Researcher	Deep interview Observation	3 hours	1
Researcher as observer	Observation	2 weeks	2 (6 hours/visit)

Week 1-2: observation period

3 Focus Groups: only communities

Point of view	Method	Length	No. Site visits
Researcher	Observation	3 hours	1
Participant	Participatory excises ondimensions: Natural – definition Spatial – maps Temporal – time line Organizational – stakeholder map	1 day	1

Week 3: 1st validity check

2018 – 2nd fieldwork

Community/ organization Individuals 10 interviews

Point of view	Method	Length	No. Site visits
Researcher	Deep interview	3 hours	1

2nd validity check

Figure 3.2 Fieldwork flow

Secondary Data Collection

The secondary data (listed in Table 3.2) were mainly the product of organizations. Therefore, these were collected through related sources by obtaining access to archives and documents through informants in each organization. These secondary data were collected to analyze the dimensions of IWRM, LRM, the relations between IWRM and LRM, and also CEK and the relations between CEK and the management of the VRB. These data were collected (Hox and Boeije, 2005) from:

(1) Organizations' data archives: MoM, monitoring data, maps, reports, and so on

(2) Internet-based search: regulations, policy documents, and so on.

Table 3.2 Secondary data

No.	Types of Data	Name of Documents	Owner
1	Related regulations documents	Law (UU), government regulation (PP), ministerial regulation (Permen), minister's decree (Kepmen), local regulation (Perda) on water resources management, spatial planning, volcano management, disaster management, heritage conservations	Government of Indonesia Related Ministries
2	Planning documents	Strategic plans (Renstra, RPJMN, RPJMD) Spatial Plan RTRW DIY 2010-2030 Volcano Hazard Map: KRB Merapi 2010 Water: Pola and RPSDA WS POS 2015-2035 Catchment: RPDAST Opak Disaster: RPB DIY	Related Ministries, Bappeda DIY Bappeda DIY BPBD BBWS SO BPDAS SOP BPBD DIY

3	Minutes of Meetings	MoM for water councils' plenaries TKPSDA WS POS Forum DAS Opak DSDAP	BBWS SO BPDAS SOP PU-P ESDM

These data encompassed all the concepts used in this research regarding policy settings. All these policy documents are used in the analysis of all the sub-questions. The respondents referred to some documents during interviews, but some were found as a result of the snowballing method from these referred documents. These documents were cross-referenced with the results of interview analysis to answer each sub-question.

3.6.3 Sample Size and Selection

To determine sample size and selection, certain actions were required to comprehend the type of methods needed to obtain primary data. Therefore, a set of characteristics was developed to find the selected samples using non-probability, purposive sampling (Kothari, 2004, Ladner, 2014). This means that samples are derived from a list of related stakeholders. Secondary data were acquired before the actual fieldwork occurred. This was important to understand the context of problems and multi-stakeholder settings.

Interviews and observations were conducted to acquire the primary data. As is common in the ethnographic approach, the process stopped when saturation of data occurred. Using this method, the sample size is not so large but represents the heterogeneity in the groups/organizations (Angrosino, 2007). Researching a diverse group requires more observation than researching a homogeneous group does. Therefore, size is a function of the sampling technique used and the selection criteria. The strategy for the current research required at least two types of participants from each group and organization: extreme participants and typical participants (Ladner, 2014). These participants were observed in their natural setting. Depending on the observations, rounds of interviews were conducted. The number of interviews for this research was around 10 per sub-case (community) and 15 for the government organizations, as dictated by a combination of time and resources (Kvale, 2008).

Samples were selected from those with in-depth knowledge (at least 5 years tenure, preferably more) and active practice of CEK, IWRM, lahar management, and volcano management based on their expertise. To do so, at the beginning of the fieldwork, it was necessary to find informants related to the specific groups. It is also part of a validity test to randomly sample group members. Purposive sampling was conducted for officials and key persons in groups and organizations to gain in-depth understanding of this research. This understanding was achieved through deriving insights into their attitudes, values, and contexts. The number of samples collected in total in this research was 57 respondents across the two fieldwork sessions. The representation of the samples is summarized in Table 3.3. All primary data were recorded; interviews and focus group discussions were either audio- or video-recorded, observations on daily activities were recorded in photographs or videos and field notes. Additional observations in 2017–2018 were made of special rituals and recorded in videos and photographs. The interviews posed open-ended questions focusing on historical experiences, cultural institutionalization, and transfer mechanisms. For the secondary data, reports, regulations, news articles, and related documents collected from the case study and respondents were studied. These data were also compared with the interview findings.

Table 3.3 Representation of the samples

Unit of analysis	Samples representation	Number of samples	
		2016	2018
Groups: local communities	Sub-case 1	8	-
	Sub-case 2	9	-
	Sub-case 3	8	-
Organizations: government, community based, experts	National	6	3
	Regional	7	4
	Municipal	8	-
	CBO	1	2
Total		47	10

3.6.4 **Validity and Reliability**

For the purposes of this research, a validity check was conducted to ascertain the relevance of the evidence provided by the informants in terms of content, criteria, and construct (Verschuren, Doorewaard, et al., 2010, Kothari, 2004, Flick, 2008). In this research, the content validity check was used to test whether the research included adequate measurements. When samples are representative of the methods used (qualitative), then the validity is substantial. Criterion-related validity was ascertained in this research by checking whether measurements proposed later usefulness in a predictable manner. This was achieved by performing the same measurements for all the units of analysis until the predictability of measurements was obtained. Construct validity is reflected in the degree to which research builds a sound theory derived from the study's propositions as predicted. Furthermore, the triangulation of data collection methods conducted in this research also increases its degree of validity.

Reliability, which derives from the consistency of sound measurement of research, was checked by testing the stability aspect of measurement, consistent results from the same instrument, and the equivalence aspect: the errors of different samples (Kothari, 2004). The reliability condition is enhanced by standardizing the condition and a carefully designed direction. Again, triangulation may also increase the reliability of research.

Conducting the methods in the correct order and also providing a step-by-step method for both primary and secondary data collection enabled the internal validity checks to be performed. These data were compared continuously until predicted patterns were found. Reliability was checked by producing saturation in data and consistency, with the help of Atlas.ti coding. Presenting the ongoing results to the second fieldwork respondents for verification also checked the validity and reliability of the findings. These respondents were representative of the organizations or communities in the first fieldwork, but not necessarily the same persons as in the earlier fieldwork.

3.6.5 **Data Analysis Methods**

The data were analyzed using Atlas.Ti software, through the content of interviews, focus groups, and other secondary data. These data were coded according to the theme of the analytical framework, which emerged from the data. Axial coding processes were also conducted in order to rearrange the variables and indicators that emerged from the conceptual framework. The summaries of analyses are described in tables or diagrams to visualize the results. The results of the analyses were cross-referenced with the triangulation method to check the relationships between data and between concepts in answering the sub-research questions and the main research question. The analysis methods used for this research depended on the nature of the data (see Table 3.4).

Table 3.4 Type of data analysis method

No.	Types of Data	Data Analysis Method
1	Policy and planning documents	Content analysis: policy review (Atlas.ti)
2	Maps of river basin territory, hazard map, spatial plan, Sabo dam system	Spatial data analysis (my maps google)
4	Interview, observation, focus group	Content analysis: using coding in Atlas.ti of verbatim transcripts, videos, photos, and field notes
5	MoM of water councils meeting	Content analysis: using coding in Atlas.ti
6	Triangulation	Atlas.ti and data compiling in chapters

All the empirical chapters, Chapters 4 to 8, used primary data (57 interviews, three focus groups, and a two-month observation period with photographs and videos) and secondary data (around 160 documents ranging from regulations, MoM, to press releases, and so forth). Additionally, for Chapter 4, the data included earlier works by other researchers. The literature reviewed in that chapter included some prominent Javanese historical texts, such as Babad Tanah Jawi and Babad Kraton by different authors (Olthof, 2008, Ras, Pantja Sunjata, et al., 1992), as the original part of the Kraton heirloom scripture, two Serrats (poetry used in song about the Javanese life philosophy), both translated versions with original writing in Indonesian: Serrat Wedhatama (Satyopranowo, 2000) and Serrat Wulangreh (Harsono, 2005). Other articles and books about Javanese culture, especially on Yogyakartan culture were also included (Tanojo, 1962, Geertz, 1976, Magnis-Suseno, 1988, Koentjaraningrat, 1985, Endraswara, 2013, Arif, 2010, Mulder, 2005, Purwadi, 2010, van Naersen and De Iongh, 1977, Dradjat, 2009, Carey, 1986) to support the primary data. Meanwhile, content analysis was performed on four planning documents (RPSDA, Pola, RTRW, RPDAST), seven laws (water resources management, irrigation, spatial planning, disaster management, local government, groundwater conservation, environment conservation and management), more than 80 related regulations, and MoMs (2010–2017) of the water councils (TKPSDA, DSDAP, Forum DAS, and Komir). The respondents referred to these secondary data or the reference lists within these documents that related to the water policy setting.

3.7 Operationalization: Variables and Indicators

The synthesis of concepts defined in the conceptual framework was converted into variables and indicators to make it practical to work with the data, as described in the last part of Chapter 2. The preliminary operationalization of the concepts, variables, indicators, measurements, list of observations, and guiding questions is found in Appendix 1, which was used to start the analysis. However, as the axial coding processes were refined, the indicators in the CEK framework were re-clustered and shifted, and the analysis frameworks for IWRM, LRM, and volcanic river basin management (VRBM) were amended.

Thus, the operationalization of variables and indicators for the analytical framework for CEK underwent changes from the preliminary version. This operationalization was most useful for answering sub-question 1 on CEK. However, the indicators were re-clustered as a result of axial coding based on the findings used to understand the CEK formulation process. This is presented in section 3.7.1. This process was needed because the preliminary operationalization based on the literature, when applied to the research context, proved to be insufficiently precise.

As explained above, to answer the other sub-questions, the preliminary operationalization was used only as a starting point to identify the actors and their roles within the dimensions of IWRM and LRM. For analytical purposes, further analytical frameworks and operationalizations were developed based on axial coding processes grounded on the findings. For further analytical frameworks, the research used the multilevel governance (MLG) concept of water resources management (Moss and Newig, 2010, Termeer, Dewulf, et al., 2010, Gupta and Pahl-Wostl, 2013, Edelenbos, Bressers, et al., 2013) to explain the phenomenon on the ground. These are used to present the empirical chapters (5 on IWRM and 6 on LRM) and analytical chapters (7 on VRBM and 8 on CEK in VRBM). These analytical frameworks resulting from the axial coding are explained in sections 3.7.2 and 3.7.3.

3.7.1 Analytical Framework for Independent Variable (Cultural Ecological Knowledge)

The original conceptual framework was used to code and cluster the empirical findings. This was directly applied as the CEK analytical framework. The indicators of the variables were used as axial coding: the historical experience, the transfer mechanisms, and the five senses wisdom, to answer the first sub-question: What are the main elements of cultural ecological knowledge in a volcanic river basin and how is it formulated? The operationalization of the concept into variables and indicators is explained in Table 3.5.

Table 3.5 Analytical framework for CEK in a VRB

Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Historical experiences	Managing nature's dynamics	Experiences in managing the volcanic river basin	Activities and actors in managing the VRB	What kind of nature dynamics happened? What kind of natural resources management was performed and how? Who are the actors? What significance do these experiences have for the VRB?
	Response	Experiences in responding to temporal experiences	Activities and actors responding to patterns of	What kinds of temporal experiences are responded to? How, who, and what are recorded?

Variables	Indicators	Measurements	Things to be observed	Guiding Questions
			nature in the VRB	What significance does these temporal experiences have for the VRB?
	Conservation	Experiences in conserving the volcanic river basin	Activities and actors in conservation of the VRB	What kind of conservation activities exists? How are these activities implemented and by whom? What significance do these conservation activities have to the management of the VRB?
Mechanism of transfer/forms	Internalization	Existence of:		
		1. Myth	Stories and orally transmitted histories	What kinds of myths and rituals exist in the locations? Are there indigenous actors involved and who are they? What do the myths and rituals mean for the VRB?
		2. Rituals	Activities related to performing offerings, festivities, performances.	
	Artifacts	Existence of:		
		1. Sacred or conserved locations	Location and significance of these sacred locations	Where are these locations and landmarks and what do they consist of? Who is guarding them and how? What do these locations and landmarks mean for the VRB?
		2. Landmarks	Location and significance of these landmarks	
	Resources management practices	Existence of:		
		1. Related to water	Activities and actors in managing water resources using local/indigeno us knowledge	What are these practices on water? On lahar? On the volcano and volcanic river basin? Who is using them and how? What do these practices mean for the management of the VRB?
		2. Related to lahar	Activities and actors in managing lahar	
		3. Related to the volcano and the VRB	Activities and actors managing volcano and the VRB	
		4. Premonition	Activities and actors performing premonition for the VRB	What are these premonitions on? Who is performing them and how? What do these premonitions mean for

Variables	Indicators	Measurements	Things to be observed	Guiding Questions
			condition	the VRB?
		5. Seasonal calendar	Activities and actors using seasonal calendar	What are these practices on the seasonal calendar? Who is using them and how? What does this seasonal calendar mean for the VRB?
	Worldview	Existence of:		
		1. Cosmology	Activities and actors on theory of the universe	What are cosmology, philosophy, and values about? Who is using them and how? What does the cosmology mean for the VRB?
		2. Philosophies	Jargon or motto in perceiving the world	
		3. Values	Taboos or regulations	
	The five senses wisdom	Existence of:		
		1. Sight	Visual indicators	What kind of visual, hearing, touching, tasting, smelling indicators are used and for what? Who is using them and how? What indicators mean for the management of the VRB?
		2. Hearing	Sound indicators	
		3. Touch	Feel indicators	
		4. Taste	Flavor indicators	
		5. Smell	Scent indicators	
Cultural Institutionalization	Structure	Existence of institutionalized structure	Activities and actors in managing the culture and its society	What kind of cultural structure and dynamics exist? Who is in them and what is their focus of activities? What do these structure and dynamics mean for the management of the VRB?
	Dynamics	Existence of dynamics in the cultural structure	Activities in managing the culture and its society	
Formulation Processes	Legitimization	Process for legitimacy	Activities and actors who gives importance to knowledge	What kind of legitimacy and symbolizing activities exists and how are they performed? Who is performing them? What does the process mean for the management of the VRB?
	Symbolization	Process in symbolizing	Activities and actors who gives meaning to knowledge	

Source: Adapted from Kirkhart (2000) and March (1957)

The result of the axial coding of the interviews with the analytical framework was clustered into the relations of the indicators. This was used to explain not just what CEK is, but also how it is being generated. This is presented in Chapter 4.

3.7.2 **Analytical Framework for Dependent Variable (Volcanic River Basin)**

In accordance with the conceptual framework, the IWRM dimensions were used as preliminary indicators that were later developed in the axial coding process. However, the preliminary conceptual framework did not help in constructing the structure of the thesis in a clear way and in presenting the answers for the sub-questions 2, 3, and 4, especially as the IWRM and the LRM dimensions are interrelated in an entangled manner, which is studied using Goldstone (1996), as explained in section 2.4.3. Therefore, an analytical framework was developed based on answering the sub-questions, using the MLG concept (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Termeer, Dewulf, et al., 2010, Edelenbos, Bressers, et al., 2013, Hooghe and Marks, 2003).

This concept is understood as the different hierarchical systems involved in the policy for, and the management of, water resources, the management levels (national, regional, and municipal), and the interactions between actors. The policy settings are based on the regulations and policy briefs, which are determined at national level; the derivatives in planning documents in the lower levels are explained as part of management strategies. The managerial settings explained actors' hierarchical structures; this functions as a set-up for determining which actors belong to which level and also the scope of management. Within these actors, interactions take place, either at the same level and inter-level. The same analytical framework was applied to cluster the condition of water (Chapter 5), lahar (Chapter 6), and volcanic river basin (Chapter 7) into levels of policy settings and managerial contexts (national, regional, municipal). As implied in Chapter 2, the research investigates also the interaction attempts and integration level of the governance settings by mapping out in a diagram how actors in each multilevel condition interact with one another, using Figure 2.4 in Chapter 2 to guide the location of actors within MLG.

The diagram is based on the interview and secondary data analysis results. The actual diagrams will show the name of the actors and the level to which they belong. This is dealt with in Chapter 5 on IWRM, Chapter 6 on LRM, and Chapter 7 on VRB. For more information refer to Table 3.6.

Table 3.6 Operationalization of multilevel governance analytical framework for IWRM and LRM

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Policy settings used for IWRM, LRM, and VRB chapters	Regulations	Regulations at national level	Existence of regulations in the management of water, lahar, volcano (names and what is managed)	The main regulations to be used (law) and their derivatives, and how they are implemented	What kinds of regulations are implemented for the management of water, lahar, and volcano? What are the other interrelated regulations? Who is the implementer?

Multilevel governance (hierarchical) used for IWRM, LRM, and VRB chapters	National	Actors at ministerial level or agencies at national level	Existence of activities of management for actors at each level in management of water, lahar, volcano (names, volumes, etc.)	Main actors for each of the levels, how they manage their domains within each level	Who are the actors at each level and how do they manage their domains (water, lahar, volcano)?
	Regional	Actors or agencies at regional level			
	Municipal	Actors or agencies at municipal level			

Depending on the conditions existing in the interaction attempts, it is determined whether the interactions are attributable to level 1: coordination, level 2: collaboration, or level 3: cooperation. Determination of the levels is based mostly on interview analysis of whether the interaction attempts have been successful in delivering integration.

Additionally, in Chapter 7, as it addresses a more detailed VRBM integration level, the level of integration is proposed with scores ranging from 0 as no integration to 3 as the highest or complete cooperation. The scores are based on the performance of interaction attempts in bridging integration, by means of 0.3 and 0.6 increments between the main scores of 0 to 3. This method eliminates the middle point, as the idea of this scoring is also to provide trends toward the levels. Table 3.7 summarizes the detailed scoring system.

Table 3.7 Integration level scoring

Score	Meaning
0	No interaction mechanism exists
0.3	Interaction mechanism exists
0.6	Interaction mechanism is utilized for limited information sharing
1	Coordination (existing interactions are used for full information sharing)
1.3	Coordination includes shared information and aims are communicated
1.6	Coordination includes shared information and aims are aligned
2	Collaboration (full information and aims shared)
2.3	Collaboration includes information and aims sharing, with budget communication
2.6	Collaboration includes information and aims sharing, with budget alignment
3	Full cooperation (full information, aims, and budget shared)

The scoring system in Table 3.7 is based on the concepts explained in Chapter 2, but it is presented in more detail to show the in-between condition from one level of integration to the next. This is helpful in Chapter 8 to present sensitively the impacts of CEK in a culmination process toward the management of a VRB.

However, the earlier framework as explained in the appendix does not provide the answer to the intermezzo sub-question: How and why does lahar management relate to integrated water resources management? The types of relations are investigated between LRM and IWRM, presented in the order of the above structure to seek concurrence and alignment between the two managements. However, as for LRM it includes volcano and lahar management, this interrelation with water management created a scope in which VRBM emerged. The following patterns or interrelations were used to determine the dominant interrelations on the governance side of water-lahar-volcano management. The trade-offs and synergies that happen within the policy settings, managerial contexts, and interaction attempts are what constitute the level of integration between lahar and water management. Therefore, based on the conceptual framework, the analytical framework presented in Table 3.8 was adopted. The results are presented in Chapter 7.

Table 3.8 Operationalization of interrelations between IWRM and LRM

Variables	Indicators	Measurements	Things to be observed	Guiding Questions	Interrelations
(1) Isolated	Different things are not related to one another	Completely alone	Condition of secluded sectorial management	What part of water-lahar-volcano management is isolated, why and how? Who is doing this?	Which patterns are more prevalent between IWRM and LRM, seen from the interaction attempts?
(2) Coherent	Consistent in forming the same aim	Supporting results	Condition of inter-sectorial support	What part of water-lahar-volcano management is coherent, why and how? Who is doing this?	
(3) Juxtaposed	The fact of two things being seen or placed close together with contrasting effect	Contradictory results	Condition of inter-sectorial contradiction	What part of water-lahar-volcano management is contradictory, why and how? Who is doing this?	
(4) Parallel	Two things being side by side always touching, never converging	Boxed management	Condition of not knowing what others are doing	What part of water-lahar-volcano management is parallel, why and how? Who is doing this?	
(5) Overlapping	Extending over to cover partly	Trade-offs and synergies	Condition of inter-sectorial merging or managing the same things	Main insight: What part of water-lahar-volcano management is overlapping, why and how? Who is doing this?	

Source: Adapted from Goldstone (1996)

The interrelations of water and lahar are also investigated at organization and individual level. These are operationalized with additional concepts as referred to in Chapter 7, using the boundary organizations and boundary spanners concepts. The operationalization of these concepts is shown in the appendix related to Chapter 7.

3.7.3 **Analytical Framework for the Relations of the Independent Variable to the Dependent Variables**

To find the relationship between CEK and the IWRM/LRM approach, the concept of influence was used. This influence was the second layer of knowledge acquired from this research. Therefore, even though the structure of Table 3.9 is the same as that of Table

3.5, it is bound to an interrelation between the concepts and regarded as reaching the culmination of the research stage. By addressing this – the interrelations of CEK in lahar and water – the fifth sub-question is answered. The operationalization of this concept was based on the literature and limited to three variables only as presented in Table 3.9. This operationalization is used in Chapter 8.

Table 3.9 Operationalization of interrelation patterns of CEK to VRB

Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Neutral (0)	CEK non-existent	Non-existence of CEK	What type of influence exists between CEK in the IWRM dimensions?	What kinds of water/lahar management are impacted by CEK?
Positive (+)	Existence in supportive influence	Existence of CEK to support water/lahar management	When supportive, what are the proofs? Why is it supportive?	
Negative (-)	CEK exists but is not being used	Existence of CEK in water/lahar management, but not used	What types of CEK exist but are not being used?	

Source: Adapted from Kirkhart (2000) and March (1957)

The possible interrelations are described as neutral (0), positive (+), and negative (-) according to the findings that relate CEK to water and lahar management in a VRB. The analysis will also show the main interrelations that are happening in this research context. If the trend is (0), then current management practices have no relation with CEK. If the trend is (+), then CEK does make a contribution to current management practices. However, if it is (-), then current management practices have indeed neglected CEK, although it still exists in daily practice.

With these analytical frameworks, the operationalization of all the variables is explained. This operationalization was used as the structure of the thesis, which presents the relationships of indicators and answers the research questions. Implementation of the operationalization results in each of the sub-questions being answered, and these answers, in an accumulating way, answer the main research question. For additional information that resulted in 'by-products' of this thesis, appendices were prepared to explain the process of coding and further operationalization.

CHAPTER 4

IDENTIFYING MAIN ELEMENTS OF THE CULTURAL ECOLOGICAL KNOWLEDGE

4. Identifying Main Elements of The Cultural Ecological Knowledge

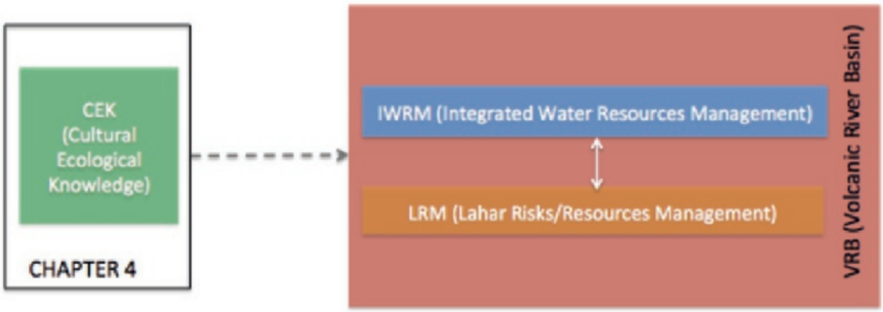


Figure 4.1 Addressed CEK Concept within the Research Framework

4.0 Introduction

This chapter addresses the sub-question "What are the main elements of water-related cultural ecological knowledge (CEK), and how is it formulated in a volcanic river basin?" The CEK is the independent variable in this research framework (see figure 4.1), which relates to water and lahar management in the volcanic river basin context. The findings implied that the main elements of CEK are identified and their interrelations convey the formulation patterns. These stemmed from historical experiences of human-nature relationships, which needed legitimatization processes before being formed into mechanisms of transfer for future generations. These mechanisms of transfer are developed into five forms of CEK: (1) philosophy and values as the core and more practical forms: (2) internalization (rituals and myth), (3) resources management practices, (4) artifacts and (5) five senses wisdom. These forms are ever symbolizing, which means a form can be about the same thing but symbolized as different things at once. However, the CEK-related quotes are interlinked with the findings on the IWRM and LRM chapters.

Therefore, this chapter is divided into two parts: the main elements and formulations process of CEK. The first part concerns the findings for the main elements of CEK in the sub-cases and regional level of the Opak Sub-basin. Within the village level, in each of the sub-case, these CEK elements are elaborated. The elaboration will include their locations, observations, interviews, and focus group discussions of the communities. Within the regional level, the cultural ecological knowledge forms presented are based on the findings for Javanese culture in the Yogyakarta Special Region. These are based on the triangulation of data. At the end of this chapter, a comparison between CEK at a regional level and village level are drawn. The second part explains about the CEK formulation. It connects the cultural institutionalization with the processes of legitimization and symbolization. These understandings of CEK's main elements and its formulation can contribute to improving the integrated resources management in this volcanic basin.

4.1 Main Elements of Cultural Ecological Knowledge

In chapter 2, a working definition of CEK was defined as knowledge used and transferred inter-generation based on the cultural context of the location. As a result of the literature review, three main indicators were summarized. These are the historical experiences, the mechanisms of knowledge transfer, and the human nature relationship-based wisdom. The three elements of CEK found in this empirical chapter are categorized based on the conceptual framework, although the categorization differed once the axial coding analysis was performed. Also, interrelations of elements are discussed, and finally drawn upon are; the essential concepts, and how the CEK works in the context of current society.

4.2 Historical experiences

The historical experiences are summarized as responding to environmental conditions, protection or conservation of resources, temporal experiences, and managing dynamics of a complex system. The experiences investigated are related to the volcanic river basin characteristics of the location under study. The rivers named in this section are tributaries of Opak River, which takes different names from up-, mid-, and downstream. These experiences were drawn from the village level and confirmed at the regional level.

4.2.1 Historical Experiences at Village Level

The sub-case 1 still experienced pyroclastic flows, lava and even big stones of fire in their village by 2010 eruption. In addition, there was continuous lahar flow in the Gendol River every rainy season from 2010 to 2017. The respondents explaining the instances of the pyroclastic flows, flames, and lahar were living survivors of the fateful night in 2010. They report that earlier, the villagers were never afraid of the volcano, but, the 2010 eruption taught them extreme experience due to the malign impacts, as explained:

> Therefore, because there were no stories of people who were viewed by old elders, they still understood the Mt. Merapi eruption starting from 2004, 2006. Previously, lava was just incandescent, but it had a maximum lapping distance of 500-1000 meters, at that time. Here is a spectacle in the rice fields. Mt. Merapi has issued the truth. Melting (lava) is great to watch. Including 2010, in the beginning, they also watched. (Subardjo, Argomulyo Village, 2016)

They responded by understanding Mt. Merapi's 'eruption clock' and keep track of this in their memories. Nevertheless, the 2010 experience changed their views towards the volcano and laid deep emotional memories as many villagers died, scorched in their beds. Those who survived evidently will pass down this experience to their future generations. On the lahar experience, the villagers were aware of earlier experiences of managing lahar flood in their rivers, although the lahar channel changed from one tributary to the other. Based on their experiences, the volcano and the rivers are considered as 'sacred' geography, which is explained the next section on sub-case 1 mechanism of transfer. The cycle of lahar corresponds with the rainy seasons. Some villagers still used the traditional seasonal calendar to determine the changing of the season for cropping patterns and water allocation, aside from the flooding and lahar season.

Meanwhile, in sub-case 2, the severity of damage was happening most dramatically in 2010-2011. In the time, the lahar over-flooded the Code River dikes and entered the Riverside community, submerging the kampong to 1-2 m deep of its' original elevation. The villagers are aware of annual flooding in the Code River, as explained:

> Annual (flooding) always present, this (dike) is to prevent (water), earlier it is built to overcome flooding, right? If every year there is (flood), it's just not big, if it's big there might be (every) 4 years. (Mrs. Murni, RW 10, Kampung Jogoyudan, Gowongan)
>
> However, for lahar with this much volume, another respondent stated that the condition was terrible. This condition made them think alternatively, then to dredge the sediment out of their riverside Kampung, raising the ground to +60 of its original elevation. Aside from that, the residents have learned that raining in the upstream will cause a flood when the water level reaches a specific number, and it took 45-60 minutes for the flood to flow.
>
> Already, we already know the timing is 45 minutes-1 hour from the top to the city. So we already know when there is half an hour, so the valuables are raised, and we immediately evacuate. (Atok, RW 11, Kampung Jogoyudan, Gowongan, 2016)

These temporal experiences on regular flood and lahar have enriched their knowledge on responding and adapting to nature's dynamics.

In sub-case 3, the Opak River has been giving the village enough water to cultivate rice. Thus, the villagers respond to the river as a life force of nature and somewhat 'sacred.' Their explanation proves this claim on 'sacrificed victims' or *tumbal* after any disrespectful behavior is given to the river.

> Thereby the tree is (a stone mortar) for horse's drinking water. It was taken (from the Opak River) with a tool, but cannot be removed, and death belongs to God, but strangely after the person ordered to remove it (the stone mortar) he died.(Dalbiyo, Tourism Village Secretariat, Kebonagung, 2016)

These examples show that the villagers respect the Opak River and believe that there are certain supernatural powers to protect it. Thus, making them conserve the river condition is important for them, both as acknowledging the water and respecting the cultural taboo for not disturbing the river. However, the eruption did not impact too far for them. The severity of damage did not interfere with daily life, except for the lahar sedimentation in the Opak River, which silted the riverbed and made the river smaller. This fact interfered the villagers' income in tourism as the river can no longer be used for the Dragon Boat Festival. They also learned that the paddy fields get flooded each rainy season, especially in 2010-2015. In determining the rainy season, the temporal experience of the farmers indicates the use of the traditional seasonal calendar for their cropping pattern and flood season.

4.2.2 Historical Experience at Regional Level

On the regional level, all research participants agreed on the historical experience on natural dynamics as the volcano eruption, the annual flood of the rivers (Opak and Progo), including lahar flood, which flows to the South Java Sea. The residents of the region respond to these natural dynamics by making these locations sacred. For them, some believed that Mt. Merapi and the Sea are sacred geographies based on the myths. Thus, they are considered as artifacts, which are explained later in the regional CEK's mechanism of transfer. The temporal experiences endured by the residents of the region consist of the eruption cycle and the seasonal patterns partly based on the seasonal calendar.

4.3 Mechanisms of Transfer of CEK

After understanding actual historical experiences, they are translated into forms of the mechanism of transfer. These forms are internalization, worldview, artifacts, and cultural values. Meanwhile, the five senses wisdom of human-nature relationships is substantive (context- geographic specifics) and methodological (relying on the human senses). The starting point of any CEK in this basin is the logic of rational thinking in observing nature (ilmu titen) to see patterns of nature's dynamics, as explained below:

> It is called in the past as ilmu titen (phenology). In the old days, our ancestors observed (nature). Oh, on this date this happened. Then they develop a standard, like so. (Martadi, Kebonagung, FGD)

The mechanism of transfer is presented in each sub-case, and for the whole region, using the similar clustering of (1) internalization (myth and ritual), (2) artifacts, (3) resources management practice, (4) worldview, philosophies, and values, (5) five senses wisdom. The worldview or philosophies relate strongly to values, which is clustered into the same form and found as the inner layer of the CEK. Meanwhile, the five senses wisdom, which initially being put as a refinement of the mechanism of transfer, is found to be more fitting as a form. Another finding is initially, in the conceptual framework, the institutionalized dynamics and structure were included under the forms of the transfer mechanism. However, this belongs more to the formulation process than as main elements. Therefore, these are explained in the next sub-section on CEK formulation.

4.3.1 Mechanisms of Transfer of CEK at the Village Level

For the village level, the respondents came from each of the sub-cases' communities. The findings of the sub-cases show similar patterns of legitimization and symbolization. However, the naming and components of each village are different and show varieties of local knowledge. The sub-cases shared everyday historical experiences. These experiences included; the natural dynamics of the volcano eruptions, the flooding experiences, the lahar, but the severity diminished as the distance to the volcano increased.

Sub-case 1 Argomulyo Village

This village is located in the upstream area of Opak; the location is approximately 15 km away of the Mt. Merapi Summit. The village has seven hamlets, namely Gadingan, Bakalan, Suruh, Banaran, Jetis, Bronggang, Cangkringan. Out of this, five hamlets which are Gadingan, Bakalan, Suruh, Jetis, Bronggang. Their village is home to 8,076 residents, and the total area includes 847 hectares with all irrigated lands, either technical, simple or semi-technical irrigation schemes (based on Monography data 2015). There were at least 100 victims in the 2010 Mt. Merapi eruption found burned on the spot, due to pyroclastic flow. They blamed the Sabo Dam as the cause, as the dams stop the flow on several locations. Besides, it made blasts to the sides, where some houses were located too near less than 100m from the infrastructure.

> If Sabo were built taller, when the blast occurred, it will go out, so like this (description with hand gestures from bottom to top). So if it were not strong to

hold back, it exploded. For example, here (pointing the Sabo by the side of his house). It (the Sabo) is strong, so it (the pyroclastic flow) blasted to the sides. To the West, there were 48 deaths, including 36 here, which are my children, wife, and parents. (Kasur, Gadingan).

The map below shows the four Sabo Dams with their sub-dams in the village at Gendol River, also CEK-related locations and positions of each interview that were taken (figure 4.2). The river is a typical lahar channel type; no water passes through it during the dry season. Even during the rainy season, only braided type streams run through it.

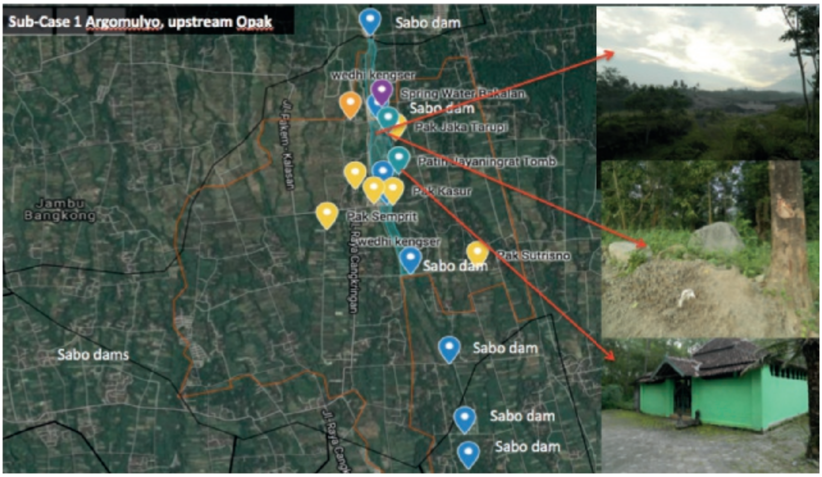


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Figure 4.2 Spatial distributions of Sabo Dams and CEK related sites in Argomulyo (Fieldwork, 2016)

In sub-case 1, the historical experiences relate to the volcano eruption, pyroclastic flow, lahar, and flood. The most compelling finding is how they describe their lives to Mt. Merapi as values and philosophies. These are "living in harmony with the volcano," and the hamemayu hayuning bawono, which explains the same meaning. They also perceived the Mt. Merapi as a reminder of God, to whom all this life belongs to, which resembles the philosophy of sangkan paraning dumadhi presented more detailed in the regional level.

> I told my kid, I took him to Mt. Merapi. Son, you need not be arrogant to others. See there; the Mt. Merapi is so big; people are so small, and look they are busy with their sickles, like ants. Human living on earth is nothing, does not compared to those who own Life (God). (Kasur, Gadingan Hamlet, Argomulyo, 2016)

The internalization

The internalization of CEK is presented utilizing the Myth that confirms the existence of Mt. Merapi as a place of spirit or translated into force of nature. The Gendol River is used as their paths to the human world. This path is the 'force' channel in the form of lava, lahar, or pyroclastic flow. The Myth of Jayaningrat is celebrated in the ritual called Tambak Kali in Gendol festivity; this is an example of how a myth is symbolized into the practice of rituals. It was supposed to remind people to live in harmony with the Gendol River. Besides from the offering and cultural performance, it also included cleaning the river from the trash. Since the eruption, the festivity stopped, as some believed it lured the lahar and pyroclastic flow to their village.

> It was meant as prayers, but when the (2010) disaster (pyroclastic flow) occurred, the lahar, we were the main the casualties. Tambak Kali was celebrated two times before. But, yes it was in 2010 Mt. Merapi eruption, it's November 2010. After the Tambak Kali, villagers have prejudices; the reason the eruption occurred was the festivity. (Sudirman, Ex-chief Village Argomulyo)

Aside from that, the bride stone located nearby the Jayaningrat Tomb has a myth of safe zones from lahar in the Gadingan Hamlet.

The artifacts

The artifacts are related to the Myth of Patih Jayaningrat Tomb (figure 4.2-3) by the Gendol Riverside, Gadingan Hamlet. It explained the lahar risks of living nearby the location due to 'a curse,' which relates to the Myth of the Patih. The curse as told was:

> You (Jayaningrat) are so vain, I (Suto Menggolo) already lost, but you still torture me. Just see in the future, your house (tomb) will be flooded with lahar from Merapi. (Sutrisno, Argomulyo, 2016)

It means that the Tomb location is the signpost for lahar flow. Anything beyond that point from the riverside is safe.

Additionally, there is also a myth about the bride stones (figure 4.2-2). Located nearby it, are arranged as two stones at the front with a third stone at the back mimicking the formation of a traditional wedding. In this depiction, the bride and groom are delivered to the altar by a parent or grandparent. This stone formation is believed to draw safe zones.

The resources management practices

The practices revealed are the sand mining activities, the seasonal calendar, the utilization of floodplain, and the utilization of Gendol River base flow. The ancestors predicted this sand mining activity, by stating:

> But, be not so surprised, for today's society, understanding has been shifted because there is a plus point (economic benefit), instant and promising. In the old days, elders said, "There will be a day when you will be able to auction the Gendol." In ancient times, Gendol was still intact; sand from the Mt. Merapi was as high as the embankment. Today, it has become a reality; everyone is selling the Gendol River. (Subardjo, Argomulyo Village official)

Aside from that, the use of *Pranata Mangsa* (seasonal calendar) has diminished, and more people trust the BMKG (climate office) data. This calendar divides the year into 12 different seasons or *mangsa* within the four main seasons: rainy (*rendheng*), rainy to dry, dry (*ketiga*), and dry to rainy. In each season, the biological or physical indicators are used to determine the season. Nevertheless, the primary season of *ketiga* (dry season) and *rendheng* (rainy season) are still used in comparison with the modern approach. Another practice is the utilization of *wedi kengser* or floodplain as a result of lahar sedimentation. This location is used for temporary farmland during the dry season and is a common practice for the villagers.

Additionally, the utilization of Gendol River's base flow, when all groundwater wells and springs are hot, is described below:

> Then this Jaka Tarupi, the (Gadingan) hamlet chief, he does not want to disappoint those who gave him orders. He dug a well in the middle of the Gendol River for drinking water because the water there rather had that rusty-look. So they thought of taking the water from there, extract it to the hamlet, yes it works, great even, the law of gravity of the earth, is flowed to lower (ground), nice water, overflow, which is used to drink, enough, now people can make fishponds. (Sutrisno, Ex-Chief Village Argomulyo).

Also, about the lahar, the *wangsit* practice is passed down from earlier generations. The practice describes how the previous Sultan IX visited the village and knew when lahar flood is coming by standing and meditating in the middle of Gendol River. It relates to the taboo of panicking during lahar flow.

The worldview

The worldview in this village consists of the cosmology of Mt. Merapi being the spirits' place and the Gendol River being the passage embodied into the conservation of sacred locations. Consequently, the philosophy of *hamemayu hayuning bawono* (beautifying the world's beauty) is translated as living side by side with the volcano and evacuated when it is near eruption promptly. The values are concerning the *hamemayu* philosophy and the relations to living with Mt. Merapi, such as the taboo for panicking during lahar flow. The villagers believed that people should calmly watch the lahar by the side, by sitting, as commanded by the late Sultan. Other values relating to the philosophy is on the villagers' relations using *gotong-royong* or collective action during daily lives and especially during a disaster, and empathy or *tepa selira*.

The five senses wisdoms

This sub-case also produces more five senses wisdom than the rest as they had the extreme experience of 2010 eruption. It means that they have grown more sensitive in using their five senses as indicators, especially about hazards of the volcano and its impacts. For example, the sound of "*gleng-gleng*" for lahar coming, but the sound of "*kemrosak*" (mimicking the sound of water hitting the stones and pebbles) when regular water flood flows. Another wisdom is on the change of temperature and taste of groundwater quality after the eruption. It is not suitable for drinking but good for skin disease treatment.

Additionally, the visual indicator of *uceng,* a type of small fish is used to determine good water quality. Also, the visual of birds flying as to the indicator where the lahar flows are explained:

> There are signs before Mt. Merapi erupts (kurdho), always signs. The Javanese Eagle. The eagle will fly around here. Giving signs to be aware, aware of, Sister, be ready. When the eruption occurred, according to Mr. Surono (a leading geologist). He told us so, "when it flew over to the South, the lahar will flow through Gendol, when to the Northeast then it's another river to the East, it means to Boyolali, there, to the West, meaning Krasak River and the rests. (Sutrisno, Ex-Chief Village of Argomulyo, 2016)

As summary figure 4.3 shows the CEK Formulation Pattern in Sub-Case 1 Argomulyo:

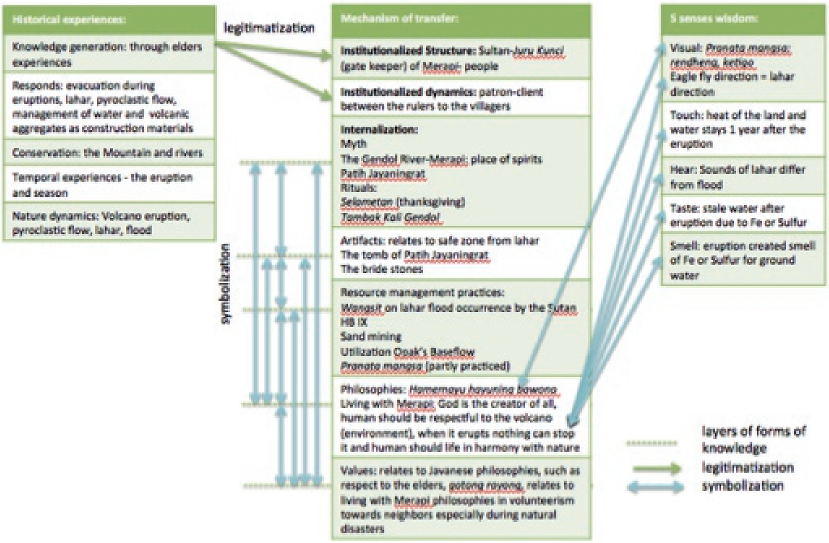

Figure 4.3 CEK patterns in Argomlyo

Sub-case 2 Gowongan Sub-District (city area)

The Gowongan Sub-district is located in midstream area of Opak, with the location being approximately 30 km away from Mt. Merapi, directly in the heart of Yogyakarta city. Although the site is comprised of 13 RWs, the focus of this sub-case study is on Kampong Jogoyudan resided half of the area. Here, it has direct impacts from the Mt. Merapi lahar and access to Code River (pronounced Choday) with 7 RWs, namely RW 7-13. This sub-district is the home of 8,248 residents. Out of which, 1,174 registered as poor people, residing in a total area of 49 hectares with most land use as being residential or business (based on Monography data 2016). Half of this number, at least around 4,000 residents, are living in the Kampong Jogoyudan (the exact number is always changing due to the unregistered number of seasonal residents). There were no direct victims, yet all the houses in RW-8 and RW-10 were at least one meter submerged with the lahar. Also, those lining by the riverbanks along the kampong. The indigenous kampong residents claimed that those people in the *wedi kengser* (floodplain) had it coming.

> In the past the trees are abundant, floods occurred in the past never had victims. Now, there are always casualties, because in the past, no one dared to build at the riverbank. (Andi, RW 7, 2016)

It is not a safe place to live, yet people who reside there mostly live at least 40 years based on the respondent's interview of 11 people. The location is also directly at the philosophical and imaginary axis of the Yogyakarta Kingdom. Thus people's understanding of this cultural artifact is an essential aspect of knowledge. The following figure 4.4 shows the map of Gowongan Sub-District with Kampung Jogoyudan. By the riverside, it is the most impacted from lahars, where green areas are the Sultan Ground (*wedi kengser*) that has developed into residential.

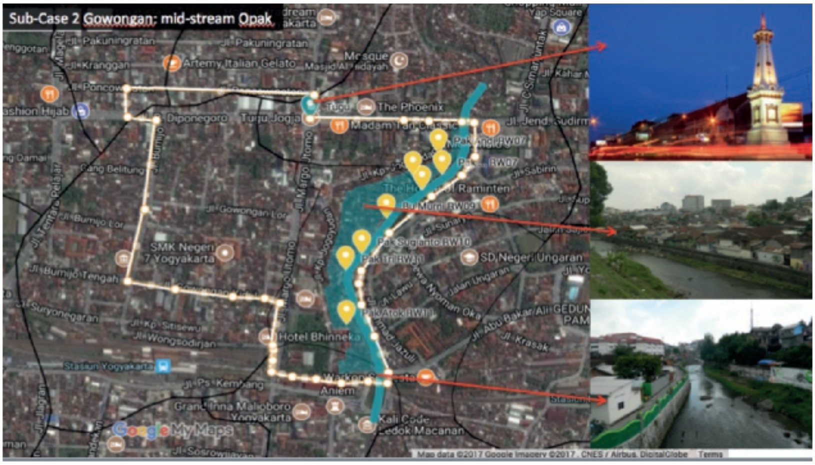

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Figure 4.4 CEK related sites in Gowongan (Fieldwork, 2016)

In sub-case 2, the tributary of the Opak River is called Code (pronounced Cho-Day). The historical experiences on extreme conditions were mostly annual flood and lahar, but no volcano eruption. The most robust water-related CEK use is found in the riverside settlement of Kampong Jogoyudan. The elements of CEK found are as follows:

The internalization

The forms of internalization are myth and rituals. They are still in line with the sub-case 1, with relation to a regional-wide myths. These are the Mt. Merapi (as the ancestor), and South Java Sea Queen (as ruler of spirit Kingdom). These myths explain the relationship of up- and downstream forces of nature for this VRB. The respondents explain how this is celebrated as thanksgiving rituals of *labuhan* and *merti Kali Code.* Like the myth, the *labuhan* is a regional-wide CEK; it relates the myths of Mt. Merapi and the South Java Sea in the form of annual thanksgiving. This ceremony is used to appease the ‘spirits’ living there (the natural forces), which relive the myths related to both. Meanwhile, the *merti* is also explained as a thanksgiving to the River Code.

The artifacts

These are explained by the existing of imaginary philosophical axis relating the Mt. Merapi, Tugu (a landmark in figure 4.4-1), Kraton (palace complex), Panggung Krapyak (monument), and the South Java Sea or the MTKKS axis and the *wedi kengser* or floodplain. This axis is relevant to the current spatial plan. It is used as a disaster mitigation strategy to observe the two natural forces: the volcano and the sea, which still believed by the people to hold spiritual relevance. The *wedi kengser*, (the word *wedi* meaning land), and *kengser* (meaning dragged), are pertinent terms, thus. Therefore, the combination means soil flowing from upstream. The *wedi kengser* or floodplain located in this sub-case is mostly the problem of urban riversides, where illegal settlers occupied the locations (figure 4.4-2). All the FGD respondents agreed on the fact that the *wedi kengser* is, in fact, the Sultan Ground.

This claims confirmed the earlier finding in the region's level of Sultan Ground.

> People got their land from their grandparents, at the *wedi kengser.* Based on the history, the *wedi kengser* belonged to the government; the Sultan Ground is what it is called. Those who managed it owned the *cangkok,* the adjacent land with a certificate nearest of the to the floodplain. (Andi, RW 07, Gowongan, 2016)

The *wedi kengser* are 'owned' or utilized by the nearest adjacent landowner, but nowadays by new incomers. Thus, the consequences of being evicted whenever the Sultan asks are part of their future reality. The location of the floodplain by the riverbanks (figure 4.4-3) is at the lowest elevation of the kampong.

The resources management practices

The sub-case 2 does not have too many CEK referred to, the practices on water and lahar related management are the water wells dredging, the sand mining and floodplain. The wells dredging are employed to those located by the riverside, to make the water fill the wells again. The residents use the sand mining of lahar materials for the landfill of the riverside's kampong elevation and construction materials of the houses. The *wedi kengser* located behind the dikes are utilized as a residential area and not in-line with the CEK. However, those situated in the river channel are used as temporary non-irrigated farmland during the dry season, such as corn, cassava, and vegetable. The total area of the land might differ as it is based on the natural sedimentation processes.

The worldview

It is related to the philosophies of beautifying the world's beauty. It reminisces the balance of the human-nature relationship in the past, where clean water flowed in the river, and the bamboo plants were abundant by the riverside. The bamboo riverside helped with pertaining the riverbanks' stability and provided biodiversity by the floodplain. The worldview relates to the values of *gotong-royong* or collective action and *tepa selira* or empathy, but the use is only apparent during disaster times or some festivities. The purpose of these values is also evident in the community participation for river communities, through the Pemerti Code (community-based organization – CBO) on river restoration programs and tourism.

The five senses wisdom

It relates to the myths mentioned above: the sound of *lampor* as lahar early warning, the visual of dark clouds as lahar warning, and the visual of the type of fish for water quality (*biotilik*). The sound of *lampor* or spirits marching down the river, making sounds like horse troupes, as an early warning system for lahar or flood, can be sensed by those who are spiritually gifted. These individuals are referred to as 'wise person' or Kraton people. The visual of dark clouds in the Mt. Merapi area acts as a potential lahar warning, with the timing of evacuation in 45 minutes, just after the rain started up-stream. The *biotilik* uses the visual of types of fishes to determine the type of water quality; for this sub-case, the catfish is an indicator of bad water quality.

As a summary, figure 4.5 shows the CEK Formulation Pattern Sub-Case Study 2 in Gowongan:

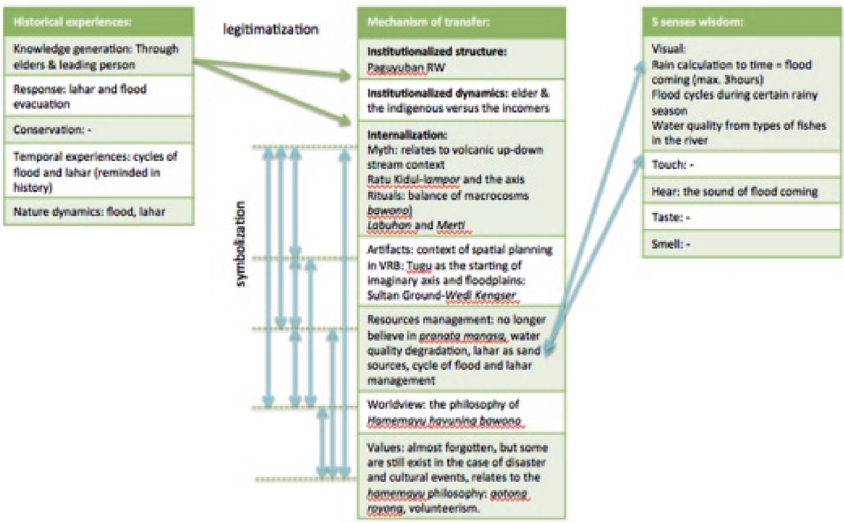

Figure 4.5 CEK patterns in Gowongan

Sub-case 3 Kebonagung Village

Kebonagung Village is located in the downstream area of Opak just before the fork of Oyo River joins in (coming from Karst Area in Gunung Sewu). The location is chosen as it still bears the same characteristics of a volcanic river basin. The location is approximately 45 km from the Mt. Merapi Summit. The village has five hamlets, namely Tlogo, Jayan, Kalangan, Kanten, and Wolosono. The village is home to 3,545 residents, and the total area includes 1,678.36 hectares with all irrigated lands, either technical, simple or semi-technical irrigation schemes (based on Monography Data 2016). The location is famed for its tourism village title, as it was the place for Dragon Boat Festival during Chinese New Year before the Mt. Merapi eruption. After the eruption, the village proposed a different approach to the tourism strategy of agricultural education. The branding was already there before the eruption with the initiation of Museum Tani Jawa in Canden hamlet (from 2007). However, the focus on the agricultural activity was not highlighted as the Dragon Boat Festival got more significant financial support from the provincial government. However, due to the siltation of the riverbed post-eruption from the accumulation of lahar materials, the water sport can no longer take place. There were also tourism docks that were no longer functioning, as it was situated 100-200 meters away from the water of Opak River.

> Once, the weir was full of water, there was no land around the embankment. In the past, the depth of (water) was 7 meters. But since lahar, for four years now, no boat can float (too shallow). The pier was built on the east side. But yes, it was, full of mud now, so (it is) useless. (Dalbiyo, Tourism Village Secretariat)

The sub-case 3 presented historical experiences on the river conditions. However, the sub-case showed not so much on lahar. The flood in 2010 was the only occurrence that the respondents remembered caused by significant lahar sedimentation flowing downstream in the main Opak River. The results have also drastically silted the riverbed and filled the river channel with deposition. After dredging activities performed by the RBO or BBWS SO in 2011, the river channel was filled again with sediment in 2016.

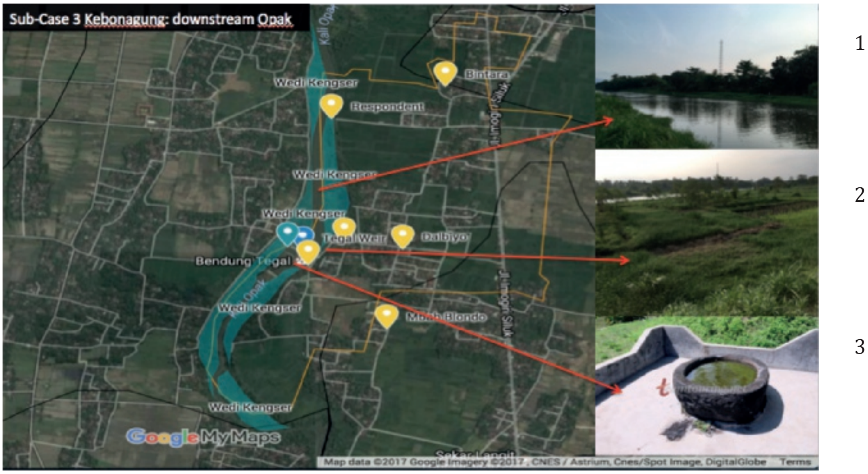

Figure 4.6 CEK related sites in Kebonagung (Fieldwork, 2016)

On the forms of CEK, the following information was concluded:

The internalization

The myth of *lumpang* (stone mortar) found in the Opak River during the Tegal Weir construction in the 1990s. It was believed to have supernatural power, as the project manager and the 'wise' person who removed the stone to make way for the construction both died. The villagers understood these incidents as *tumbal* or human sacrifices, also relating to the values for taboo in disturbing the river. The thanksgiving rituals of *wiwitan* (farming activities), *nini thowong* (spiritual doll performance), and *panen raya* (main harvest) are maintained in the agricultural activities as this also suggested economic benefit for agricultural tourism. These activities are done at certain times based on the seasonal calendar or *Pranata Mangsa.* It also indicates how much water is used for each of the seasons.

The artifacts

These are found in the forms of the *lumpang* (stone mortar, figure 4.6-3) and the *wedi kengser* (floodplain, figure 4.6-2). The *lumpang* related to the human sacrifices mentioned above. Now, the stone mortar is placed in a special location by the river to commemorate its importance in the river located in the Mataram Kingdom history. Although, historians have not concluded for sure what the function of the stone and how it relates to the Kingdom's history. It is used as a taboo reminder not to disturb the river. The *wedi kengser* (floodplain of the Sultan Ground) has expanded, as the lahar materials added the riverside distance to the river up to 100 meters.

The resources management practices

The farmers' group performs the practices. These are the parts of the seasonal calendar or *Pranata Mangsa,* fallow land management, traditional sand mining activities, and the utilization of *wedi kengser.* The seasonal calendar is used with new modern approaches from climate data. Only three seasons out of 12: *rendheng, ketiga*, *kasanga* are still acknowledged along with their five senses wisdom. The fallow land activity is related to the *Pranata Mangsa* during the dry season. The farmers let the land to 'rest' for the coming planting season, which believed to give time for the land to recondition to its balance. The traditional sand mining is seen using the bamboo raft and shifter to collect the sand from underwater. The villagers are against machinery sand mining, as it is believed to be against the taboo to disturb the river's natural balance.

The utilization of *wedi kengser* as temporary agricultural lands have been increasing. This floodplain is cultivated with non-irrigated plants, such as cassava, corn, and weeds for the cattle food. Since the 2010 eruption, for the siltation and sedimentation processes, some people are using the *wedi kengser* for grass cultivation. The villagers also recognize the term *wedi kengser.* They understand the consequence of using land is temporary.

> In our term, it is called *wedi kengser,* so if we manage it, it is not appropriate, because it is the river. (Bachroni, Disaster volunteer of the village, FGD)
>
> Plenty, the most grass is growing in my plot. I sell those grasses. But, if it (the sediment) is dredged, I am also happy. Because it means more people (tourists) coming, the tourism village can be revived, even the rowing competition. The grass is only for me. (Prapto, nearest resident to Tegal Weir, FGD)

This floodplain utilization is defined by customary law belonged to the Sultan Ground. The villagers understand their rights of use, but realize that this land belongs to their Sultan. If the sedimentation is removed, the villagers give their consent for the benefit of all people.

The worldview

The farmers present their worldview as the *nrimo* philosophy, or the philosophy of acceptance, which explains their attitude towards the natural process of lahar sedimentation. It is considered as partially blessing in disguise, the eruption brought fertility. It explained in the resources management practice of the lahar sediment as temporary farmland and volcanic ash as fertilizer.

The values

The taboos for disrupting the river also relates to *hamemayu* philosophy. These were found during the construction of the Tegal Weir, resulted in human sacrifices or *tumbal*. This *tumbal* takes place whenever there is an obstruction to the balance of the environment or the *bawono gede*. Respondents support this explanation. On many occasions, when there are disrespectful activities towards the river. For example, electrifying or poisoning the fishes in the river or joking while swimming, and there were always human victims later.

> When the fishing using poison, the fishes floated (died). But, afterward, there will be (human) victims; most were not married (Bintoro, Kebonagung, 2016).

This taboo is helpful in conservation activities for the river conditions in comparison to the other two sub-cases. Other values such as the *gotong-royong* or collective action and the *musyarawarah* or discussion are used. The value of *gotong-royong* is still used daily but diminished in frequency compared to the condition in the past. This value is specially used within agricultural activities. Most farmers are rice farmers, where farming activities are diligently provided for time-to-time tending the paddy fields. The *musyarawah* to solve problems are based on cultural terms and usually solved in consensus.

The five senses wisdom

The communities explained about many indicators concerning farming activities and nature's condition. First, they explained about the different use of layers in soil by the visual or the color and touch. This pure geological knowledge of fertility and what type of soil can be used for handicrafts or farming for different kinds of plants and vegetables. An example is this following quote on visual of worms for fertile soil:

> Generally the farmers (know), as long as the soil has many worms, it is fertile. (Blundu, Organic farmer association, 2016)

Secondly, they explain about the visual of Mt. Merapi eruption as a sign of the coming of fertility, especially when the ash is blown to this village direction. Third, is on the use for the *Pranata Mangsa* indicators related to the five senses wisdom. The 3rd *mangsa:* the dry season, with the visuals of the breaking of Kapok fruit, paddy panicles. The 6th *mangsa:* the sound of *sonthe* insect, a suitable time for planting, when not raining, for the start of the rainy season. The 8th *mangsa:* better for farming, visual of the beginning of the rainy season. The 9th *mangsa:* the sound of animals' (cats') mating season for the start of the dry season. Based on this explanation, the seasonal calendar is partly used.

As summary figure 4.7 shows the CEK Formulation Pattern in Sub-Case 3 Kebonagung:

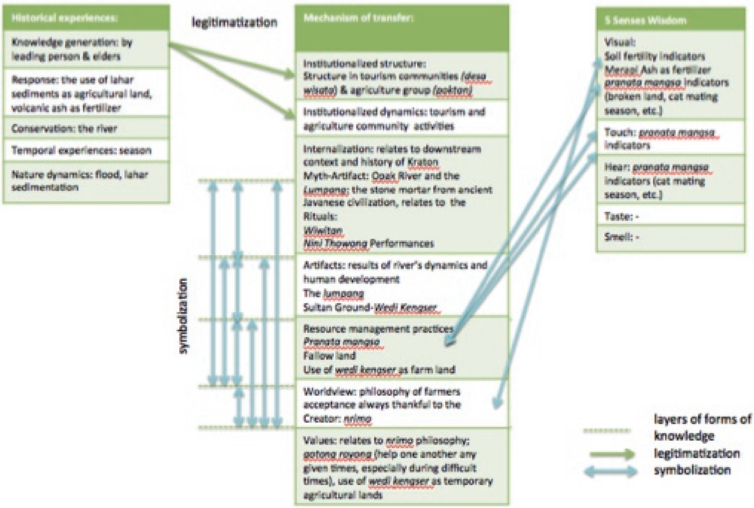

Figure 4.7 CEK patterns in Kebonagung

4.3.2 Mechanisms of Transfer of CEK at the Regional Level

The regional level includes not just the Opak Sub-Basin, but also the Main Opak Basin, half part of the Progo Basin (south) and the Serang Basin. The case study is located within the Opak Sub-Basin originating at Mt. Merapi, so it means the regional level consists of a broader scale. The whole region consists of 3,186 km2 (BPS, 2010), with

476 km2 located in the Opak Sub-Basin (my maps Google). The Sub-Basin also coincides with the municipals agglomeration of Yogyakarta- Sleman - Bantul (Kartomantul). The types of CEK's mechanisms of transfer are found as follows.

The internalization

It is explained by the myths of Ratu Kidul (mystical Queen of the South Java Sea) and Mt. Merapi as the place for ancestors. The myths were used as the ways to promote the understanding of a volcanic river basin, which has two dynamic natural forces of the volcano and the sea to be conserved and observed. The myths are symbolized into annual thanksgiving rituals (*labuhan*) offered to the volcano and the South Java Sea on each Javanese New Year. This ritual is seen as the Sultanate pact to honor nature, thereby proposing conservation management to the whole catchment from the origin to the estuary of the river basin.

> Likewise, with Mt. Merapi, we have *Merti* (Thanksgiving) for the hamlet. Start questioning, why has the forest has begun to clear up? We forget (to conserve). Benefit of a *merti* is thanking God. The form is like this (ritual), expressing their thanks. But more importantly, is to escort the water resources to become sustainable and stays clean. (Bayudono, an expert on water resources, 2016)

During a *merti* people give offerings, sit, and chant. They start observing in detail, what has changed or broken in the surrounding environment, be it the river or forest. As many people are gathered at the same time, they decide an activity to address the problem. So, the ritual also has a function of social interaction attempts.

However, this event in 2016 mostly was in the form of cultural performances ranging from Javanese, the Kraton's troops, and dancers, marching bands, even Chinese Dragon parades. It showcases the different cultures existing in Yogyakarta City and does not provide a clear relation to the Code River. The aim is to highlight and honor the name of the river in the region's level awareness. The people of Yogyakarta remember the name Merti Kali (river thanksgiving), but the goal to protect the river's environment is somewhat missing in the whole festivities, except for the river cleaning-up.

Another form of the ritual, the *labuhan* has a similar procession but especially done on the Islamic New Year's Eve. It is performed in two locations, Mt. Merapi and the Parangkusumo Beach near the Opak estuary (figure 4.8). The offerings presented with admiration to both forces of nature, with the promise of keeping the balance of environment (*bawono gedhe*). While practicing the rituals, people observe the condition of the environment. This thanksgiving functions to balance the macrocosms. More about this practice is explained in the case studies level. It also functions as a symbol of *hamemayu hayuning bawono* philosophy, which relates the myth of macrocosm. The previous gatekeeper of Mt. Merapi was Maridjan, who is appointed to his death during the 2010 eruption.

In 2006, there was a previous eruption, but it was not significant, and Maridjan was resistant in evacuating. In 2010, he did the same, but this time, the eruption was far more significant in scale (Donovan, 2010). He was one reason upon many that many victims did not evacuate on time. The next gatekeeper is his son (https://www.theguardian.com/world/2012/nov/15/merapi-volcano-spirit-guardiantradition), and so far there has been annual *labuhan* at Mt. Merapi summit area in Glagahardjo village the way his ancestors did it. The gatekeeper is the bridge between the human realms to the afterlife world.

Figure 4.8 Labuhan at Pos Sri Manganti-Mt. Merapi (left) and Cepuri-Parangkusumo Beach (right) (Documentation, 2017)

The artifacts

These are related to the volcanic river basin context and water management. For example, the philosophical axis connecting the volcano to the sea is completed with landmarks to symbolize the myths explained above. The ancient irrigation area of Mataram Kingdom is still used today as proof of the remnants of know-how from centuries ago (see figure 4.10 below). They may not have used the same term in the past in Javanese. However, the Mataram Kingdom owned ancient irrigation systems, which were recorded in many tax charters (Christie, 2007). Java Island's ecological condition with the characteristics of high rain intensity relating to the direct discharges of the river has posed difficulties in the development of these ancient irrigation systems. This condition is because most of the weirs in those times were built using logs or bamboo mesh with stone fillings. Nonetheless, the Javanese language has developed terms for technology in relation to water engineering such as *dawuhan* (dam), *segaran* (reservoir), *gangsiran* (underground channel), *weluran* (irrigation channel), *wuatan, tambak* (pond)*, tamwaka* (embankment)*, tameng, suwak, talang* (gutters)*, arung* (discharge/runoff) in the 5th century (Arif, 2010).

Besides, there are Javanese terms to describe the types of irrigated lands such as; *sawah* (wet rice fields)*, gaga* (dry or hilly rice fields), and *tegal* (dry fields for other crops) (Christie, 2007). The inhabitants of Yogyakarta still use these terms as the Javanese language has survived and used in daily activity for most members of the society. For the case of the Opak sub-basin, it is recorded in "Babad in Sangkala" in the year 1637. In this time, the King ordered a dam to be built in the Opak River. Also, in 1667 in Winanga River a reservoir *(segaran)* called Segarayasa was constructed in three stages; 1652 (according to "Babad Momana"), 1659, 1663 using the water from Opak River in Plered, Bantul (Arif, 2010). Even so, no exact location can be said about these dams. The site for the reservoir in Plered is recorded through the name of the village as the *segaran*.

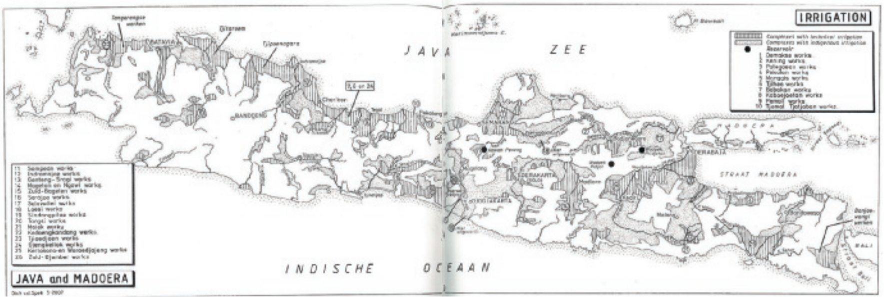

Figure 4.9 Map of 1940s irrigation area, Yogyakarta area shows that the irrigation systems were mostly indigenously built (Ertsen and Ravestijn, 2008).

The ancient indigenous irrigation areas are labeled with dotted hatch near Djogjakarta (figure 4.9). These were further developed into *Daerah Irigasi* (DI) as explained in the chapter on IWRM, as the current DI Mataram. The irrigation channels of ancient days were using land embankments; the traces of these old channels are developed nowadays with modern masonry construction since the Dutch Colonial Era. Although as seen in the figure above, the southern part of Yogyakarta was not developed even until the 1940s. This irrigation area heritage is preserved, but to know which area was initially Javanese-built is difficult as there was no documentation of the irrigation scheme. Most data was focused on the taxation system for irrigated fields in the ancient times suggest locations, but no specific references about the irrigation scheme (Christie, 2007).

Related to the irrigation is the artifact of the Mataram Channel. The Mataram channel was built in the 1940s is considered new from Westerners' point of view. However, it is proof of inter-basin transfer knowledge from Progo to Opak River with 31.2 km in length. It was believed the Sultan Hamengku Buwono IX at the time of the construction did this to avoid his people being sent away by the Japanese to other locations in Indonesia. The purpose of the channel is inter-basin transfer (at moment the term may not exist) between Progo to Opak to guarantee water supply from Progo. Progo has a more steady discharge to Opak, which at the dry season in some parts faced droughts. The following figure 4.10 indicates the location of the Mataram Channel in Sleman Regency (dark blue line crossing from West to East).

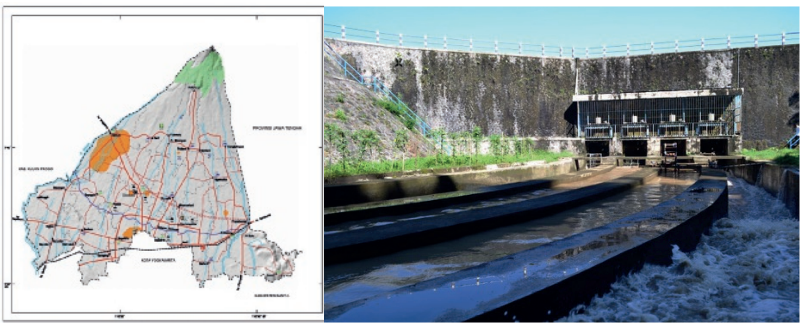
Figure 4.10 Left: map of Mataram Channel Scheme in Sleman Regency (KemenPU, 2012) and Right: current condition of Karang Talun Weir inlet of Mataram Channel (Public Relations of BBWS SO, 2016)

The channel connected many streams in these two river basins (figure 4.10 left) in the Sleman Regency. It is used to distribute the water using gravitational force to downstream areas of Bantul, Yogyakarta City and Kulonprogo. This inter-basin infrastructure connects the water transfer from Progo to Opak in the sub-case 2 (midstream) and sub-case 3 (downstream). The knowledge in building this channel was based on the Sultan's Hamengku Buwono IX prophecy and is preserved as a cultural heritage on water.

> The Mataram Channel is very modern in the era HB IX. It is not (explained) in the Chronicle of Java. The Mataram Channel was made by the Sultan IX as a form of the Dutch asking a lot of workforces, which at the time will take the people of Jogja away. Many people of Jogja do not go elsewhere. It was continued in the era of Romusha (Japanese forced labor). It was such a phenomenal project. It existed until now. I think the central and regional government must make every effort for this Channel to become a heritage legacy. (Prince Wiro, humanist, 2016)

Although, the land use in Sleman and Yogyakarta City center has changed from agricultural to residential. The function of the channel in urban areas has changed into the drainage. In rural areas, however, the water is still used for agricultural purposes.

The people of Yogyakarta also have great attention to the spatial arrangement of the region, which is based on the philosophical and imaginary axes, and it is preserved as cultural heritage. This effort is exclaimed in the Local Regulation no.1/2015 on Yogyakarta's Special Status and visualized in the Local Regulation no. 6/2012 on Conservation of Cultural Heritage. The existence of an imaginary axis is not debatable as in reality; this axis is in the form of streets; therefore, no buildings can interrupt the axis. This axis consists of Tugu-North Square-Palace-South Square-Krapyak Stage. The Kraton complex as the city center was built on a non-flooded hill (*geger bulus*) and is an ancient geomorphological knowledge of a river basin since the first Sultan (Olthof, 2008). With all these artifacts, the whole Opak Sub-basin is a philosophical plane. In this sense, Mt. Merapi can spread its lahar through rivers originated there, to the terminal at the South Java Sea. This understanding of the concept of a river basin existed in ancient times. Meanwhile, the philosophical axis expanded the imaginary axis to Mt. Merapi-Tugu-North Square-Palace-South Square-Krapyak Stage-South Java Sea. This axis is a bit difficult to maintain as it covers 55 km of length.

As portrayed in the following figure (figure 4.11), the philosophical axis is not easily transformed into reality. No road reaches to either the summit or the beach. There are infrastructures built along the rivers that correspond to the axis. The rivers are meandering, making it debatable whether one can still see the implementation of this axis in original forms.

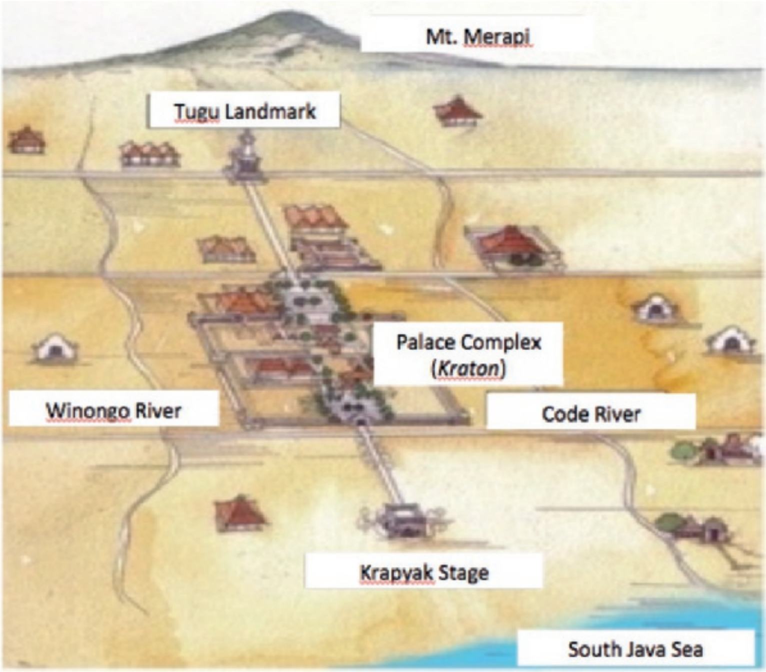

Figure 4.11 Imaginary and Philosophical Axis depicting up-downstream relations of the river basins and the spatial planning arrangement of Yogyakarta (Local Regulation no.6/2012 on Conservation of Cultural Heritage, 2012)

In recent work, the relations of the Mt. Merapi-Kraton-South Sea Axis (MKSS) with the geo-volcanological condition were found. The axis is rationalized as the way the ancient Javanese explained the situation of Yogyakarta as it stands between two natural forces. These forces are Mt. Merapi volcano and the South Java Sea trench as a source of many earthquakes(Troll, Deegan, et al., 2015). This study also explained the myth of Mt. Merapi and the Queen of South Java in oral tradition. It is used to describe the simplified interaction of volcanic activity and earthquake. This interaction is a form of action-reaction occurrences, where Yogyakarta is placed in the middle and can be affected by these two forces. This axis relates to the worldview of Yogyakarta, as the three layers of *Bawono's* or the worlds.

The claims about the location of Yogyakarta were based on *geger bulus wangsit.* Mt. Merapi can be seen straight from all directions South of it and the relations of the geological plates between Mt. Merapi and the South Sea. Therefore, this research proposes that the axis, together with the river basin concept, can be seen as a philosophical plain of Yogyakarta. The concept of a philosophical plane proposed it is only an axis. It suggests the entity has a width and it includes all the virtues of the river basins of Progo and sub-basin of Opak in Yogyakarta, which originate in Merapi into one plain. However, the landmark markings in the philosophical line (i.e., Tugu, Kraton and Krapyak Stage), makes it easier to see the sense of directions of the two natural forces in the region.

The volcano-earthquake is reciprocating activities between the two forces (the volcano and the sea), as the geological plates are adjacent to one another (Troll, Deegan, et al., 2015). This condition also explains that the axis marks the approximate location of this forces and it expresses that this axis not just a two-dimensional virtue, but even more of a three-dimensional entity. It can be said that the ancient Javanese understood their geological locations and used the axis as a way of hazard precaution. The philosophical axis also relates the relationships to the river basins concept, which highlights the fact that the founder of the Kingdom was aware of the threats of Mt. Merapi hazards as well as up-mid-downstream relations. Although not all respondents agreed on the subject, one stated that this is just made to fit the concept. However, since he is not Javanese, this is what may have caused the difference in the statement.

> The philosophy of building, the Kraton (palace) has its history. Those items are the Sea, Kraton, Tugu, Mt. Merapi. The line (connecting them) was relatively straight. In the past, we did not understand what is the importance of this line? Once we have this disaster (2010 eruption), then we understood the meaning. (Sigid, Head of Implementation Division, BBWS SO, 2016)

This condition also explains that the axis marks the approximate location of these natural forces (the sea and volcano). It expresses that it may not just a two-dimensional virtue, but also more of a three-dimensional entity. It can be said that the ancient Javanese understood their geological locations and used the axis as a way of hazard precaution. The philosophical axis also relates the relationships to the river basins concept, which highlights the fact that the founder of the Kingdom was aware about the threats of Mt. Merapi hazards as well as up-mid-downstream relations. Although not all respondents agreed on the subject, one actually stated that this is just made to fit the concept. But since the respondent is not Javanese, it caused the difference in the statement.

On account of the location for his Kingdom, the first Sultan chose the existing Yogyakarta as a result of spiritual revelation by his ancestors in Pacethokan Village, in southern central Java Island. This spiritual revelation is known as *wangsit*. This location was where spring water was found and the geomorphological condition to be the parable of the back of a turtle (*Geger Bulus*), also passed by six rivers.

> So, when the separation (*Palihan Nagari*) happened in 1755, the Mangkubumi Prince (Sultan Hamengku Buwono I) was supposed to get the land in the East (Java) area in Surabaya. His Highness did not accept it, instead chose the area in the West: Garjito Forest, to be exact at the Pacethokan Village. There was a spring there; now it is located in Taman Sari (water castle inside of Kraton complex). How did His Highness get this *wangsit*? It was because the place was segmented with six rivers, 3 in the west and 3 in the east. In the east are Opak, Gadjahwong, and Code rivers. In the west are Winongo, Bedog, Progo Rivers. With this assumption, it will never be flooded. (Bayudono, an expert in water and agriculture, 2016)

This historical fact determined the location of Yogyakarta Special Province today. Here, its river basin characteristics were already calculated in ancient ways deeming the site to be flood-proof and protected from the Mt. Merapi volcano. Since then, the Sultans have all been aware of these advantages. This location is indeed strategic based on modern river basin assessment condition. The slope of Mt. Merapi is slightly slanted several percent to the South or downstream, while the rivers are also flowing in the same direction (BBWS SO, 2011). This philosophical plane is visualized as follows:

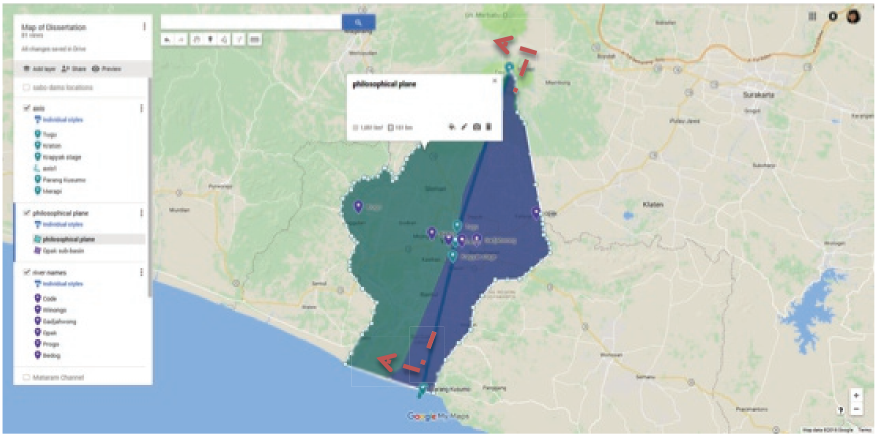

Figure 4.12 Proposed philosophical plane (green and purple) with river basin geomorphological conditions (purple) created with Google My Maps (2016)

Figure 4.13 Elevation section diagram of Mt. Merapi-Yogyakarta-Sea and the *geger bulus* location in meter (Fieldwork, 2016)

This condition is added with the mostly sandy soil characteristics, which is understood by the community. Knowing this made water penetration naturally easier into the ground and provides for rich groundwater deposit.

> The type of soil in the floodplain of rivers in Mt. Merapi is sandy, (even) my house in Kalasan although far from Kuning River, the water is clear. Until now the well never dried. (FDG Jogoyudan Gowongan, Andi, RW 7).

This claim explains the knowledge of the people about the soil characteristics, which relates the volcanic soil types and its high ability to absorb rainwater. These resulted in the excellent quality of groundwater in Yogyakarta. The map below supports this; describing the spatial area of the groundwater basin of the Yogyakarta-Sleman where Merapi is the highest location.

Another artifact is the land itself. After the Giyanti Treaty, it was stated that the Sultan Hamengku Buwono has the domain of all property in the western part of the Mataram Kingdom (KPH. Notojudo, 1975 based on (Antoro, 2015)). The Rijksblaad of the Sultanate No.16/1918 and the Rijksblaad of the Paku Alaman No.18/1918. The grounds are titled with old treaties. They defined those lands belong to the Sultanate where the land rights have not been given to a person or a village. Therefore the utilization of the land needs permission from the Kraton. In this regard, based on the Local Decree No. 1/2013, the Sultan Ground is defined as those lands belong to the Sultan and the Pakualaman. Either it is royal or non-royal land, which is located in the region. This definition is not very clear; additional information was collected based on reports of academics in the field.

> Not only in the city. But, if we dig, it is our faults. The Agrarian Office provided them with certificates. People from all over the *Betheng* (palace wall) also have ownership. It is very strange. But, Sultan's land cannot be bought. Most kept to *Mage Ssari* (given land use right by the Sultan)." (Respondent, PU-P ESDM, 2016)

At this moment, data collection of these grounds is still an ongoing process in the whole region. This process is a special task for the newly established Spatial Planning Agency (2015). Many of those lands have ownership issues with persons or business entities. The land is in use for the benefit of the people, such as; tourist attractions, businesses, schools, mosques, and offices of government agencies in Yogyakarta. Land use status of these public tenants is called *Mager Sari.* It means people can occupy but have to acknowledge that the Kraton or Pakulaman still own the land. In this regards, those grounds have special regulations based on the Sultanate's view of its land use. Most of the royal grounds located in the city center are heritage sites of the Sultanate. The rest of the lands have different functions. Some are forests for conservations, as offices areas for village/regency administrations, even schools and universities. Other types of land use in floodplains and beaches are supposed to be left empty, unless for non-permanent activities.

This spatial plan also relates to the philosophical and imaginary axis of Yogyakarta. Most of these lands (Kusumoharyono, 2006, Hasim, 2016) include forests, beaches, floodplains (*wedi kengser*), and village grounds (*tanah kas desa*). In relations to IWRM, these lands are where conservation areas are located. Hence, they are also protected by the Kingdom's status either on Sultan Ground or Pakualaman Ground. The concept of *wedi kengser* is noteworthy, as the communities in all the cases will express it. A definition for this is the land along the river, which the form, characteristics, and functions change according to the natural situation and conditions (Sihombing, 2004). During the dry season, it is as farmlands. However, during the rainy season, it drifted as part of the river body. It resulted as the *wedi kengser,* moving to other places. This definition is similar to a floodplain. Therefore, in this research, the term is used interchangeably. Overall in Indonesia, this belongs to the government, but for Yogyakarta, this belongs to the Sultan.

The worldview

There are many philosophies related to the Javanese worldview. Amongst those, there are three main ones, which are often cited from the Sultan's speech and explained by one of the respondents in 2016. These are:
(1) *Manunggal ing kawula Gusti* (unity of King with the subject), the people following the Sultan's order and the Sultan listens to the people,
(2) *Sangkan paraning dumadhi* (remember the origin and purpose of life), which is to govern the ones' life with wisdom,
(3) *Hamemayu hayuning bawono* (beautifying the worlds' beauty).

These philosophies are strongly related to the history of the Sultanate origin or the three commandments *(tri prasetya paugeran).* They are symbolized in artifacts along the philosophical axis, suggesting conservation or hazards mitigation into the spatial planning or the philosophical axis and plane of Yogyakarta. This concept of ancestor also relates to the practices of *labuhan* in Mt. Merapi. The *Tri Prasetya Paugeran* was a wise understanding of Brawijaya V as King or Maharaja of Majapahit in the 15th pronounces. In embracing his new faith from Quran, Surah Al Anbiya: 107 stating, "And We sent thee not, but for (become) a *rahmah* (mercy) to the worlds." The word *rahmah* is Arabic and translated into English as mercy. However, this is not an accurate translation since *rahmah* can also mean godsend, grace, bounty. It states human as a leader with wisdom to the worlds. As a King, under the will of God to govern the Kingdom, he was supposed to manage where he is the lord (Koentjaraningrat, 1985, Mulder, 2005).

The first philosophy relates to the people's obedience in following the Sultan's order. For example, during lahar, as the Sultan ordered to evacuate, the inhabitants of the upstream Opak followed suit for one's safety. The Sultan prepared all the need of the evacuees through the related regional and municipal agencies as they are under his authority*.* The second is explained by the reference made about Mt. Merapi as 'my ancestor,' which told as 'Here is where I was born, and here I would die." It explained the nature of *nrimo* or farmers' acceptance in sub-case 3 (Kebonagung). In retrospect, this also relates to the honoring towards the environment as explained the *hamemayu* philosophy. The most significant philosophy in light of this research is the third one. This philosophy is shortened as the *hamemayu* philosophy.

Upon those many philosophies, the first Sultan of Yogyakarta adopted one main philosophy as the vision of his Kingdom (Boechari, 1976), *"Hamemayu Hayuning Bawono."* The core of Javanese culture is embedded in the *Hamemayu* philosophy (Geertz, 1973, Endraswara, 2013). The word *Hamemayu* is taken from the word *"ayu"* or beauty, *"memayu* "means to beautify, or can also be meaning '*payu'* or to protect, and also as *"rahayu"* or peace and prosperous condition, while the induction *"Ha-"* means to intensify. Therefore the word *Hamemayu* means the obligation to work for beautifying or preserving, while *Hayu* means beauty or safety, "*ing"* is a related word as *"in," Bawono* or the world/universe. This philosophy lives amongst Javanese from the Majapahit Era and continues to sink in shared values and norms of the Javanese ways of living. The respondents often discuss the philosophies in this study, especially those who understand the culture of Yogyakarta.

The *Hamemayu* as a whole concept is very overarching which connects anything in human life, from him/her self and to God, towards others, the environment, and the world, and the afterlife. Javanese culture owes its dissemination function through oral traditions, and so is the way for the development of *Hamemayu* concept throughout the centuries is dispersed. However, when asked about whether the people of Yogyakarta still practice these philosophies, not that many can explain. This philosophy is reflected in the following quote:

> The people of Yogyakarta are practicing it. I know that. But if the question is the definition of *Hamemayu,* then they might be confused to answer. (Rani, Secretary of Region and Head of PU-P ESDM, 2016)

Further, it is observed that the philosophies live within the community, although not expressed in a straight way, but rather in their consciousness.

The Javanese worldview sees the world (Endraswara, 2013, Koentjaraningrat, 1985) through the three worlds or *bawono*: (1) the human-God (*bawono cilik*), (2) the environment (*bawono gede*), and (3) the after-life (*bawono langgeng*). The context of the research evolved in the *bawono cilik* and *bawono gede*. This worldview relates to the *hamemayu* philosophy as the guide of attitude towards other humans and the environment, to be just and honoring nature.

The first world (*bawono cilik*) is explained as the micro-cosmos, where it represents the human world in connection of human to God, in family and personal life. It is embedded in everyday life of each Javanese as an unconscious context. It means the direct spiritual communication between the Sultan with God and the ancestors. The following quote is related to this claim:

> He (the Sultan) said, it was an order from there (the spiritual world), maybe his father (the Sultan IX) is still accompanying him. (Respondent, PU-P ESDM, 2016)

This practice of *wangsit* or premonition by the Sultan or Kraton people as explained later, bear the legitimation needed as a CEK.

The next world is equal to the environment world (*bawono gedhe*): macro-cosmos, where humans live in their habitat. This world represents where the connection of humans to others, to the environment, in society, in the country. Or, in this study, it is referred to as the whole volcanic basin or the environment. This basin is also where the Sultan reigns. In this location, the urban spatial forms of the palace complex are called the *catur gatra tunggal.* It represents the four elements of the governance (1) the Kraton as government, (2) the Beringhardjo market as economic force, (3) *Alun-alun* or the square as the democratic and participation symbol and (4) the mosque as spiritual force (Dradjat, 2009).

Upon this land, flow many rivers that originated from Mt. Merapi to the South Java Sea. These rivers are the tracks that are taken by the Queen of South Java Sea, when she visited Mt. Merapi, Kraton or the Taman Sari water castle. The *bawono gedhe* also uses the imaginary axis as disaster mitigation means to observe Mt. Merapi from the city center. This axis is acknowledged as a heritage on spatial planning in Yogyakarta. The line connects north to south, Mt. Merapi (upstream), the inner city of Yogya: the Tugu (monument), the Kraton (palace), Panggung Krapyak (the stage) and the Sea.

The last world is the afterlife world (*bawono langgeng*). It represents the afterlife portrayed as Mt. Merapi and the South Sea. Mt. Merapi is a spirits' Kingdom: the mystical or spiritual world. The Bawono Langgeng concept explains this world. A person who is appointed as the gatekeeper or *juru kunci* appeases these spirits in Mt. Merapi. This person is responsible for holding the *labuhan* ritual each Javanese/Islamic New Year as a form of offering.

Regarding the Kingdom of the Queen of South Java Sea (Ratu Kidul). It is explained in Babad Tanah Jawi that the Queen made a pact with the Sultan Hamengkubuwono I to always protect his Kingdom from the danger of Mt. Merapi. This service is a way to repay his kindness in stopping the *gara-gara (*mischief) to devastate her Sea (Olthof, 2008). Three respondents with similar quotes support this claim, as explained:

> Our parents said there were a lot of spirits, something like ghosts. When the sun sets, on the road from Parangkusumo (Beach) was a golden chariot. The chariot name was *Lampor.* It travels from the Parangtritis/Parangkusumo (Beach) via the rivers to Mt. Merapi, every the night of the 1st of *Sura* (Islamic and Javanese calendar new year). The Javanese people perceive this as sacred. (FGD Gowongan, 2016)

Aside from New Year's eve, whenever the Queen passes in the rivers towards Mt. Merapi with the *lampor,* later the flood or volcanic eruption or earthquake occurred to the region (Schlehe, 2010). The river community representative also supports this claim for the 2010 lahar:

> When the flood came, it was on YouTube, the sound of the flute. (Endang, AKSY, 2017)

The *lampor* became a sort of spiritual early warning system for disasters related to the Mt. Merapi and lahar for the people living in the region.

The values

These values are related to or symbolized the philosophies. These are:

(a) Obeying the Sultan, for water management – the use of the Mataram channel for irrigation inter-basin transfer,

(b) The value of upstream conservation in Mt. Merapi,

(c) Displacement of people located in the hazard zone,

(d) Do well to the environment and humanities,

(e) Fatalism or *nrimo* attitude towards Mt. Merapi. It is explained, as staying put in the hazard zone, because the indigenous felt they are home, so being dead is nothing, as long as they are home, and

(f) *Gotong-royong* (collective action) during troubled times of lahar flow, also in daily water-related activities, such as in irrigation maintenance, water allocation or other similar events.

The resources management practices

The first form is the premonition (*wangsit*) that can be defined as a result of observation. It is explained as knowledge passed into a dream of the Sultan. The premonition can be about anything, but for this research, it is the eruption, which relates to the water and lahar management, the flood-free zone*,* lahar occurrences, the understanding of the basin as philosophical plain, among other aspects. An intriguing fact, there are former spiritual advisors of the Kraton (Ki Joko Permono to his ancestors Ki Juru Martani), who had a *wangsit* about Mt. Merapi activities. They claim to explain each 700 years cycle of eruption (Troll, Deegan, et al., 2015) mark the beginning of a new era, a better era (Schlehe, 1996).

These claims are supported with scientific proof using the calculation of SiO2 composition in the soil of Mt. Merapi (Allard, P., 2010). An excerpt from BPPTKG (volcano center) explains that there is a difficulty in reading Mt. Merapi's activity and trends due to the mountain's character are changed:

> After 2010, we are still looking for the right (pattern). (Dewi, BPPTKG, 2016)

It means that the 2010 eruption was probably out of the calculation, or maybe it was still considered as a mild eruption. If the 2010 eruption with VEI of four devastated the region for at least 1-2 years afterward, a 700 cycle's impact might have been able to affect things on a much grander scale. No wonder after each of the 700 year-eruptions, a new era in leadership emerged. Based on this calculation, the next 700 years cycle will happen around the year 2100.

The following quotes detail about the resources management practice on the types of trees being used by the ancestors to protect or conserve water.

> So our culture knows how to behave towards Mt. Merapi, about conservation, protecting the stream, including the springs. Those are the cultural knowledge that needed to be developed. And people who are in the infiltration area, they are already aware of and understand what plants are suitable there. They already know the trees: Gayam tree (also known as Tahitian Chesnut, latin: *Inocarpus tedulis*), Banyan tree, Ketapang tree (latin: *Terminalia catappa*), *Munggu*r tree (also known as Tamarind tree, latin: *Samanea saman*). (Fauzan, Head of WRM Divison, PU-P ESDM DIY, 2016).

The same trees were found in most locations of holly springs. A *Beringin* or Banyan Tree is planted, as a way to protect the site and gather the water. These examples expressed how to behave to the conservation area using the types of trees that are good for the water infiltration and conservation, among other things.

The following resources management practice is called the *Pranata Mangsa* and described as a form of phenology. It studies the cycle and seasonal natural phenomena, especially on climate, plant, and animal life. Extensive research on this topic is done on the use in Gunungkidul, Oyo Sub-Basin a neighbor of Opak Sub-Basin in Karst region (Retnowati, 2014). The Javanese use this knowledge also to time the water, climate, and environment. It is known as the *Pranata Mangsa*. The indigenous calendar is a seasonal calendar and cultivating timeframe, which relates to environmental changes. Retnowati (2014) explains *Pranata Mangsa* is an inherited seasonal calendar. It is considered as part of the cultural identity in middle Java's agriculture-based community, particularly in the area of water and land management. While Djaldjoeni (1984) further enlightens the fact of Pranata Mangsa was used for the regions of Mt. Merapi-Merbabu region. Also, it is used and by the old Javanese Kingdoms of Medang, Pajang, Islamic Mataram as a guide not only agricultural activities but also for economic, administrative and military activity.

This calendar shows the correlation of temporal aspects in wisely managing Javanese environment. It is part of the *Hamemayu* concept of using water and land according to their natural cycle. Javanese people have inherited this seasonal calendar mostly for agriculture for centuries. According to Djaldjoeni (1984), this calendar was formulized further back to the eighth century rather than the commonly known Pakoeboewono VII's formulation of *Pranata Mangsa*.

However, the calendar formulation has not changed. It designated the summer solstice in the peak rotation on 22 June 1855 (Tanojo, 1962) applicable in this volcanic region. There are 12 different timeframes on the seasonal calendar (table 4.1). In this calendar, each of the *mangsa* represents seasonal change in characters in the form of indicators from animal behavior, and plants growth stage (five senses wisdom).

The five senses wisdom

This wisdom is related to the seasonal calendar of *Pranata Mangsa* and *lampor* as early warnings of the flood. The expert and organizational respondents support this and earlier research on *Pranata Mangsa* in the Yogyakarta Special Region.

This calendar, with its five senses indicators, is explained in table 4.1 below:

Table 4.1 The *Pranata Mangsa* seasonal calendar using five senses wisdom (Tanojo, 1962, Retnowati, Anantasari, et al., 2014, Daldjoeni, 1984)

No.	*Mangsa*	*Mangsa Utama*	Date	Length (days)	Ecological indicators	Farmers activities
1	*Kasa* (Kartika)	Ketiga – Terang	22/06-01/08	41	Famers a type of grasshopper dwell into the ground and leaves falling	Burn rice straw after harvest, begin to grow diversified crops (non-rice)
2	*Karo (*Pusa)	Ketiga – Paceklik	02/08-24/08	23	Crops grow, Kapok fruit tree (*Ceiba pentandra*) and mango start to flower.	
3	*Katelu/Katiga* (Manggasri)	Ketiga – Semplah	2/08-18/09	24	Bamboo shoots grow.	Crops harvesting
4	*Kapat* (Sitra)	Labuh – Semplah	19/09 - 13/10	25	Springs recharged, Kapok tree bear fruits, small birds start nesting and lay eggs.	Crops harvest continue, working on land for Paddy Gaga
5	Kalima (Manggakala)	Labuh – Semplah	14 /10-09/11	27	Starts of heavy rain, Tamarind tree has young foliage, caterpillar exists, moth gets out its nest, *Lempuyang (Zingiber zerumbet*), and *Temu Kunci (Boesenbergia rotunda)* sprout its leaf.	Fixing the irrigation system and make side drainage on paddy fields, paddy Gaga spreading.
6	Kanem (Naya)	Labuh – Udan	10/11-22/12	43	Fruits (*Durian, Rambutan, and Mangosteen*) start to spring. Whistling ducks appear in watery places.	Spread seeds on seeding area.
7	Kapitu (Palguna)	Rendheng – Udan	23/12-03/02	43	A lot of rain and flood in rivers.	Move seeds to paddy field.
8	Kawolu (Wisaka)	Rendheng – Pangarep-arep	04/02-28/02	26/27	Cats mating season, larva appears on the surface.	Wait for the plant to grow.
9	Kasanga (Jita)	Rendheng – Pangarep-arep	01/03-25/03	25	Rice flowering; crickets began to emerge; cicadas began to sound, the rest is still possible flooding appeared, falling reed's flowers.	Attend and tend the fields.
10	Kasepuluh (Srawana)	Marèng – Pangarep-arep	26/03-18/04	24	Rice began to turn yellow, many pregnant animals, small birds start hatching eggs.	Attend and tend the fields.
11	Desta (Padrawana)	Marèng – Panèn	19/04-11/05	23	The birds feed their young, breaking the fruit of Kapok Tree.	Harvest short-lived plants.
12	Sada (Asuji)	Marèng – Terang	12/05-21/06	41	The temperature falls and feels cold (*bediding*).	Time to plant crops: soybeans, indigo, cotton. Working on fields to grow corn.

The findings on CEK in this regional level covered in the river basin level are actually in the Yogyakarta Special Region context. These were investigated through an intensive review on Javanese literature, current research, and interviews with experts and stakeholders. Based on these findings, the forms of CEK for the whole kingdom are based on their historical experiences of the existing nature dynamics of their location.

This history reflected the existence of the volcano-human realm (river basin) – sea or representing the concept of the volcanic river basin and recognizing the context of up-downstream relations.

The patterns of CEK interrelations at the regional level are visualized as follow:

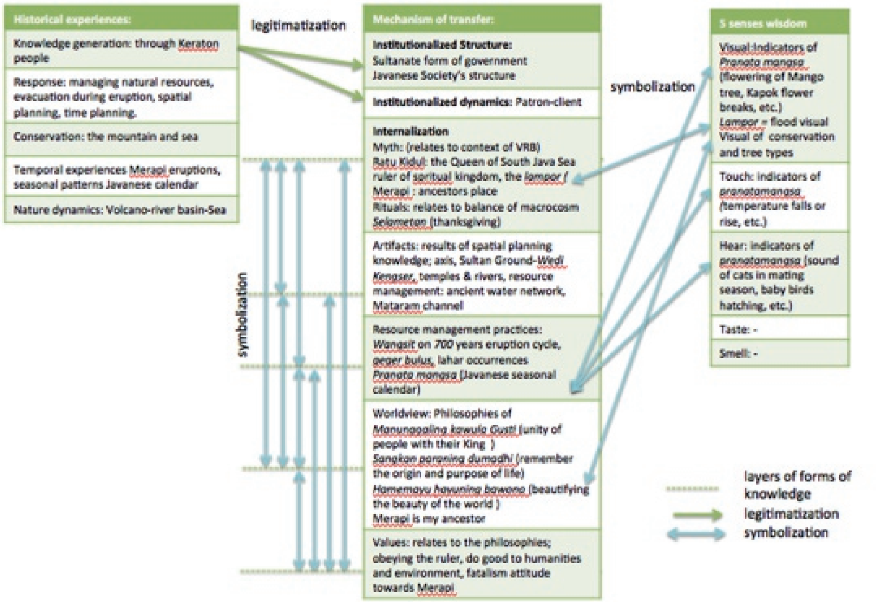

Figure 4.14 Patterns of CEK in the Yogyakarta Special Region context

4.3.3 Summary Mechanisms of Transfer

All of the forms of CEK's mechanism of transfer synthesized in the literature review are found in this volcanic river basin. Some differ across villages, while some correspond to the regional level, or are similar between villages. The following table (table 4.tab2) summarizes the main elements of CEK for the regional level and the village level.

Table 4.2 CEK's Mechanisms of Transfer

Locations	Yogyakarta Special Region	1) Argomulyo (upstream)	2) Gowongan (midstream)	3) Kebonagung (downstream)
Mechanism of transfer				
Worldview, Philosophies, and Values				
Worldview	The three layers of worlds (*bawono* concepts), the MKSS axis as the embodiment	Mt. Merapi as a spiritual place, the Gendol River as spirit passage.	The Mt. Merapi-Kraton-South Java Sea (MKSS) as axis Code River as one of the passages of South Java Sea Queen, and natural forces (flood & lahar)	The Opak River is a sacred location signified by the history of Mataram Kingdom
Philosophies	The unity of people with the King Remember your origin	Living with Mt. Merapi	Beautifying the world's beauty	Thankful always to the Creator: *nrimo*

Locations	Yogyakarta Special Region	1) Argomulyo (upstream)	2) Gowongan (midstream)	3) Kebonagung (downstream)
	Beautifying the world's beauty			
	Mt. Merapi is my ancestor			
Values (related to philosophies)	*Gotong-royong* or collective action, especially during disaster	Collective action & empathy all times, especially disasters.	Collective action during disaster	Taboo of disturbing the Opak River channel (*lumpang* or mortar stone)
		The panicking taboo during lahar		
Internalization				
Myth (related to ritual)	Mt. Merapi as spirits kingdom	Gendol River-Mt. Merapi spirit's place	Code River as *lampor* channel	Opak River
	Ratu Kidul - *lampor*	Patih Jayaningrat	Ratu Kidul-*lampor* and the axis	The *lumpang* (stone mortar)
Rituals practices (thanksgiving related to the myth)	*Labuhan* (annual thanksgiving to the Mt. Merapi and the South Java Sea)	*Selametan* (safety thanksgiving)	*Labuhan*	*Wiwitan* (farming thanksgiving)
	Selametan (safety thanksgiving)	*Tambak Kali Gendol*-thanksgiving	*Merti Kali Code*-annual thanksgiving	*Nini Thowong* performances-harvest thanksgiving
Artifacts				
Sacred locations	Philosophical Axis-Plain as a volcanic river basin	The Mt. Merapi as the location of the spirits		
	The floodplains in the river channel or the *Wedi Kengser* as Sultan Ground			
	All rivers originated at Mt. Merapi	The Gendol River as the deities channel	Code River as Opak tributary is also the location of spirits	Opak River as the location of the spirits
Landmarks	Ancient water network and Mataram channel	The tomb of Patih Jayaningrat, the bride stones (lahar-safe zones)	The *Tugu* (monument) as the starting point of the imaginary axis (spatial plan)	The *lumpang* and Tegal Weir (sacrifice & taboo)
	Temples location by the rivers	-	-	-
Resource management practices				
On the Water				
Conservation	Special tree types for water conservations	Conservation for spring locations and the Gendol River.	-	The Opak River floodplain is conserved with limited farming
Utilization	The *Pranata Mangsa* seasonal calendar-biophysical indicators.	Utilization of the Gendol River's base flow. Thermal hot water at 1st year post-eruption. Main seasons indicators of *Pranata Mangsa*	Dredging of water wells by the riverside due to submerged by lahar.	The river water is used for irrigating farmlands. Some *Pranata Mangsa* seasons identified.
On the Lahar				
Utilization	Sand mining of in rivers originated at Mt. Merapi	Modern sand mining industry for economic purposes	Sand is used for construction materials and landfill	Limited-traditional sand mining for economic purposes
		Use of lahar sediment as fertile land located in the floodplain as temporary farming		
Hazard	*Wangsit* (premonition) on *the* 2010 lahar occurrences	Animals running downstream as eruption EWS, stay at riverside during lahar	Not crossing the river during lahar	-
		On-time lahar evacuation (the used of cloud visual and *kenthongan*)		

Locations	Yogyakarta Special Region	1) Argomulyo (upstream)	2) Gowongan (midstream)	3) Kebonagung (downstream)
On the Volcano and the Volcanic River Basin				
Conservation	Conservation areas of the volcano into sacred location Philosophical plain as volcanic river basin (conservation)			Fallow land during the dry season
	The river floodplain or the *wedi kengser* is Sultan Ground			
	-	Utilization of *wedi kengser* or floodplains as temporary farmlands (in dry season)		
Utilization	*Wangsit* (premonition) on *geger bulus,* as Kraton location	-	-	Volcanic ash as fertilizer
Hazard	*Wangsit* on *700* years eruption cycle	On time eruption evacuation (using animals activities as indicators)	-	-
Wangsit (premonition)		On lahar flood occurrence by the Sutan HB IX	-	-
Five senses wisdom				
Visual	Sights of *Pranata Mangsa*	Eagle fly direction = lahar direction	Cloud in the Mt. Merapi upstream as rain time to flood. Fish types as water quality indicators.	Worms and color of the soil as fertility indicators. *Pranata Mangsa* indicators.
Sound	*Lampor* as flood or lahar EWS, hearing indicators for *Pranata Mangsa*	Lahar sound differs from regular flood, *Pranata Mangsa* indicators (dry and rainy)	Sound of *lampor*	Sound of cat mating, insects, birds as *Pranata Mangsa* indicators for farming activities
Touch	Feel indicators for *Pranata Mangsa*	Temperature changed (40-70'C) after eruption and unused for 1 year.	-	Feel of temperature drop in the dry season (*Pranata Mangsa*), soil humidity as fertility indicator.
Taste	-	Flavor change for water wells post-eruption as water quality indicator	Water from well still fresh even after the 2010 eruption	
Smell	-	Scent of sulfur in water post-eruption	River smell as water quality indicator	-

The table presented different coverage of myths. Some are micro myths at the hamlet level (bride stone in sub-case 1). Others are at mezzo level for the whole village (Jayaningrat tomb in sub-case 1 and the *lumpang* stone in sub-case 3). While for the macro-level or entire region is the *lampor* and the Queen South Java Sea. The myths are represented in artifacts, and other forms of CEK also accompanied them, such as rituals, resources management practices, and worldview. For water artifacts, the Mataram channel is the most significant infrastructure. The rivers' role is also essential as it is the water channels from up to downstream, the Mt. Merapi as the Opak rivers' origin, and the South Java Sea as the terminal. The MKKS philosophical axis reminds the link. Meanwhile, for the artifacts of volcanic river basin context, Mt. Merapi as the source of eruption holds virtues for the management of natural resources. These artifacts and myths related to the types of philosophies and values used for each community. They are based on the context of the location and the natural dynamics, which are experienced by the community.

The *hamemayu* philosophy is accepted and translated in different ways, all about the balance of the environment. The CEK on water resources management practice varies, based on the condition of the sub-case, but the sand mining activities and temporary farming on floodplain exist throughout the case study. Also, the *Pranata Mangsa* (seasonal calendar) is used by sub-cases 1 and 3, as their inhabitants are mostly farmers. However, in sub-case 2 at the inner city, they no longer believe in such practice. The use of five senses wisdom is more common and sensitive for the upstream village (case 1), especially towards volcanic activities and its relation to water resources than others. This condition is because they live closest to the mountain, and they had terrible experiences in 2010.

4.4 CEK Formulation Patterns

This part of the chapter is based on the analysis of the interviews, where the CEK indicators were reorganized in the axial coding process. The term CEK formulation is used to clarify the different meaning of the word 'generation', appearing as two terms throughout the text, to avoid confusion. These are; 'generation of knowledge' and 'inter-generations transfer'. Therefore, the term CEK formulation is used to explain the production of knowledge, which is transferred within the inter-generations context. The role of cultural institutionalization is divided into institutionalized structures and dynamics. Also, the processes of legitimization and symbolization, formulation pattern are more related to the formulation patterns of CEK than as part of the mechanisms of transfers or CEK forms. These are divided into two levels: the regional level and village level. The roles of this institutionalized society is determining the certain person within the group to legitimize the product of CEK. The following summary (table 4.3) presents the general overview of the formulation process

4.4.1 Cultural Institutionalization

The CEK patterns for each village and at a regional level show prominent cultural institutions. They differ from one another. It depends on the type of natural dynamics they addressed and the social structure of the community member. The following table 4.3 presents the comparison of their structure and dynamics:

Table 4.3 Cultural Institutionalization

Institutionalized structure and dynamics				
Levels of case	Regional Level	Sub-case 1 Argomulyo	Sub-case 2 Gowongan	Sub-case 3 Kebongagung
Structure	Kraton and the people (patron-client)	Hamlet chief and the people Forum SKSB	*Paguyuban* RW leader and the people	Tourism village initiatives (*desa wisata),* agriculture museum initiatives, farmers group (*poktan*)
Dynamics	Kingdom dynamics: formal and ordered	Farming and disaster activities: rural life	Urban activities: modern life	Farming and tourism activities: rural life
		Follow orders from the Sultan		

At the regional level, the institutionalized structure is about Kraton (the Kingdom palace) people and the people (subjects). The dynamics are about the relationship explained as patron-client or using the philosophy of *manunggaling ing kawula Gusti* (the unity of King and his people). This relationship supports the legitimization process to take place within the Kraton people. It suggests formal dynamics by the Kraton and patron-client implementation. The regional level dynamics are supported by the current structure of the Kingdom's Special Status, fitting in the authority of the regional government. This status permits the Sultan and the Paku Alam as the Governor and Vice Governor for life. Although this position is renewed every five years, the same structure will serve the Region/Kingdom. For these people, the patrons are the Sultan and the Kraton people, making the decisions for them based on cultural knowledge. However, these decisions are also made based upon modern science from the approach of professionals in governmental agencies. They are the main people involved in the legitimization process of CEK.

The CEK survived due to some historical facts, which relates to the historical experiences of this culture in Yogyakarta. The blood ties of the rulers in Yogyakarta carried these experiences. They came from the Syailendra Dynasty, who ruled most of Java Island and also Sumatera Island then. There are of course many theories from historians of what happened during the 7th and 8th centuries over what dynasty gained control over which one, but for this research, the correlation is not so significant (Muljana, 1968, Purwadi, 2010). Syailendra Dynasty built Borobudur and Prambanan temples. The Kingdom in which they reined was called Medang or Old Mataram, which later became the Buddhism Kingdom. This Kingdom decided to move further to East Java due to the Mt. Merapi eruption in the year 928 Saka (or 1006 AD), and the Kingdom was buried under volcanic materials. This fact was based on Pucangan inscription found in Kolkata, India. It stated the Mahapralaya or Great Disaster (Bemmelen, R. W. v., 1956), but geological evidence of Mt. Merapi doubts the date (Newhall, Bronto, et al., 2000). However, there were also other theories about this, which included the Sriwijaya's Kingdom attack, or because of a more strategic merchant location in Brantas delta (Boechari, 1976).

Hence, the descendants of Mataram established their new Kingdom, Majapahit in East Java. It lasted for two centuries from 1293 to 1500. It was the golden age in history for the archipelago. The Kingdom area covers many parts of modern Indonesia combined with Malaysian territory, Singapore and some part of other islands in Indonesia. This Kingdom flourished to be one mighty Kingdom. The most influential figure was Gadjah Mada, a Mahapatih or Prime Minister of King Hayam Wuruk. He vowed to expand the Kingdom by getting many small kingdoms as an integral part of Majapahit (van Naersen and De Iongh, 1977, Olthof, 2008, Purwadi, 2010).

Later the Kingdom settled back into Central Java after the crumble of the Great Majapahit Kingdom and called itself the Pajang Kingdom, but this time, it was converted into Islam (Muljana, 1968). This Kingdom arose from the ash of old values and great lore glory of its predecessors. It still maintained great cultural traditions, lives up to Javanism paradigms and high in pride as a sovereign. It first declared its foundation in 1568 and later on during the colonization era. It was a short-lived Kingdom until 1586 (Carey, 1986, Purwadi, 2010). Due to the difference in views of the Sunan Pakubuwono III, which was the Sunan during that time with his half-brother's son Prince Mangkubumi about the role of VOC in Mataram. Later on, Pajang was split into two kingdoms, Surakarta and Yogyakarta after the Giyanti Agreement on the 13th February 1755 (Koentjaraningrat, 1985, Dradjat, 2009). The following quote from Prince Wiro supports this claim:

> (Prince) Mangkubumi told his uncle (Pakubuwono III), "Uncle, I cannot accept this agreement (Ponorogo Agreement)." He asked permission to go outside of the palace's walls to do Dutch resistance. Then in the details, he was given the blessings, with the provision of an heirloom (a spear), called Kyai Kanjeng Plered. Now it has been nine years since Prince Mangukubumi against the Dutch; the Dutch never won though, the prince and his team always win. So the Prince Mangkubumi was invited to a peace talk with the Dutch called the Giyanti Agreement, in 1755. (Prince Wiro, Prince of Yogyakarta, humanists, 2016)

The Yogyakarta Sultanate has been a part of the Republic of Indonesia since 1945. As a special region, several laws have passed through the development of the Indonesian democratic government. The most important of all in supporting this autonomous status of governmental forms are:

(1) Law no 32/2004 on Local Government: as the start of decentralization government in Indonesia, which gives more power to the regional government to deal with their internal matters.

(2) Law no. 13/2012 on the Special Status of Yogyakarta Special Region: this law empowers the special status specifically on Yogyakarta, which adds to the region's preserving its way of life and heritage.

(3) Based on this Special Status, the following structure of government is established:

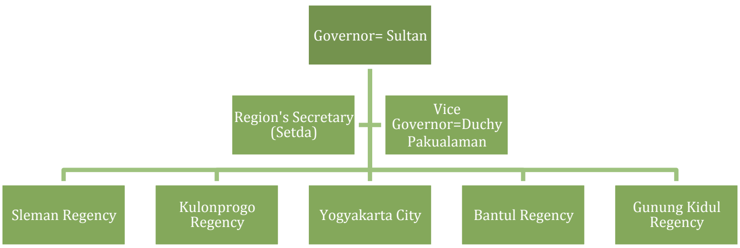

Figure 4.15 Structure of Government reflects the combination of the Sultanate and the Regional Level

From 1945 to this day, the form of government stays. This condition is partly due to the characteristics of the people of Yogyakarta, which are submissive to their leaders. The bloodline of the Kraton is for governor, and the Kadipaten is for vice-governor. It is common for the indigenous people not to question the doings of the Sultans. The following quote illustrates this claim.

> So far, there are still, because people may not understand, it means like *sendika dhawuh* (your wish is my command). One of the types for characters in Java is like that. In Yogya, the indigenous people are still obedient, now with the new form of society, whether this still true or not. (R. Bima, Humanist UGM, 2016).

In this modern era, heterogeneous society is commonly leading to its dynamics. Its indigenous society accepts the given government form of the Kingdom. Incomers do not always understand this. Therefore, a challenge for the government and the sovereign is to handle it in its practice. This relation expressed a form of ‘patron-client’ society as described in many works on Indonesia (Aspinall, 2013, Blunt, Turner, et al., 2012). The patron for this region is the Sultan and his court members. The people in the regencies act as clients. This layered hierarchy has also occurred in other parts of Indonesia, although a Governor only heads them. The difference is that the Sultan always reigns for life, as he is the primary decision-maker in this region.

The main points in maintaining the sovereign of this Kingdom, include: (a) The procedures for filling the position, position, duties, and authority of the governor and vice governor; (b) DIY Local Government organizations, (c) Culture; (d) Land; and (e) Spatial planning. In reality, even before the law was established, some of these privileges already existed. For example, the Sultan and Adipati, monarchy as a form of government, Javanese culture, land ownership of the Sultan and the Adipati, existence of *catur gatra tunggal,* and imaginary-philosophical axis (Dradjat, 2009, Purwadi, 2010, Carey, 1986). Among all of the points mentioned above, the only one, which is still very strictly followed, is the procedure for filling the positions of governor and vice-governor. On government organizations, the government has the authority to emphasize more to what priority it has; the following quote gives an example:

> The Sultan must be Governor, the Pakualaman; the King must be the Vice Governor, the second we can decide for ourselves on institutional manners. (Rani Sjamsinarsi, Head of PU-P ESDM, 2016).

This shape hybrid forms; being both a kingdom and a part of a republic show the cultural internalization through its structure. Especially concerning the leaders, this hierarchy presents itself in the highest rank as a set of regulations (also supported with Law no.13/2012 on Privilege Status of Yogyakarta). The Kingdom uses philosophies as a motto or jargon for their government. It is part of the culture to use this form of thought to reflect behind meanings of doings.

At the village level, the structures and dynamics differ, based on the activities and initiatives of the community. Although different, the structures have similarities to the regional level on patron-client, where a leader of the community, be it a hamlet chief, a group leader, etc. become the patron, with the rest of the community as the client. The commonality also conferred the leader as the spearhead for related dynamics, be it water-related disaster management, irrigation management, or water-related tourism activities.

For sub-case 1, their community institutionalized structure and dynamics consist of the Sultan, his *Juru Kunci* or the gatekeeper of Mt. Merapi and the people. The structure comprises the hamlets’ chiefs, the SKSB (social communication channel) forum, farmer groups, and the water user association (WUA). The dynamics are stronger disaster n between the hamlet’s chiefs and SKSB in cooperation of the villagers about what to do.

Meanwhile, in sub-case 2, the *paguyuban* RW or the informal communities' group based on sub-village level is done in this level. The RW or *rukun warga* is the division under the village level, but the *paguyuban* RW is a self-organized initiative, which consists of several RW's within the Kampung Jogoyudan. It mediates the RW with the village, as the Kampung has a special characteristic for the Riverside community. For example, it is seen in the arrangement of the riverside infrastructure enhancement program (M3K) to minimize flood risks. It is also seen in the lahar of 2010 – during this period, the *paguyuban* RW also helped in distributing the international relief fund, among other things.

In sub-case 3, the institutionalized structure and dynamics are seen thus: the tourism village communities or *desa wisata* with tourism activities, farmer's group (poktan) agricultural tourism and normal farming operations. These two are making sure that agriculture cultural values and practices are conserved. Another essential feature is the tourism community; the existence of the Agricultural Museum, where the dynamics of the communities created the pull-push factors between the *desa wisata* and the museum organizer.

4.4.2 CEK Processes: Symbolization and Legitimization

Further analysis shows similar patterns on two main processes involved in the CEK formulations, (1) legitimization and (2) symbolization. These processes arise from the content of the interviews with experts and organizations' respondents and supported by secondary data.

Legitimization

The first process relates the knowledge formulation, which describes the CEK always starts at the historical experiences responding to the natural dynamics of conservation and temporal experiences. These experiences are selected and refined in the process of legitimization by the institutionalized structure and dynamics of the community before transferred to the next generation. The following excerpt explains this process:

> Because things like this (*Pranata Mangsa*) cannot be separated from the necessary legitimacy. Why? It has started early in the patterns in the community since HB VII, but people still believe. The term is [like this], that the Kapok tree, it cannot be felled, for the water supply, it depends on who is banning it, if the ban were from the Sultan, people obey, (but they do not obey) if the ban were from the grandmother nearby. This condition is legitimacy. (R. Bima, Humanist UGM, 2016)

The current Javanese society has indeed changed, although the legitimation of a patron in contemporary society is still an important thing (Pye, 1999). Thus, someone name is at the Kraton is always made as an essential decision base. This legitimization explains that things like *Pranata Mangsa* are a product of their era and it needed legitimization of the highest societal order, for example, the Sultan, to exist. Based on this explanation, the researcher also found out that that the *Pranata Mangsa* is still used in the adjacent river basin (Serang and Progo) of the Kulonprogo Regency (although under the same administrative boundary of Yogyakarta Special Region, it is not included as the case study of Opak sub-basin):

> The *Pranata Mangsa* is still used in the neighboring river basin (Serang and Progo) of Kulonprogo Regency. It is in the Regent's Regulation no. 29/2016. (Dirgantara, BPDAS SOP, 2016)

In this regard, the calendar functions as the cropping pattern for the farmers, and the Regent, with the highest hierarchy of legitimacy of regency, determines it annually. The role of a leader in determining the CEK is becoming part of current society is pictured here. This example is a formal way to legitimize the knowledge with supporting regulation, but there are also other ways, such as the command of the Sultan, the urge of *Kyai* in the Kraton, or the recommendation of the wise people, but it has to be coming from someone with respectable status from the socio-cultural point of view.

Symbolization

The second process is the symbolization, which is a feature of how cultural values, teachings, or philosophies are manifested in daily life. The process is, at times, layered between one form of CEK to another. These symbols can be in the form of artifacts, which remind people about the existence of these philosophies. The symbolization can also take form as activities. The following quote explains the example:

> So the Mt. Merapi symbolizes our relationship with nature, somewhat agrarian. Then the monument symbolizes *manunggal ing kawula Gusti*, the unity between the citizen and the Sultan. (Bayudono, water resources expert, 2016)
>
> Moreover, the current monument is artificial. The replica is currently under construction, what we have now been originally called the monument of *Pal Putih* (*Witte Pal*). The height (of the original) was 25 meters. The old monument was the one symbolizing it and *golong gilig* (ball and cylinder). (Prince Wiro, Kraton Representative, 2016)

The monument also signifies the MTKKS philosophical axis. The axis is the symbol of the convergence relationships of the river basin from upstream the mountain and to its terminal downstream at the sea as explained:

> If you want to live sustainably conserve the water, about the axis of philosophy, according to one, the fact is the reality the axis is imaginary, but in fact, if one looks it (carefully) at it is the convergence between the mountain and the sea. The mountain is the center of the water, and the sea is receiving it. The river flows into the sea. Why the Prince Mangkubumi chose the location (of his kingdom) in Jogja. (Bayudono, water resources expert, 2016)

As seen from the patterns from each sub-cases and the regional level, these processes are ever connecting in different forms of CEK. Thus, the philosophies and values are set as 'the inner layer,' while the four alternative forms function as 'the outer layer' or the embodiment of them.

4.5 Summary of Cultural Ecological Knowledge

The main elements of CEK are described as the historical experiences and the mechanism of transfer. The historical experiences are the base for knowledge to be used and developed. The experiences stemmed at the local and regional level. The strongest CEK related to the water-lahar management are the philosophies of how the community level and l of government officers see their world *(bawono)* and the myth of Mt. Merapi and Ratu Kidul. It is explained the up-downstream relations and the philosophical axis of the volcanic river basin. Aside from that, the *wangsit* and *Pranata Mangsa* are also compelling findings as these are still relevant to the current practices in the Sultanate.

Another interesting fact is that the current irrigation system is based on the ancient irrigation plot of lands since the ninth century and the Mataram channel since the 1940s. It proves the CEK is developed throughout times. All the sub-cases in the village level and the case of the regional level show similar patterns of groups of actors (even though different in each community), which hold the legitimization processes. The existence of the Sultanate's cultural traces is found in the philosophies, values, myths, rituals, or resources management practices. Another similarity is for the symbolization processes; each form of internalization are interrelating to one another in reciprocating ways. Based on the overall narration, the researcher realizes similar patterns existed overall in the findings. Thus, they are used to portray the interrelations. These interrelations are found mostly in the worldview. They are comprised of philosophical ideas based on cosmology, others on human's life, relations of human-nature-God.

The mechanism of transfer has five possible types, as follows: (1) the philosophies and values are clustered together as the core of the CEK forms. This clustering is based on where the CEK originated before symbolized into the other four forms. (2) The internalization is expressed as myth or legend and rituals. This first form symbolizes the philosophies. In the cases, the myths and rituals usually are intertwined and part of one another. (3) The artifacts as results of knowledge are manifest of philosophies related to the myth with its rituals. These are always in physical forms, and their characterization is easy to spot, as they are architectural or archaeological heritage. (4) The resources management practices, which are characterized by measurements of resources concerning utilization, location, or time. These forms can also be symbolized into a myth (i.e., the flood management with the myth of *lampor*), artifacts (i.e., the use of *wedi kengser* or floodplains as temporary agriculture lands) and five senses wisdom (i.e., the *Pranata Mangsa* indicators). (5) The five senses wisdom is not a stand-alone form, as it is always related to other forms of CEK, and also stemmed in philosophies and values.

Accordingly, the CEK in the case of sub-basin Opak is more dynamic than the proposed CEK in the initial framework (see chapter 2). Similar patterns of interrelations and processes exist throughout this chapter (figure 4.17), but with different elements of the knowledge expressed for each category. The categorizations of the CEK indicators were done based on the conceptual frameworks were a rather segmented and one-way process (chapter 2). It did not provide the opportunity to see the interrelations between the indicators. Patterns of interrelations show a need for rearrangement of this original framework.

For example, under the historical experiences, the understanding of the natural dynamics is always necessary. They resulted in (1) the response of community (can be in the form of activities), (2) conservation, and (3) temporal experiences. Thus, these three are grouped as one, as they are linked more strongly and explained the historical experiences categories.

The knowledge formulation is linked closer to institutionalized structure and dynamics. Together, they form the legitimization process. These patterns of interrelations and processes are visualized as follow in figure 4.16:

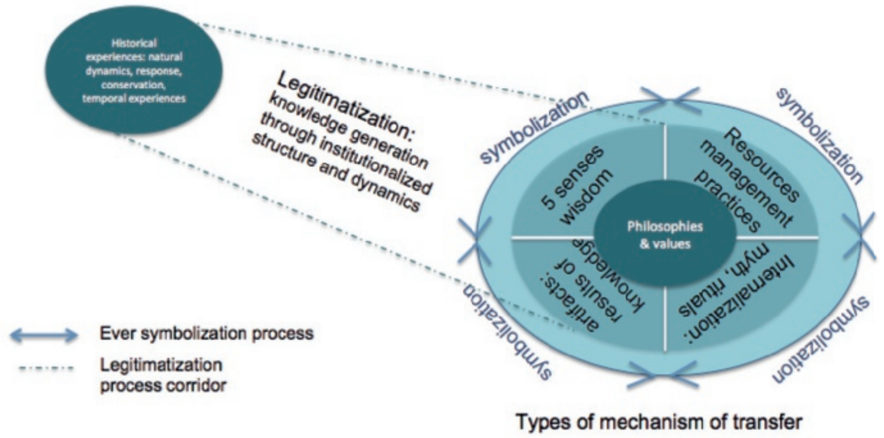

Figure 4.16 Formulation of CEK based on this research

The CEK is aligned with the integrated approach in looking at nature as one holistic system, which in this study connects water to other resources. This chapter aimed to identify CEK's main elements regarding the management of water and lahar in a VRB. These consist of historical experience, formulation processes, and the forms of the mechanism of transfer. These three points are importantly taken as notes for further steps of this research:

1. The CEK formulation began from the recorded historical experiences (either orally transferred or written). However, these need legitimization by certain groups to be transferred to later generations. This process is essential in transcending into philosophies. It later developed into ever-symbolizing knowledge: the internalization of myth and rituals, the cultural artifacts, the resources management practices, and the five senses wisdom.

2. The CEK is still used, some partially, like the seasonal calendar of *Pranata Mangsa,* the utilization of floodplains or *wedi kengser,* and some holistically, for example, thanksgiving rituals of *labuhan* with the philosophical axis-plane as a whole river basin and the myth of Mt. Merapi and Ratu Kidul. However, it needs analysis from the researcher's point of view to recognize them and their relationship to the water-lahar-volcano management, which adds the significant role of conservation to some locations.

3. The CEK in use has potential contributions to the water and lahar management in the volcanic river basin of Opak in Mt. Merapi, as transfer of knowledge or communication strategy, also in water and lahar related disaster strategy and

water-lahar resources management practices with the contextualization of modern scientific approaches.

Based on these results, the traces of CEK are using the integrated approach between water, volcano, and lahar management. The CEK is a crucial knowledge to be conserved, as it is more accessible to the communities than the scientific approach.

CHAPTER 5

MANAGING THE WATER RESOURCES IN A VOLCANIC RIVER BASIN

5. Managing the Water Resources in a Volcanic River Basin

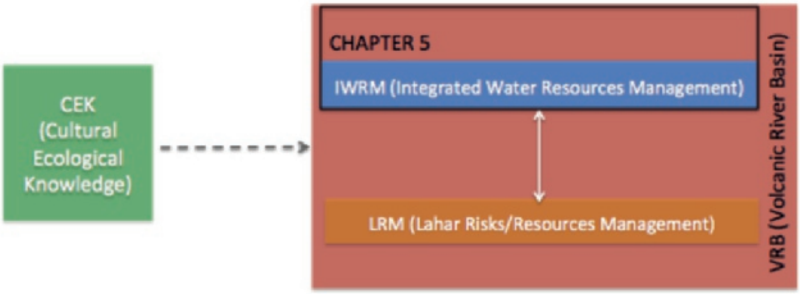

Figure 5.1 Addressed Concepts within the Research Framework in Chapter 5

5.0 Introduction

This chapter answers the question of "How is the integrated water resources management (IWRM) approach implemented in a volcanic river basin?" It uses the upper half of the conceptual framework (as visualized above) as the dependent variable of the research. The chapter explains the existing implementation of the IWRM in this volcanic river basin. The IWRM approach is accepted as a given condition of the Indonesian water management context when the approach was adopted after the 1997 monetary crisis.

The multilevel approach in water governance organizes this chapter. These implementations are located at the national, regional, and municipal level. Based on the IWRM approach, the river basin concept (DAS) is used as the unit of management. However, for Indonesian cases, this is translated into river basin territory (WS). Therefore, this chapter is divided into the structure of IWRM implementation in multilevel governance view. (1) policy setting, (2) managerial level, where it is divided into multilevel, (3) the existing interaction attempts to implement IWRM, and (4) integration level of this implementation.

Firstly, this chapter starts with the context as it describes the currently implemented water resources management policies for the case study, looking it from the national perspective. The policy setting is explained using document content analysis to describe the current regulations, sketching the development of the law and the dilemmas it faces. This part also discusses the layers of policies that produce the rules in which the corridor of water management's institutional relations is based. Secondly, the chapter discusses the managerial level through three levels of governance: national, regional, and municipal. In doing so, the river basin territory (WS) is seen as the interrelation of the national and regional levels, and the catchment (DAS) is located between the regional and municipal levels. The reality of water management is described to explain the implementation of policies in the three main pillars of IWRM based on the water resources management law: water conservation, water utilization, and water-related hazard control. This section explains which institutions or organizations are responsible for which aspects of the dimensions and how they relate to one another. Thirdly, it presents a more in-depth analysis of multilevel governance interrelations. This interaction is shown in the themes of interaction attempts: budget, water, disaster, where the formal and informal interaction ways are taking place within the themes. The themes and types are found based on interviews, reports, and regulations. This section explains how the interaction happens for each of the themes and in each of the level. Fourthly, the level of integration is determined into three levels: (1) coordination, where data are shared, (2) collaboration, where projects are synchronized, and shared vision is established, (3) cooperation, where projects are synchronized with data sharing, common vision, and entailed budget sharing. This integration level will be used throughout the empirical chapters.

The chapter uses this structure to present the current condition of IWRM implementation in each of the levels, with an emphasis on the regional level as 'the main playing field'. The chapter ends with the conclusion of how integrated the current implementation is, based on the layered findings within the multilevel water governance condition.

5.1 Policy setting in IWRM

In this section, content analysis of governmental regulations and interviews are used to sketch the policy setting. This overall policy setting in water resources management in Indonesia is toned with the IWRM concept. However, the policies do not refer directly to the concept, which was brought in by the Global Water Partnership and the World Bank (Global Water Partnership, 2000, World Bank Group, 2015) whereby the forms of the implementation is adapted to possible Indonesian contexts. The Indonesian regulation context has strong hierarchies supported by the national government. These hierarchies apply to all regulation products. It starts with the national constitution, law, government regulation, president's regulation minister regulation (national level), regional regulation, governor regulation (regional level), and municipal regulation, mayor's regulation, etc. (municipal level).

In the field of water resources, this starts with the Indonesian Constitution of 1945 in chapter XIV, article 33, point 3 which states:

> "The land, the waters and the natural resources within shall be under the powers of the State (national government) and shall be used to the greatest benefit of the people."

With this context as an opening to water resources management, it is an assurance that water is amongst the resources that is owned and managed by the government. This context is also showing the highest hierarchical order for all natural resources management in Indonesia, and is governed by the national government. This section highlights this condition and presents the setting based on this arrangement into phases and implication of IWRM policies.

5.1.1 Phases of IWRM Policy

Based on the constitution, the policy of water resources management in Indonesia is developed. Due to time scope limitation starting from 2010 to 2017, only two significant laws are going to be discussed here; Law no.7/2004 on water resources management and the Law no.11/1974 on irrigation. However, the development in the water management sector in Indonesia is divided into three historical timelines: phase 1 (2004-2013), status quo phase (during 2013), and phase 2 (after 2013-now). This condition is due to the annulment of Law no.7/2004 in 2013.

Overall policy setting in water resources management in Indonesia is toned with the IWRM concept as a result of the WATSAL (Water Sector Adjustment Loan) in 1999 (Government of Indonesia, Inter-Agency Task Force on Water Sector Policy Reform, 1999). The policies do not refer directly to the IWRM concept, but the project implementation is toned by river basin level management, rather than the existed water project-based development. The idea was brought in by the Global Water Partnership and the World Bank (Global Water Partnership, 2000, World

Bank Group, 2015). The Indonesian IWRM is translated into the Law no.7/2004 on water resources, using the river basin territory (WS) as the unit of management, in opposition to a catchment or one river basin (DAS).

Phase 1: 2004-2013

This phase is highlighted by the establishment of the Law no.7/2004 on Water Resources, as opposed to the earlier version of Law no.11/1974 on irrigation. This law no.7/2004 also points out the main actor as a ministry, but not naming it directly. It is because the 'regulation language' aims for flexibility if a specific condition is to happen in the cabinets' arrangements (merger or abolishment). Thus, the jurisdiction of water resources fell upon as the Ministry of Public Works. This jurisdiction is handled through the Directorate General of Water Resources within the ministry. An essential definition of the water resources management of this law is described as:

> "Water resource management is the effort of planning, implement, monitor and evaluate the implementation of conservation of water resources, efficient use of water resources, and water-related disasters mitigation."

With this definition, the five pillars or aims of integrated water resources management in Indonesia is shaped under these categories: (1) the increase of **water conservation**, (2) **utilization of water** resources for the justice and welfare of the people, (3) **control** and mitigate the damage of **water hazards.** This condition is done with the help of two complementary pillars, (4) increasing the role of **community and private sector** and (5) building a network of the **information system** on water resources. The first three pillars are used throughout this chapter as clusters in each managerial level. The water conservation pillar mandated in this law highlights the importance of catchment conservation, using both infrastructures and plantations. The water utilization pillar is regulated with water allocation and water balance, especially on surface water. The hazard control manages flood, landslide, lahar, erosion, etc., but does not explicitly guide on how. These pillars are used in each of the derivatives of the law products: (1) PP no. 42/2008 on water resources management, (2) PP no. 38/2011 on rivers, (3) Perpres no.33/2011 on national policy for water resources management, and (4) Keppres XII/2012 on river basin territory delineation. In operationalization of these regulations, the Ministry of Public Works also sets many decrees: (1) No. 04/PRT/M/2008 on guidelines for the formation of water resources management coordination team in provincial, regency/city and river basin territory, (2) No. 22/PRT/M/2009 on technical guidelines and procedure in preparation of water resources management framework (Pola) and (3) No. 02/PRT/M/2013 on guidelines for development of basin water resources management master plan (RPSDA). This complete set of regulations guarantees the implementation of the IWRM approach from the legal stance of view.

The law also sets the scales of management based on river basin territory (WS), which includes one or more basins/catchments (DAS) under one authority. It introduced the establishment of the river basin organizations (RBO) by the national government. The WS is determined on the equity adjustments following the condition of neighboring and interrelated wet and dry river basins. Water infrastructures, such as weirs, irrigation channels, or dams, are used for these inter-basin transfers. However, throughout the law, there is no reference on how to manage water-based on geological characteristics, for example, a volcanic river basin, or Karst, among other cases.

The Status Quo Phase (2013)

This status is since the law no.7/2004 was annulled in 2013, based on the protests of some NGOs, had made some drawbacks for the development of water resources management in Indonesia. The main protestor was the PP Muhammadiyah, an Islamic NGO, based in Yogyakarta who had concerns about the issues on water privatization expressed in parts of the Law. The whole debacle was dealt with when the current Minister of Public Works and Housing was the General Director of Water Resources. As the event happened in Yogyakarta, one of the respondents was a witness.

> I remembered in details, at the time (names omitted) are against the Law for water resources management, due to the water privatization issue. But, at the time he (name omitted) cannot decide, because it was so political, in the end, the annulment occurred. (Respondent PU-P ESDM, 2016)

The respondent was also mentioned about how the Presidential Decree on the river basin territory delineation came in 2012, just before the Law was annulled in 2013. This condition made the Ministry lose some grasps in the foundation of the water resources management, due to the status quo created by the annulment. The Ministry cannot work on the water resources sector without any legal basis. It is impossible to regulate this locally as there was no national 'legal umbrella' to be used.

In 2013, it was of deep concern that the national government structured their legal base for water resources before the end of the year, for the water sector to run. The importance of legal base in the implementation of water management policy was hindered during this status quo. The RBO's authority loss its foundation of existence, because it was founded based on the Law no.7/2004. The local government also suffered from this, as they also lost some authorities on the water management. This condition forced the national government to withhold its legal base using older Law. The requests for annulment were related to the issue of water privatization. Although from the perspective of water managers in the water resources sector, they saw this as part of opportunities in providing role-sharing opportunities in public-private partnerships. One of the respondents defended this role sharing idea as follows:

> The Law on water resources management has wisely hinted the need for role sharing. The goal was not that (privatization of water). It recognized the national government might not be able to do it (water resources management) alone. (Respondent PU-P ESDM, 2016)

During this status quo, the RBO still works on managing the water resources based on its past status as the manager in the river basin territory. However, it does not have the legal foundation to back up its decisions. The projects, operation, and maintenance of the water resources sector are still held as business as usual, but when things went wrong, the RBO cannot be responsible. This condition is dangerous, as the national government no longer supports their works. Therefore, a quick response was made to address the 'vacuum,' and this condition is explained further in phase 2.

Phase 2 (after 2013 – 2017)

With the annulled Law no.7/2004 in 2013, this development brought the water resources management a step back to the old version of water law, which is the Law no. 11/1974 on Irrigation. It was created during the centralized regime in the 1970s and not yet acquainted with the concept of water resources, but merely: water. The Law no.11/1974 also based its theory of management on technical solutions as described:

"Water system is a set of structures and water sources and/or irrigation infrastructures according to the provisions of the engineering construction sector in the irrigation area."

Therefore, the old law is complemented with a series of Minister of Public Works and Housing's Regulations since 2015 (total of 30s regulations) to implement current water resources management condition. The rules are using the content of Law no.7/2004 to have a solid base for on-going management. Added to these conditions, is the merging and reshuffling of the ministries in 2015 (due to change of presidency) and the Law no.23/2015 on Local Government denoting the divisions of authorities and jurisdictions, between levels of governments in all sectors. Especially for the water resources, this applied to the division of authorities in the management for all water infrastructures. Even so, this division of authorities does not work, as it is opposing the centralized nature of the Law no.11/1974. This condition created some stagnancy in the regional/provincial government for other sectors, as it gave back much of the supervisory and monitoring dominance to the national government. This condition calls for the urgency to set an updated law on water resources management in Indonesia to back-up the implementation of IWRM. Notably, the contradictions created stagnancy for the regional government and overload tasks for the national government. These conditions are explained in the next section of the managerial context.

As introduced above, the establishment of Law no. 23/2014 on Local Government redefined the division of authorities, between national-regional-municipal governments across all sectors. Especially on water resources, this applied to the division of jurisdictions in the irrigation areas with its channels, drainage systems, wastewater, and groundwater. The law supports a more precise delineation of the existing divisions of authority, but contradict with the setting of boundaries using the river basin territory (WS). The following table 5.2 presents some water-related excerpts taken from the Law no.23/2014:

Table 5.1 Division of Tasks between National, Regional, and Municipal

Tasks	National Ministry of Public Works and Housing (KemenPUPR)	Regional Provincial Public Works Agency (PUP-ESDM DIY)	Municipality Municipal Public Works or Water Agency (DSDAEM Sleman, DPU Yogyakarta, DSDA Bantul)
Water resources	a. Trans-provinces river basin territory (WS), trans-boundary WS, and national strategic WS. b. Primary and secondary irrigation systems and areas (>3000 ha), in WS, trans-boundary WS, and national strategic WS.	a. Natural resources and coastal protection structures in trans-regencies/ municipalities WS. b. Primary and secondary irrigation systems and areas (1000 ha - 3000 ha) inter-municipalities.	a. Water resources and coastal protection within one municipality. b. Primary and secondary irrigation systems in irrigated areas (< 1000 ha) in within municipality.
Drinking water	a. Water Supply System (SPAM) nationally. b. SPAM across provinces, and national strategic importance.	SPAM across municipalities.	SPAM within a municipality.
Wastewater	a. National wastewater management system. b. Domestic wastewater management system across Provincial Region and national strategic importance.	Regional domestic wastewater systems.	Domestic wastewater systems within a municipality.
Drainage	a. National drainage system development.	Drainage directly with the trans-municipalities rivers	Drainage system connected directly with a river within a

	b. Drainage trans-provincial a national strategic importance (including rivers)		municipality.
Geology (e.g. groundwater and volcano)	a. Delineation of groundwater basin (CAT) b. Groundwater conservation zones in cross-country and trans-provincial areas. c. Conservation of geological and geological heritage d. Volcano status and early warning e. Potential and early warning of soil movement. f. Balance of resources and reserves of national mineral and energy resources. g. Delineation of geological disaster-prone areas.	a. Conservation zones on deep groundwater basins in provincial Areas. b. Permit on drilling, excavation, usage, and groundwater exploitation within a province. c. Determination of the value of groundwater within a province	Not available
Catchment (DAS)	Implementation of DAS management	Implementation of DAS management inter-municipalities within a province	Not available

This law does not differ much from the earlier versions of authorities divisions for water resources under the annulled water law. However, with the old law being re-implemented, the authorities of local government are becoming limited in comparison to the national government's authorities. In this law, rivers and lakes are merely referred to for transport and hydropower, where the national government took charge. The authority on water bodies is also not defined, which made this condition refer to old Law on Irrigation. This contradiction created some stagnancy. It created the confusion in the regional government on what they are supposed to handle in regards to water resources management when all the water bodies belong to the national government. One of the respondents explained this condition as follow:

> Yeah, since it was annulled, the Law no.7, all the authorities delegated for water resources are all returned to us (Ministry of Public Works under the Directorate General of Water Resources). (Tri Bayu Adji, BBWS SO)

Thus, the function of the national government in water resources management is heightened. But in the era of local autonomy, it is representing a contradictive condition or stepping backward.

5.1.2 Implications of Political Conditions on Water Resources Management

Within phase 2 (after 2013), the merging of ministries as the result of cabinets reshuffling in 2015 reshaped the clustering of work for a more efficient arrangement. The merging of Ministry of *Perumahan Rakyat* or PR (Housing), which handles the housing allocation and preparation, into the KemenPU in 2015 was a reunion, as the ministries were separated in the 1980s. Thus, adding to name of the KemenPUPR and additional responsibilities. However, this condition also relates to the reshuffling of the General Directorate of Spatial Planning, which was earlier under KemenPUPR, transferred to BPN or National Land Agency. This condition made the coordination for water development become comprised of inter-ministerial tasks between the KemenPUPR with BPN. In contestation to the WS delineation, the spatial plan uses the administrative boundaries of national, regional/provincial, and municipal government.

Related to these observations are a series of specialized terms. Terminologies such as the National Strategic Region (KSN), Provincial Strategic Region (KSP), or Municipal Strategic Region (KSK) are used to highlight those locations under priority for development. In the implementation, the WS supports the KSN priority lists, by providing the water supply needed for the event. Judging from the establishment of the water resources law, three years ahead of the spatial planning law, presumably the WS is referred there. However, the WS is not acknowledged in the spatial planning law. Unlike the DAS, which is related to, on natural conservation regions. The spatial planning law merely refers to water resources as water utilization and water-related hazards control, especially highlighting the importance of water balance to support the strategic regions.

Other than the ideas discussed, the KemenLHK is also a merger result between the Ministry of Environment (LH) and the Ministry of Forestry (*Kehutanan*). This merger makes sense as the forests have a substantial role in the balance of nature. Thus, joining the Ministry of Forestry with the Ministry of Environment gave it an even more purposeful role in natural resources management. The merger has promoted the importance of the ecoregion definition under Law no. 32/2009 on environment conservation and management, which is used by the Ministry of Environment:

> "The geographical region with similarities in climate, land, water, indigenous flora, and fauna, also the human-natural interaction patterns, which portrayed the natural system and environment integrity."

In short, the ecoregion for the Indonesian archipelago is presented as one island. Again, the WS term is not used anywhere in the law, although this law is four to five years younger than the annulled water law. The DAS concept, on the other hand, is acknowledged as part of the ecoregion to address the conservation of water.

The inexistences of WS in both sectors indicated the fragmented policy addressing water resources. It also represents the contestation of terminologies in water resources, development, and environmental sectors. The multilevel managerial contexts in the latter section are divided into national, regional, and municipal. The WS is located as national-regional interrelation and DAS as regional-municipal.

The changes of the Law no.7/2004 have created inevitable 'chaos' in the national-regional-municipal government relationships as the cooperation and collaboration ties no longer work. However, things are not changing so much at the managerial level. Aside from the gaps between terminologies and domains of stakeholders in Law no. 11/1974, the KemenPUPR is doing its business as usual, although with extra responsibilities. This condition is the successful results of addressing the terminology gaps by the sets of Minister of PUPR Regulations.

The merging of the ministries and the restructuring of the KemenPUPR also added further complications in the tasks of Directorate General of Water Resources (DGWR) or Ditjen SDA. Post-2013, the KemenPUPR established the Minister's Regulation no. 20/PRT/2015 on Organization and Working Procedures of Technical Implementation Unit (UPT) at the Ministry of Public Works and Housing. Based on this regulation, the water infrastructures all belong to the SDA. Meanwhile, the operation and maintenance of main urban drainage tasks that were once belonging to Directorate General of Human Settlement (DGHS)-Ditjen CK are transferred to Ditjen SDA. Hence, the Ditjen CK manages the drainage in smaller scales (the neighborhood level).

Moreover, based on Law no.11/1974, all irrigation responsibilities are under the authority of the Ditjen SDA, which was formerly national-regional-municipal cooperation. In practice, it is still too 'fresh' to assess how this arrangement is handled, as the transfer of authorities was only commencing in 2016 (during the fieldwork). Therefore, as a summary, the following table presents the comparison of the main findings based on document analysis from the two main phases:

Table 5.2 Phases of Indonesian IWRM Policies (2004-2017)

Differences	Phase 1 (2004-2013)	Phase 2 (after 2013-2017)
The definition of water management	Water resources management	Irrigation management
Policy Products	Law no.7/2004, Gov. Regulations, Presidential Decree, Minister's Regulations	Back to Law no.11/1974, 1 Gov. Regulation, an extensive list of series Minister's Regulations
Role sharing	The national and local (regional-municipal) government shared roles	Most mandates are back to the national government (based on Law no.23/2014 on Local Government)
Partnership opportunity	The private sector gets better chance	The private sector may take the role after the national government-owned or local-government-owned enterprises also after lengthy scrutiny
Main stakeholder in water management	Collaboration of ministries as mandated by the law	Dominated by the Ministry of Public Works and Housing as mandated by the Regulations

With the Law no.11/1974 being re-instated, it gave back much of the dominance of the national government, which in line with the target of re/building the 65 dams in 5 years since 2015 (Erdianto, 2018)**.** However, the centralized nature is problematic as the current water governance condition is not as simple as it used to be in the 1970s. Nowadays, NGOs, private bodies, CBOs, and local communities are aware that water management and water governance are multileveled, multi-actors, and multifaceted issues. By limiting the collaboration of stakeholders, it creates a 'bottleneck situation' where all water-related issues have to go through the decisions' maker desk in the RBO as the branch office of the ministry. This condition calls for the urgency to set a new law on water resources management in Indonesia to back-up the implementation of IWRM, which is on the process since mid of 2018 (Erdianto, 2018). The new law should support the collaboration of public-private and national-regional-municipal partnerships, while also at the same time be aware that the notion of water privatization is not acceptable. The partnerships should promote the private sector's role, such as the electricity companies and dam managers to share the burden of water management, with the collaboration of community representatives.

5.2 Managerial Context

In this level, the managerial context as results of policy implementations is analyzed. In this sub-topic, the interdisciplinary and even trans-disciplinary discussions are dealt. This section addresses the common river basin management in Indonesia, with some introduction about the volcanic river basin setting. However, more detailed about the volcanic river basin management will be discussed further in the next chapter on LRM. During the analysis part of the interrelations of dimensions, it is obvious that one cannot simply address one dimension solely, without addressing other dimensions Therefore, this section presents the arrangement of layers of management from the national, regional, and municipal on water resources. Overall based on the existing policies, there are stakeholders in the water sector for each level of the governance, using the analytical framework of multilevel water governance. The results of this section introduce the main actors in water resources management: who is doing what and how. Although so, the management of water is not based solely on the public sector, with the private and community also play their roles. This part is arranged based on the pattern arisen from Indonesian IWRM's multi-level governance (national, regional, and municipal) and its pillars (water conservation, utilization, and hazards control), which simultaneously addresses the water in the WS (national-regional) and DAS (regional-municipal) levels.

5.2.1 National: policy orientation, but fragmented management

In general, all aspects of the implementation of IWRM within the national level suggest the coordination of inter-ministerial, inter-sectorial, and multi-interest stakeholders. But, the implementation condition is not yet showing the integration between these stakeholders. Each of the IWRM pillars (conservation, utilization, hazards control) has a lead sector headed by a ministry or an agency. Even so, much of the main works for all water resources are mandated to the KemenPUPR (Ministry of Public Works and Housing), with its Directorate General of Water Resources (DitjenSDA).

> So basically, water and all its form are managed by us (Ditjen SDA, KemenPUPR). (Respondent Dam Expert, INACOLD, 2018)

This condition is in line with the implication of IWRM to cover the entire water cycle. The national government set up the guidelines for most implementation, with special attention given to the establishment of Pola (framework) and RPSDA (master plan) for the regional level using the river basin territory (WS). As explained in the IWRM policy setting, there are other related ministries for each component of the water management pillar. The law no.7/2004 explains the general guidelines for all kinds of the river basin. Moreover, this law is supporting the Law no.26/2007 on Spatial Planning, which highlights the importance of the development of strategic areas in Indonesia. It means the water resources development priority should go in line with the priority of strategic areas development mandated by the spatial plans.

National Water Conservation

The water resource is divided into surface water and groundwater management. Meanwhile, the water in the atmosphere is merely monitored and used for climate prediction. Based on the findings, more utilization priority is given to surface water, as it is mandated by the law. The Bappenas address this in their RPJPN or the National Development Long-Term Plan (20 years: 2005-2025), which later translated into the RPJMN (mid-term or 5 years) and adopted by each ministry into Renstra or strategic plan. In the water resources management sector, the RPJPN stated (Bappenas, 2005):

“Water sources are managed in the principle of 'one river one management and one consolidated planning.' Taking into account the various interests of the community along the river basin, from upstream to downstream to balance the interests between sectors, between national agencies, between provinces, between districts/municipalities and river basins. In turn, it can create synergy between stakeholders and prevent horizontal and vertical conflicts.”
Referring to this quotation, “one river” is translated into not merely river basin, but into Wilayah Sungai (WS) or River Basin Territory. Again, the term WS is absent in this long-term plan, although the water resources law was established a year before the RPJPN was published. Fortunately, this condition does not stop the implementation of the WS into the existing water resources management.

The water utilization is the main domain for the Directorate General of Water Resources (DGWR) under the KemenPUPR. It covers the water allocation, especially surface water for irrigation, water supply for domestic, municipal, and industry (DMI), and also environmental flow. For groundwater utilization, it belongs more to KemenESDM (Ministry of Energy and Mineral Resources) domains, as it is considered as part of the excavated resources. An exception is given to underground stream in Karst area as it has the character of surface water but located under the ground, hence also belong to DGWR.

The delineation of WS is the base for the establishment of the river basin organizations (RBO) under the Directorate General of Water Resources (Ditjen SDA). There are 133 WS in Indonesia based on the Presidential Decree (Keppres) no.12/2012, located in 34 Provinces and RBOs. The DGWR is also responsible for overseeing the preparation of all frameworks (Pola) and master plans (RPSDA) for each of the WS. The RBO is called *Balai (Besar) Wilayah Sungai*, depending on the numbers of divisions it has, also the authority of WS. Aside from this ministry, there are other main stakeholders as partners: (1) Perum Jasa Tirta (Dam Operator), (2) PT. PLN (Indonesian Power Company), (3) Perpamsi (association of government-owned drinking water companies) and (4) KemenTan (Ministry of Agriculture) on the types of plants and water needs, but is not concerned with the irrigation channels and its water supply.

For the groundwater utilization, the Ministry of Energy, Mineral, and Resources (KemenESDM) manage the nation-wide groundwater basins. The ministry, under its Geological Agency, manages the Centre for Groundwater Resources (PAG) defines and monitors the groundwater basin (CAT) at the national scale at PAG. But, based on the law no.23/2014, more the authority is put under this authority of the regional government: the groundwater extraction and regional CAT monitoring. There is 421 CAT under the Keppres no.26/2011. One of them is the CAT named Yogyakarta-Sleman, located in the study area.

National Water Utilization
Addressing the second pillar on the water utilization, the water resource is divided into surface water and groundwater management. Meanwhile, the water in the atmosphere is merely monitored and used for climate prediction. Based on the findings, more utilization priority is given to surface water, as it is the mandated by the law. The Bappenas address this in their RPJPN or the National Development Long-Term Plan (20 years: 2005-2025), which later translated into the RPJMN (mid-term or 5 years) and adopted by each ministry into Renstra or strategic plan. In the water resources management sector, the RPJPN stated (Bappenas, 2005):

> “Water sources are managed in the principle of "one river one management and one consolidated planning" (one river basin is managed by one management unit and not based on its administrative borders), with taking into account the various interests of the community along the river basin from upstream to downstream so that there is a balance of interests between sectors, between national agencies, between provinces, between districts/municipalities and river basins, which in turn can create synergy between stakeholders and prevent horizontal and vertical conflicts.”

Referring to this quotation, “one river” is translated into not merely river basin, but into Wilayah Sungai (WS) or River Basin Territory. Again, the term WS is absent in this long-term plan, although the water resources law was established a year before the RPJPN was published. Fortunately, this condition does not stop the implementation of the WS into the existing water resources management.

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The delineation of WS is the base for the establishment of the river basin organizations (RBO) under the Directorate General of Water Resources (Ditjen SDA). There are 133 WS in Indonesia based on the Presidential Decree (Keppres) no.12/2012, corresponding to the 34 Provinces that the country is based on and correlate to the numbers of RBO’s, which mostly manage more than one WS. The DGWR is also responsible to oversee the preparation of all frameworks (Pola) and master plans (RPSDA) for each of the WS. The RBO is called *Balai (Besar) Wilayah Sungai*, depending on the numbers of divisions it has, also the authority of WS. Aside from this ministry, there are other main stakeholders as partners: (1) Perum Jasa Tirta (Dam Operator), (2) PT. PLN (Indonesian Power Company), (3) Perpamsi (association of government-owned drinking water companies) and (4) KemenTan (Ministry of Agriculture) on the types of plants and water needs, but is not concerned with the irrigation channels and its water supply.

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National Water-related Hazards Control

The water hazards included in Law no.7/2004 are flood, drought, coastal, landslide, and lahar. However, it mainly aims to control water hazards from the technical point of view, but not about the safety of the people. The general hazards in Indonesia are tackled using a different law, the Law no.24/2007 on Disaster Risks Management. Based on this law, the National Disaster Management Agency (BNPB) and the BPBD (regional and municipal) were founded. The law addresses how to keep people safe from the range of possible disaster threats in Indonesia, either natural or human-caused hazards. Out of the hazards listed in the law, based on the BNPB data since 1980-2012, floods are presented as the most common (38%), while volcanic eruption recorded as having the most victims (32%) (BNPB, 2015). The BNPB manages the disaster risks and mitigation strategies through an early warning system, land use policy, evacuation routes, meeting points, and training of trainers.

On lahar hazard control, this relates to Minister's Energy and Mineral Resources Regulation (Permen ESDM) no. 15/2011 on Volcano, Land Movement, Earth Quake, and Tsunami (Geological) Hazards Mitigation. The disaster law gives guidelines, which relate to all kinds of hazards, so no specifics are given for water-hazards. Meanwhile, the second provides a more detailed explanation about lahar as partly water formed and informed about the existing of another ministry to deal with lahar (referring to KemenPUPR). More about this correlation will be unraveled in chapter 6 on lahar management.

About this fact, for volcanic river basins, the KemenESDM helps in monitoring the volcanoes under the Centre for Environmental Geology and Volcanology (PVMBG). Based on the Minister's of ESDM Regulation no. 15/2011; there are 127 active volcanoes in Indonesia. Out of these, most correlates to river basins, except for those located in Borneo and Papua. With an active volcano in a river basin, the volcano center s be part should be part of its decisions-maker. The natural characteristics of a volcano towards water management can be divided into normal condition and eruption. Under normal condition, the volcano is 'alive,' but does not disturb any human activities, and the management of the river basin usually runs.

Concerning the water resources management, risks caused by a volcano's periodical eruptions and the annual flood, pose the lahar periodical threats. The implication of the annulled law has also created the water-related hazard control as a non-referred phenomenon in the old irrigation law. As part of the IWRM implementation in Indonesia under the KemenPUPR, this pillar is missing in the current law. The volcanic river basin context is also not on mainstreamed in the IWRM implementation in Indonesia, as no reference is made to address this condition. The only reference made by the national government towards lahar as part of water-related hazards is the existence of some RBO's equipped with the extensive monitoring system and infrastructures for the lahar.

Similar information on the challenges in implementing IWRM within the national level is highlighted by this fragmented institutional arrangement and supported by findings of earlier empirical studies (World Bank Group, 2015, Asian Development Bank, 2016). However, as these studies do not cover the context of volcanic river basins as implied in this paper, their sketches are not complete. These fragmented themes of the water resources management, which were dealt with by different actors are not necessarily working or aiming at coordination or shared vision at all. This fragmentation condition is the main problem characterizing the national level IWRM implementation.

5.2.2 Regional: priority playing field, 'boxed' sector with interaction attempts

In this level, the managerial context as results of policy implementations is analyzed. In this sub-topic, the interdisciplinary and even trans-disciplinary discussions are dealt. This section addresses the general river basin management in Indonesia, with some introduction about the volcanic river basin setting. However, more detailed about the volcanic river basin management will be discussed further in the next chapter on LRM. During the analysis part of the interrelations of dimensions, it is evident that one cannot merely address one aspect solely, without addressing other issues. Therefore, this section presents the arrangement of layers of management from the national, regional, and municipal on water resources. Overall based on the existing policies, there are stakeholders in the water sector for each level of the governance, using the analytical framework of multilevel water governance. The results of this section introduce the main actors in water resources management: who is doing what and how. The management of water is not based solely by the public sector, but the private and community also play their roles. This section is arranged based on the pattern arisen from Indonesian IWRM's multilevel governance (national, regional, and municipal) and its pillars (water conservation, utilization, and hazards control). It also simultaneously addresses the water in the WS (national-regional) and DAS (regional-municipal) levels.

Regional Water Conservation

For the first pillar on water conservation, the Opak Sub-basin's land use is divided into the national park, forest, and farmland. However, other land uses also include residential, industrial, and commercial areas. The water conservation activities by BBWS SO (KemenPUPR) use the technical approach, such as reservoirs and dams, and also check dams. In the upstream, the actions performed by the RBO are through the technical proposal by building many small pools or embung. The Opak Sub-basin has small reservoirs. The BBWS SO and the PU-P ESDM DIY (Regional Public Works-Housing Energy and Mineral Resources Agency) decided this type of small reservoir. It based on the nature of Mt. Merapi's lahar in river channels will silt the reservois. If there is any big reservoir, the volume will be filled with lahar in no time, making it not a smart strategy for water conservation. Therefore, the Sabo Dam system is chosen to control Mt. Merapi originated rivers (Opak and Progo), and also to protect these small reservoirs' volume capacity. The Sabo Dam system will be explained more in the next chapter.

The locations of reservoirs are dispersed in both basins, with a volume of lesser than 1 million m3, and dam height under 15m. The water is sourced from the rivers, but the reservoir is located not directly in the river's channel, making it possible to close the water gate during lahar flood. These small dams are the works of the BBWS SO and PU-P ESDM DIY. The collaboration works between the two in terms of planning, construction, operation, and maintenance is usually done through partnerships. However, again due to the annulled law, all these dams and rivers now belong to the BBWS SO, as explained by the following quote:

> All by the national,, yes, they all being crossed-out, river management crossed-out, small dams management crossed-out. All is gone. Everything. In the future, I will no longer handle river and small dams, only irrigation. All irrigation. Rehabilitation and operation-maintenance of irrigation only, due to the Law no.23, the rests are no longer possible.
> (Respondent PU-P ESDM DIY, 2016)

The spatial distributions of these small dams located in the Opak Sub-Basin are presented in the following figure 5-2:

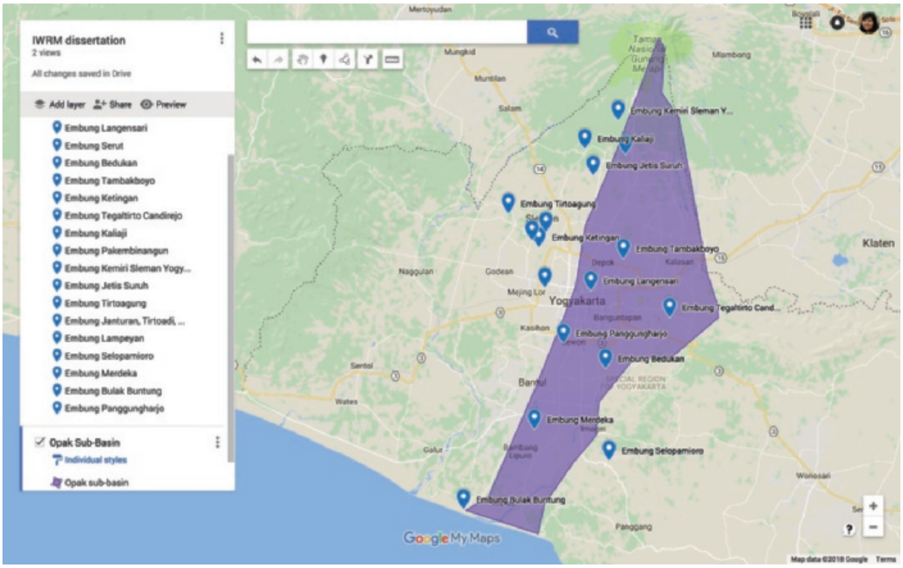

Figure 5.2 The reservoirs located in the purple hatch in Opak Sub-basin
(made with google my map https://www.google.com/maps)

Meanwhile, for the non-technical approach for water conservation, the upstream area with the radius of 4km from the summit of Mt. Merapi is dedicated as the Merapi National Parks. The BTNGM manages it under the Ministry of Forestry and Environment (KemenLHK). Aside from this protected forest area, the BPDAS-HL SOP maintains the rest of the catchment, which is also under the same ministry. The latter focuses on water conservation by preserving the land capacity to absorb water, where they use vegetation cover, land terracing, or embankment reinforcement constructions. Its activities also covered the; master plans, technical plans, modeling for the conservation of catchment, actual land rehabilitation for water conservation, monitoring, and evaluation of protected forests, inland waters, and reclamation, also the presentation of information.

The BPDAS-HL SOP formulated the RPDAST Opak (catchment conservation master plan for delineated areas in figure 5.3) and initiated the Local Regulation on Catchment Management (Perda DAS). It emphasizes the importance of the special status of the region and highlights its noble cultural values, such as the hamemayu philosophy and other local knowledge on resources management. The RPDAST Opak, the water conservation master plan proposes the land use for water conservation in line with the spatial policy directed by the RTRW DIY and the RPSDA WS POS. Although, the rough alignment is the same, the exact spot of priority for the conservation areas may differ, and at times even contradict with the current land use. As an example, the upstream area is developed into mix-settlements in the RTRW, while in the RPDAST Opak and RPSDA WS POS, supposedly it is a forested area.

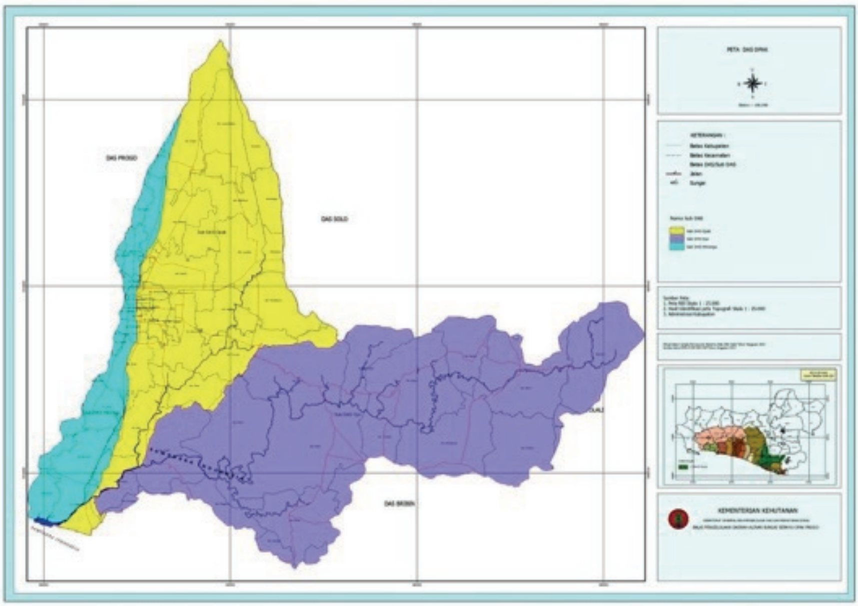

Figure 5.3 Opak Basin and its sub-basin (BPDAS-SOP, 2014)

Another critical document related to the conservation area is the RTRW DIY (Spatial Plan of Yogyakarta Special Region), which has highlighted the upstream area as a protected area. However, at the time the RTRW was legalized, the term WS has not been used. The term DAS was also misunderstood, not as a catchment, but as river flow area as being quoted:

> "The need to control forms of disruption in spatial use around the DAS." (RTRW DIY, 2010)

This condition is a standard error for using DAS as a terminology, which also found at the local level, as explained by the following quote:

> It is difficult to see the abstract boundary of such scale compare to see the physical form of the river and its floodplains or riparian area. (Respondent BBWS SO, 2016)

Therefore, this misunderstanding is also taking form in daily activities for the development of the area. Besides, the master plan proposes conservation of water by strictly controlling the land use in the catchment area. It isnot using the same wording as the *daerah aliran sungai* (DAS), but *dareah tangkapan air* (DTA) and the surface water. Also, the area surrounding them, adding the reservoirs alternatives, such as dam, small dam, and pool, also preventing the change of irrigated paddy fields to other land use. Additionally, it also proposed rainwater harvesting in the form of small reservoirs in each district, infiltration wells, and *biopori* or absorption holes (water trap holes in the land). The PU-P ESDM puts these proposed activities into practice in their annual programs.

The conservation actor also has a partner from the community side, called the AKSY. The RBO realized the importance of the community-based organization as they are more engaged with the rivers and initiated activities on rivers aiming for river restoration. Their existence is claimed as follows:

> In each river, each river community, together they formed AKSY, association on river community of Yogyakarta. When they represent themselves to an outsider, they used the

name AKSY. They are truly independent. The easiest on budgeting, they find it themselves. When they need directions from the government to us, about regulations, they asked. (Tri Bayu Adji, BBWS SO, 2018)

Even since 2015, the AKSY has been able to promote the river communities as a movement and celebrated the Indonesia River Jamboree. This characteristic is explained more in the water interaction attempts section.

Regional Water Utilization

At this level, it is managed at the WS scale, which is called the WS Progo Opak Serang. It is managed by an RBO, which is the BBWS SO under the Ministry of Public Works and Housing (KemenPUPR). Their job description covers all five pillars of Indonesian IWRM, which are translated into public works domains as; water infrastructures planning, implementation, operation, maintenance, monitoring, and evaluation. The WS POS as the unit of management comprised of these three DAS (catchments) with the Opak Basin originated from two sources: one at Mt. Merapi (Opak Sub-basin) and the other at Karst area of Gunungsewu (Oyo Sub-basin). But, for the focus of this study, the volcanic river basin, the Sub-Basin of Opak originating from Mt. Merapi is used. Although so, water utilization uses the water balance arranged at the WS and the DAS scales.

This figure 5.4 below shows only the surface water balance. The groundwater balance has never been included in the calculation as it is not part of the RBO primary responsibilities. However, instead of another regional agency, the PUP-ESDM to control the permits. The Opak Basin water balance is described by the following graph, based on a twenty-year analysis of hydrological data (1995-2015). It is displayed in the Rencana (Master Plan for WS POS) in a bi-weekly chart format (24 bi-weeks in one year, representing the 1st and 15th of each month). The graph shows the supply is still lacking from the demand, while the potential of Opak (average of 43.4 m3/sec) is more than twice of the market (average 6m3/sec). The graph also shows the demand during November and December is increasing, as it is the start of the cropping season. With the rule of 30% from total discharge as environmental flow, the yield from the river can still advance up to average 9m3/sec, with additional reservoirs or weirs to maintain the minimum discharge.

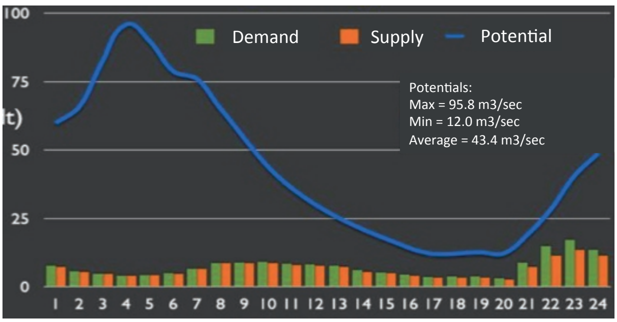

Figure 5.4 Opak River Water Balance (BBWS SO, 2014)

The utilization scheme for the water resources from the year 2016 to 2035 is described in figure 5.5 below. The Opak Sub-Basin is highlighted in the dashed-lined box and dotted with numbers

1, 2, 3 as locations of the sub-case studies. These show the plan of water utilization, which highlights the domestic water supply and industry. Meanwhile, the scheme displays that the Mataram channel acts as the main irrigation infrastructures for the inter-basin transfer between the Progo and Opak. The water supply infrastructures used for this Sub-basin are weirs, groundsills, or direct intake, even Sabo dams (lahar control structures) with multi-functionality of water intakes (BBWS SO, 2014). There are some small reservoirs based on these planning documents. However, no big reservoirs are used in the basin, as the result of the frequent volcanic activities, will easily silt the river channels or reservoirs' bed.

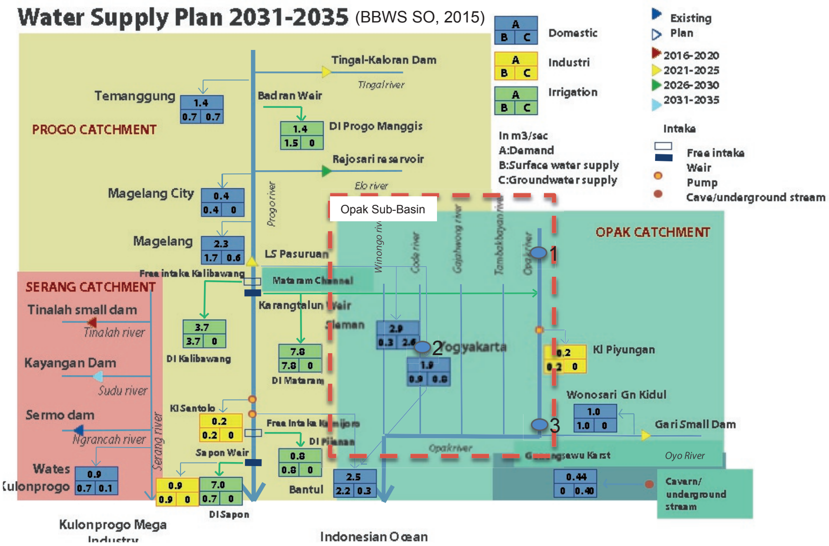

Figure 5.5 Water Supply Plan WS Progo Opak Serang

The plan to provide the water supply is using free intake or pumping in combination with weir or groundsills from the Opak River. It seems to be the best option, in retrospect to the incident of the 2010 eruption. At the time, the free intake infrastructures were submerged in lahar, but dredging the lahar sediment could still salvage them. In comparison to recovering a dam from a lahar, dredging intakes and reconstructing them require less investment to manage. These strategies are used by the RBO to manage water utilization in the volcanic river basin. Both the Pola and RPSDA should support the spatial plan (RTRW). Both are the products of BBWS SO, taking into account the recommendations of the coordination team of water resources management (TPSDA WS POS). Before the existence of WS, the utilization is based on irrigation area (DI), as the existence of irrigation water supply still dominates the usage. The irrigation area goes way back to the centuries of heritage in the history of the Mataram Kingdom ((Christie, 2007, Ertsen and Ravestijn, 2008). The most critical channel in the case study is the heritage Mataram Channel, which connects the Progo Basin to Opak Basin. The management of such a vast irrigation area falls under the BBWS SO. The BBWS SO works on water infrastructures in irrigation, river, dams, dikes, coastal protection, and lahar.

The main actor for collaborators for water utilization within the regional level is the PU-P ESDM, especially in terms of irrigation. However, as it belonged to the regional government, it has more roots and contacts with the local actors in the communities and municipal agencies. These actors are Pammaskarta (water supply cooperation), the universities (with UGM as the biggest and oldest), and the AKSY (river communities at regional level). With the current status of the water management regime, the regional actors have little involvement in this respect. Their works on rivers are stopped, also on small dams; they only work on irrigation channels under their authority. Fortunately, the MoU for SPAM Regional was a successful and collaboration between the RBO, the PU-P ESDM, and CK SPAM. They can prove some results, although this does not concern the Opak Sub-Basin at the moment as their focus is still on Progo Basin.

A community-originated actor also exists in the water provision: Pammaskarta DIY. The hierarchy of the Pammaskarta DIY and the importance of the regional government as the primary partner are explained as follows:

> The pipes are from them, in Jogja, it became a coop formed by the *Ngerso Dalem* (the Sultan), appointed here, the Pammaskarta Coop, *paguyuban…* the downlines are the Spamdes, at the village level. The coop is one, the mother (organization) at the Province (level). The *Ngerso Dalem* gave per regency some budget and a Tossa (scooter with adjoined-cart behind it). So, when something is broken, the workshop is located in each regency. When they got the budget, it goes for the pipes, and maintenance. So they have capital. (Rani, TP5DIY, 2018)

With the help of this initiative, the coverage of freshwater delivery in the provincial level is 72,85% in 2012 (SPAM DIY), and target of 100% in 2019. (https://bisnis.tempo.co/read/1019766/pu-targetkan-3-sistem-pengelolaan-air-minum-di-yogya-rampung-2018/full&view=ok), which is higher than other provinces in Indonesia at 58%. The Pammaskarta is not happy with the fact that their accomplishments are accounted for the Satker-CK SPAM achievements.

> There, I feel disappointed, the database by the Satker shows that the point is, the clean water achievement in Yogyakarta (region) is at this (percentage), with whatever it takes, even achievements of others are included. (Respondent Pammaskarta DIY, 2018)

This information presents how the government supports the community. However, the water supply accomplishment is a cooperation work, the CBO felt the injustice of how the percentage achieved is not stated transparently. They want more recognition in this statement. In reality, the 2012 data showed that 45% out of 72% are non-piped services, meaning that the Pammaskarta DIY boosts most of the percentage.

Regional Water-related Hazard Control

For the water hazard control, the leading agency is the BPBD, which work collaboratively with the BBWS SO and PU-P ESDM, during onset hazard within the disaster task force. Much of the hazards risks based on the last ten years study by the BPBD are water-related, consisting of mostly flooding (40%). The lahar flood is put under volcanic eruption hazards, not on a separate list of data. For the lahar occurrences, more data are obtained at BPPTKG (the branch office of KemenESDM). The BBWS SO works o infrastructures on to control flood in the river areas (embankments, retarding basin, etc.), either before the before, onset and after the hazards happened.

> So far, the hazard prediction from us is with water, be it flood or other water-related hazards. (Respondent BBWS SO, 2016)

Even if the PU-P ESDM no longer has authorities for the management of the river (due to the annulment of law no.7/2004 and the enactment of law no.23/2015).The agency still possesses the capacity (heavy equipment, budget, and human resources) to help during the onset disaster, as it was done so in 2010, before the 2013 incident of annulled law. With the volcanic river basins' land characteristics mostly consisting of sand and very good for water infiltration, it has good groundwater reserve. However, during an eruption, all the rivers that originate at a volcano will be natural channels for pyroclastic and lahar flow. Aside from that the physical and chemical conditions have a direct relation to the volcanic river basins learning from others in the world will change, either for groundwater (aquifer systems) and surface water (rivers). These waters, especially in the upstream area, may not be consumable during the eruption and a year after. Alternative water sources need to come from elsewhere; this is also where the Pammaskarta DIY takes up the role of water supplier during the eruption as explained below:

> I was alone at the time, during the onset (eruption), at the *huntara* (temporary shelter), the water was supplied by whom? (5 seconds pause) The Pammaskarta. We have not moved, they moved first, Pammaskarta Gunung Kidul. They connect, directly to the provincial (Pammaskarta), 'we are ready to help' (they said). The hydrants are from us, but the man force is from them. Volunteers. They do not wait. (Rani, PU-P ESDM, 2016)

As explained in the regional level, the Pammaskarta DIY has a municipal level coop. This coop in the village level is called Spamdes.

All of these narrations explain the regional level is the priority-playing field for IWRM implementation. It is due to the capacities, human resources, and budgeting supports an application that is located on this level. The roles of the RBO in all pillars of IWRM implementation are stating the high degree of involvement of national government within the regional level. On the other side, the regional government also tried to share the burden of the irrigation channel operation and maintenance.

5.2.3 Municipal: informal actors' playing field with 'boxed 'sectors

The structure of the water management within the municipal level almost mirrors those within the regional level. However, there is also community-level governance, which this formal structure does not reach. The actors responsible here are not as capable as the regional actors. The implementation of IWRM in municipal level reveals the 'boxed' sectors and domains, where the separation of public, community and private actors is evident. The mirrored models structures exist, such as the Municipal Development Agency (Bappeda) and Municipal Water Resources or Public Works or Mineral Agency (DSDA, DSDAEM, DPU). However, not all actors are apparent by the people at the village community level. Thus, in this example, only those being referred to by the respondents are being discussed. The locations of sub-case studies also suggest different types of priorities. These priorities are listed in sequence, starting from the highest priority in each sub-case. Sub-case 1, the upstream focuses on control hazard, utilization, and conserve water. Sub-case 2, the mid-stream focuses in utilize water and hazard control without conservation. Meanwhile, sub-case 3 the downstream also focus on utilization and conservation, more than hazard control.

Within the municipal level, water resources management is performed through the municipalities' agencies. The actors in this level have limited capacity and budget to address bigger problems, especially when it comes to inter-municipality coordination. Hierarchies in administration lower than the municipality no longer have any jurisdiction in water resources management. However, they give feedback and recommendations in meetings of *Musrenbang* (budget-oriented development plan). These lower hierarchies (starting from the highest) are the District/Kecamatan, Village/Kelurahan (formal structure), Hamlet/Dusun/Kampung, RW and RT (informal status). The sub-cases show that in rural areas, hamlet chiefs are more knowledgeable than the village chief, as most are indigenous. However, the village chief is the appointed person that can be from somewhere else (even from the city). In the context of water management especially in this research, these hamlet chiefs can give better inputs for the locations of potential water sources and report to water needs in secluded rural areas, i.e., on the mountain ridge, near the volcano summit, near the estuary.

In addressing the first pillar on water conservation, in each of the municipalities, water quality monitoring and evaluation is dealt with the BLH or environmental agency. Its role is not very strong for the cases used in this research. In this study, it relates to DSDAEM Sleman, DSDA Bantul, and DPU Yogyakarta. However, for the control for the conservation of forest or catchment is not as strong. It is proven by the current land use for conservation areas becoming residential areas (see figure 5.6 below). The mid-part of the upstream is developed into a built-up area.

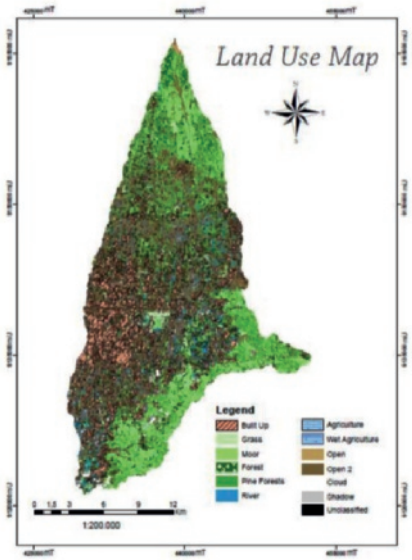

Figure 5.6 Opak Sub-Basin Land Use (Awanda, Nurul, et al., , 2017)

There are variations of community-based organizations (CBO) aimed at conservation for river communities. An example is the Pemerti Code (Code River Awareness Community), which has established a citywide river community located in one of Opak tributaries, in sub-case 2 to be precise. Other Opak River communities also have organized their own CBO, such FKWA for Winongo River, Sahabat Komunitas Grebeg Gajah Wong for Gadjahwong River, etc. There is also an activity called the *Forum Sungai* (river forum) to accommodate the river CBOs, which is supported by the BBWS SO in 2015-2016. Unfortunately, this forum does not last long, as it depended solely on the budget availability of the RBO. Both are aiming to provide better communication channels for the municipal communities in addressing their problems. Future aims for these communities are river restoration and better environmental condition for urban areas. There is also the leader of the Forum Sungai who is a pioneer Indonesian River Restoration movement, which proposes rainwater harvesting as an alternative for groundwater use.

> It's urgent. So these community organizations are growing now, (and) it affects the quality and quantity of water availability. Later, a new awareness will emerge on reduced groundwater utilization, which was felt by the public and the government. There is a problem, there is a solution, but there has to be a bridge. The bridge that connects is this (human dimension). (Respondent River Restoration Movement, 2016)

The second pillar of water utilization is divided into drinking water supply and irrigation. On water supply, the drinking water company is the most profitable. The actors on this level are the drinking water supply company owned by the municipal government. They manage water for the irrigation under 1,000 ha based on the Law no.7/2004 and Law no.23/2014. However, as the base of law is now the Law no.11/1974, this arrangement is somewhat forfeited. All the irrigation under this law mandated the national government in this respect the BBWS SO to manage them. There were stagnancy post-2013 to 2015, where the municipal government does not do anything, due to the confusion. The municipality also maintains and operates many of the small reservoirs.

These are PDAM Tirta Marta Yogyakarta, PDAM Sleman, and PDAM Bantul. Out of this three, only PDAM Sleman is used to illustrate the others, as its facility can be found in the location of case study 1 (Argomulyo, upstream). The water is taken from Gendol River, nearby a Sabo dam or lahar control infrastructures. The Sabo Dam has multi-functionality for water intake or temporary bridge. The water is processed *in-situ* and distributed to other areas. The other case studies do not have an example or even concerning the municipal level companies.

Out of the three villages, it can be summarized that most communities still rely on the wells for drinking water supply. Even if the national and regional policy insisted on the use of surface water and piped services as main sources. The management of water resources in Indonesia is still mainstreamed on the irrigation use. For piped drinking water, the coverage in the municipal level is not as good as the irrigation. There are several reasons for this:

1. The irrigation needed big infrastructure, which the villagers cannot provide for themselves. Therefore they use the provided irrigation channels.
2. The coverage of piped water distribution has not reached the locations used in these case studies comparisons.
3. The communities use wells since before the existence of piped water. They felt the water quality using the wells are better in the old days than now, and they do not need to pay extra for water use.

With irrigation management, local communities related to this sector are the farmers. These are set under the P3A or WUA's (Water User Associations). There is always a WUA at the village level, which is under the coordination of water resources agencies. The agencies manage the irrigation water supply, but in reality, the farmers operate the water circulation, daily maintenance, and operation. This type of community has strong ties with the BBWS SO, as the water they use mostly comes from a weir in the main river. However, there is a steep hierarchy between the WUA to reach the BBWS SO. The WUA's need to first be in contact with their municipal water agencies, regional level water agency, and then later to the BBWS SO. This hierarchy postpones any on-time aid that is needed by the community. Post-2013 (law annulled), there were times, when the WUAs been delegated to the Agriculture Ministry, but it seemed not to be working. This condition relates to the nature of irrigation works and the realms of the public works since the beginning era in the Indonesian irrigation systems. This claim is illustrated as follow:

> Well, now, what kind of local community we have, like the P3A (WUA). It will remain (with us) in the future; as we have the P3A, but it has been delegated to Agriculture (Ministry). So they are transferred back to us. Not working. (Respondent BBWS SO, 2016)

Aside from the WUA, there are also CBOs formed under the Pammaskarta DIY, in each of the regency. This initiative emerged as a result of the low water supply rate outside of regency's capital. However, the village level of this Pammaskarta is called the Spamdes. Unlike the RBO approach of centralized water supply scheme by aiming to provide water from the nearest infrastructure, the CBO provides the solution in supplying fresh, clean water from local sources to the villagers directly. This is an alternative solution to provide water 'off the grid.' They way they operate explained by the following quote:

> The starting point is us, but the community group (Spamdes CBO) has to exist. So, when they proposed this (water supply initiative), the group is ready. Not from our side, it will not be successful. It is more *handarbeni* (with a sense of belonging). (Rani, PU-P ESDM DIY, 2016).

An initiative is formed by both collaborations of the community and government, by providing what each can provide. The community has first to establish a group of task management, where the member of communities will independently survive in managing the water supply. This way, the community takes care of the infrastructures (the pump, reservoir, etc.) with more responsibility. The budget to provide such initiative can come from different sources: the PU-P ESDM, the CK-SPAM work unit under the Cipta Karya General Directorate of Ministry of Public Works (water reservoir and treatment), the BBWS SO (water source), and the community's contribution (human resources). The external budget sources become their partners in this cooperation.

On the third pillar or the water hazards control, this is led by the municipal's BPBD with a collaboration of disaster forum. Most of the members of the CBO mentioned above are also members of their Tagana (village disaster response team) who work collaboratively with the municipal BPBD. The way it works is by using visual monitoring of the river condition during floods and the communication of walkie-talkie radios. At this level, RBO's role is diminishing. The local BPBD is more up to date with the information on their river channels, even if the RBO owns the EWS. The RBO shares their water level data to the local BPBDs. The channel used for this radio is two-way, branching up to downstream of the rivers. These people are volunteers and mostly are villagers with another job, but whose house or fields are near the rivers, which can watch over the rivers' condition. This level is marked with the informal actors, bottom-up initiatives, but their approaches are 'boxed' within their municipalities or rivers.

As found in the sub-cases, these communities also formed other informal organizations, which are not directly linked to water resources. These have a major role in the village development, such as the Forum SKSB (communication forum on disaster information in sub-case 1), *Paguyuban* RW (informal governing body in sub-case 2), and tourism communities (in sub-case 3). The types of CBO's are based on the communities' needs.

Municipal Sub-Case 1: focus on hazard control and utilization, some conservation
In Argomulyo, the villagers are aware of the danger of living to close to the volcano. Thus the hazard control pillar is more practiced. However, for water quality conservation, the indicator used by the villagers for the excellent water quality is the existence of the *wader* fish.

> "When you want to Wader (small fishes), you can find many of them during this time." (Eko, Argomulyo)

The water quality of this spring was tested during the 2016 fieldwork and was proven to be safe for consumption after boiling. It was also the case in the respondent's home, which was feared to contain too much iron. The location of the spring is not protected, but people do honor the site and not do any sand mining extraction in the area.

There have also been impacts on the change of spring water discharge or its location. A reduction in water discharge of the river occurred for more than a year post-eruption. Some small creeks and even bigger river channels also moved its flow elsewhere, and of course, the sedimentation rate sharpened as the lahar materials stayed.

> Gendol River used to have had abundant water. (Semprit, Argomulyo, 2016).
> In the past, this spring water is the source of life for us. (Eko, Argomulyo, 2016)

A study on reduced river discharge up to 1 year after a volcanic eruption (Iles and Hegerl, 2015) supports this finding. The study was conducted in 50 major rivers in the world, with Asian rivers also included. It relates to the atmospheric condition of the area, where aerosols help in reducing evaporation, by cooling the atmosphere and lessen its capacity for water-borne. In wet tropics, the stream flow decreases post-eruption, not influenced by the ENSO.

A change of water quantity and quality after the eruption also reported, as follows:

> Primarily water, the springs have receding discharge. We think the reduced flow is not submerged caused by a lahar, but because of too deep dredging, deeper than to the previous eruption. Second, the water quality of the well changed. Its color, smell, and taste are changed. Now it looks like as if it is rusty, with yellow deposits, the relatively lumpy deposits."(Dirman, Suruh, Argomulyo, 2016)

Another report concerned the emergence of hot spring water near the river area, and also the hot groundwater temperature in the wells. The wells cannot be used due to the temperature:

> Hot. It stays hot for long; one year. (Mrs. Jaka, Gadingan, Argomulyo, 2016)

However, the same respondent also explained that this hot water was used for tourism attraction and believed to cure skin diseases. This hot water phenomenon was diminishing, due to the sand mining activity, as it cuts the groundwater channels.

Another source of water for the village is the spring at the upstream of a Sabo. This spring's discharge is stable enough. Even up to the 2016 fieldwork was conducted, the villagers still used this spring, and the quality is good enough after simple treatment of boiling the water.

> So we made waterways manually, without tools, we distributed to Bakalan. Then we needed the water in the shelter, so we use that spring, but because of over-mining, finally, the spring returned to the river. (FGD, Eko, Kuwang, Argomulyo, 2016)

The next pillar is water utilization, which is used mainly for irrigation, fishponds, drinking water supply (company and self-organized). However, there seems to be not so many activities done regarding catchment conservation for water, as most of the land use is farmlands. Thus, the consequences are to be ready to evacuate whenever there are signs of eruption. The Tagana is an informal organization on disaster response. It is capable of drawing information from BPBD DIY and BPPTKG using the radio frequency that is used to disseminate disasters information. Their input is used to determine the status of evacuation. The villagers on the slope of Mt. Merapi also have developed line information coordination in the up-down stream the rivers. The water used by the farmers to irrigate their field uses tertiary channels from the Opak tributaries, but not from Gendol River as the water level is inconsistent.

However, water in Gendol River is used as PDAM Sleman, but during the lahar flow, the extraction stopped. Different organizations manage water utilization (figure 5.7) in the village:
(1) Irrigation: by the provincial government (PU-P ESDM) and municipal water resources agency (SDAEM Sleman), fisheries (villagers), and fish seeding ponds (regional government).
(2) Rivers: Opak and Gendol where there are 5 Sabo Dams for lahar were being built already in 2010 and 2016 during the fieldwork visit, they were rebuilt (BBWS SO)
(3) Ponds: fish breeding facility (Provincial Fishery Agency) and also farmers' ponds
(4) Water from the river: used for drinking water supply (PDAM)
(5) Water wells: the residents manage the wells for drinking water (self-organize) and fisheries (villagers)
(6) Spring: village's drinking water (Village Level Government)

Figure 5.7 Water use in Sub-case 1 (up left to right, down left to right): paddy field, tertiary canal, Fe contaminated well, PDAM Sleman water extraction, the spring water near the Sabo dam GED 10, Gendol and fish breeding ponds (2016)

The water utilization in this village is still higher for irrigation, although the weirs are small and DSDAEM Sleman handles all of them. The water source for this is not from Gendol River, but small tributaries of Opak. This reason is why; they never got involved with BBWS SO for irrigation water.

> This from Silling Stream. The source is up there. Not until Mt. Merapi. The one reaches up to Merapi is only Gendol. (Semprit, Argomulyo, 2016).

There was no mention about water user association (WUA or P3A). Although, usually a village has the P3A to manage water and the tertiary irrigation canals. Although when referring to farmer group (Poktan), a respondent claimed that there are discussions on cropping and the season. Whether the respondent referring the Poktan and P3A are the same or not is not clear.

> But, there are many Poktan in their meetings to discuss cropping. (Semprit, Forum SKSB, Argomulyo, 2016).

Moreover, for drinking water, most villagers still used wells as their main source. An exception was during the first year post-eruption in 2010, where tanks of water distributed by the regional and national government even international and national humanitarian NGO were given. But, also at times even their self-help community efforts.

Also during these times, the alternative water sources were the spring water at the side and the base flow of the Gendol River. A community member based the use of Gendol's base flow on a piece of cultural ecological knowledge did not explain how this knowledge is known. In the following quote, people knows the potential of the river and the base flow, without the use of scientific knowledge or advanced technology. The person seems to know the basic understanding of hydrogeology traditionally and uses it to maximum usage.

> Jaka Tarupi again, this hamlet chief, to not disappoint those who gave him orders, and he dug a well in the middle of the Gendol River for drinking water. It works, great even, using the law of gravity it flows, nice water used to drink; even now people can make fishponds. (Respondent Argomulyo, 2016)

This explanation on sub-case 1 suggested that the community knows better about what works and not for their water provisions, even at times of disaster. The government's aid, therefore, is seen to be not 'on target' as it can only provide an instant solution with the water tanks. However, after the disaster, the community uses self-help strategies in their water provision. This provision is done, either through the spring water extraction or using their cooled-off wells. It is an interesting fact that the PDAM Sleman uses the Gendol River as the source, but the villagers do not choose to use the water from the company. They choose to use their water sources with simple treatments than using the health standard approved piped water. This condition is due to the ease of using well water. It has been used perhaps for generations, without paying water by the cubic meter, and also the installation of the pipe will need time. For them, the BBWS SO is more known as Sabo builder, rather than water resources manager.

Municipal Sub-Case 2: focus on utilization, hazard control, no conservation

Gowongan is located in an urban area presented in a kampung level. A CBO existed in informal riverside settlement area and also has an informal governing body, namely the *Paguyuban RW*. The *Paguyuban RW* is a congregation of surrounding RWs-lower level of informal government under the sub-district. The RW consist of some RTs, which is the lowest level of informal government in Indonesia. The *paguyuban* RW addresses their problems collectively. This condition does not always happen to a kampung in the whole region of Code Riverside, but for the case of Gowongan, the existence of *paguyuban* assists the governance of self-help community reconstruction and improvement programs. One example is that of after the lahar flood 2010. As for water conservation, this sub-case does not own green areas for water infiltration or reservoirs. The main pillars are the utilization, followed with hazard control.

In this sub-case, the water resources utilization (figure 5.8) is managed by different organizations:
(1) River: Code River for dredging, operation, and maintenance, the BBWS SO received transferred authority from regional government (PU-P ESDM).
(2) Wells for drinking water: managed by the residents (self-organized)
(3) Use of drainage: river as the main drainage (PU-P ESDM in cooperation with BBWS SO), also some instances are found as a public toilet.

Figure 5.8 Water use in Sub-case 2 (up left to right, down left to right): toilet use, fish cages, *wedi kengser* as farmland, household drainage to river, well infrastructure (Fieldwork, 2016)

The Riverside Kampung in Gowongan is called Jogoyudan – an informal unit of several RW's joined together by the riverside of Code, and it was a sub-level of a sub-district. It is similar to the level of a hamlet, but it does not usually have a governing body. The *Paguyuban RW* helps the community as the hub of communication between municipal government to residents. In the case of the 2010 lahar, the community received international attention by the UN-Habitat to rehab the housing conditions. This condition will be elaborated more in the LRM chapter, but the most important fact is the community has direct access to the international world during disasters.

The water management in this sub-case is provided through groundwater and community wells. The river water is highly polluted and consists of a high percentage of *E. coli.* It is only used to water small temporary farm plots during the dry season and limited fishery. The community determines the status of pollution in the river using the status dominance of *lele* or catfish to *wader* fish.

> The fish is not like in the old days. Now the fish is *sapu-sapu* fish (*plecostomus*) and catfish. (FGD, Andi, RW 07, Gowongan, 2016)

The *lele* fish is known to live even in septic tanks, while *wader* can only live in clear water. The fact that more *lele* is found in the river than any other type of fish proves that the river water is highly polluted.

In the past, there were springs on the side of the Code River, which are used for daily usage. However, as dikes and more houses were built, most of them diminished.

> No, but there used to be (this spring) in a hidden location to take a shower. But, now it has become a house. Over here, there is also a mosque for taking a shower. (Murni, RW 11, Gowongan, 2016)

A similar opinion is also expressed about this with additional information about common local knowledge about wells in the Mt. Merapi area are of good quality due to the type of soil:

> Yes, the dike 'killed' the springs. The load pressed by the sand, then the river current is contested with the water pressure. If in the past water entered the village, it is okay. The type of soil in the floodplain of rivers in Mt. Merapi is all with sand. Until now the well is never dry. (FGD, Andi, RW 07, Gowongan, 2016)

When the wells were filled with lahar in 2010, the community has to dredge the lahar from them. After that, the wells start functioning again, but the bed of the well is heightened.

> Yes. The well water is pretty good. At first, it was a bit murky, but from time to time, it got clean. (Murni, Jogoyudan, 2016)

The water quality from the well is consumable (see appendix) proven by the water sampling in the 2016 fieldwork. Thus, the water provision strategy chosen by the community in sub-case 2 is similar to sub-case 1 as the community also use well water for drinking. Here, the BBWS SO and Kimpraswil (DPU Yogyakarta or the Municipal Public Works Agency) are more known to deal with the lahar and flooding than on water resources in general. The community does not choose piped water also, as the ease of using a well and as the water never runs dry. During the lahar flood, the community got their water from their neighbors on a higher level of the riverside and water tanks dropping. After the disaster, they simply dredged the well, and it functioned again.

No irrigation usage is existing in sub-case 2. Although the river channel is used for small scale farming on the *wedi kengser* or the ex-lahar sedimentation in the riverbed and limited fishery using *keramba* or bamboo fish cage. Aside from that, during the observational period, there were times when the residents used the river as 'public toilet.' This phenomenon is considered to be acceptable by the kampong inhabitants as none of the people tried to banish the person (seen in the picture above).

For water hazard control, the *paguyuban RW* works collaboratively with the Tagana. This Tagana is the same as in sub-case 1. It consists of community members with walkie-talkies who report on the status of water level and gets information from upstream about water level there. That way, the Tagana in sub-case 2 can determine how long they have to evacuate when the water level has raised for 3 hours. The river also serves as urban drainage, as it is the lowest altitude of the city; the rainwater drains into this river. The BBWS SO has the authority to manage the river and main urban drainage, thus, made this fall into the responsibility of national government within the regional level, and the inhabitants are aware of this situation.

Municipal Sub-Case 3: focus on utilization, riverside conservation

A different type of CBO exists in sub-case 3, as this village has a strong initiative to promote the preservation of rural agricultural life. The main pillar of IWRM is the utilization, especially for irrigation and drinking water supply, while for conservation. It is done by not building any structure near the river. For hazard control, the villagers need to learn from flooding experience. The proof of conservation by the villagers is presented in figure 5.8, where the riverside location is showing lush greeneries all along the river. The water quality is not as good as the upstream river. It is also based on many different reasons, aside from the irrigation and batik home-industry utilizations. The CBOs exist there relates to tourism activities: Secretariat of Kebongagung Tourism Village and the Museum Tani (Agriculture Museum) at Candran Hamlet. Both are boosting the potential of Opak River scenery by the Tegal Weir, which relates to irrigation channels and the paddy fields. The irrigation water is used for paddy and mina (freshwater fisheries). The tourism activities include planting paddy in the irrigated field, traditional plowing using the buffalo, catching the eels in the irrigation channels and paddy fields, among other activities. As most of the villagers are still farmers, water usage in irrigation is considered very important. For this, they use the water from the upstream Canden Weir in Opak. The Tegal Weir in their village is used for the irrigation in the downstream area.

The municipal actor is the DSDA Bantul, at their branch office UPT Opak Hilir, who monitors the irrigation water. However, the irrigation area belongs to the regional level, PU-P ESDM, and the source or the Opak River belongs to the BBWS SO. Within this village, the division of authority for the irrigation and river shows a snapshot of how the water management playing field in the municipal level looks like. For drinking water, the community in sub-case 3 also mostly still use wells. Again, a similar choice is made for drinking water provision by self-organization. The quality of well water is almost similar to the two sub-cases before. The PDAM is not providing piped drinking water for this area; therefore, there is no option for them. Aside from these, the water in this village is also used by batik home-industry. The batik is also part of the Tourism Village activities and souvenir provider. The water is used in the coloring process. During the process, the best results are given when using flowing water. However, the batik industry water treatment in this village is not available. In the meantime, not many home industries, the water is only being diluted with river water. There seems to be no conservation action, aside from the planting of grass by the riverside. Also, no water quality control is at guard.

In this village, the water resources utilization (figure 5.9) is managed by different organizations:
(1) Irrigation: by the regency level government (DSDA Bantul), coming from a weir about upstream of the village of Wurkirsari with monitoring by the UPT Opak Hilir under the regency, irrigation area by the regional level (PU-P ESDM)
(2) River: Opak (BBWS SO), but the Tegal Weir managed by PU-P ESDM. It irrigates downstream farmlands.
(3) Ponds: mostly farmers' ponds
(4) Wells: villagers self-organize for drinking water
(5) Batik industry: by home-industry

Figure 5.9 Water use in Sub-case 3 (up left to right, down left to right): river as fish farm, paddy field and fish pond, agriculture tourism activities in paddy field, batik home industry, *wedi kengser* as temporary non-irrigated farmland, Opak River condition (Fieldwork 2016)

The role of water user association (WUA) or P3A for irrigation water exists, but it is diminishing. It is interesting considering that WUA, especially in villages, usually meet biweekly to discuss cropping patterns. But, only some active ones are still acknowledging this. Even a respondent claimed that without a *paguyuban* or coordination team if the farmer group (Poktan) were advance, there is no problem.

> P3A, divides water, proposing irrigation infrastructure. Water management is in P3A but the report here in Bantul there is at (D)SDA." (FGD, Kebonagung, 2016)
>
> It (P3A) is not working; less active. In the past, when it (irrigation water) was still hard to get (not enough water), it (P3A) was still persistent. (Martadi, Kebongagung, 2016)

Before the 2010 eruption, the upstream river of Tegal Weir is used for annual Dragon Boat festival on Chinese New Year. The tourism village initiative organizes this condition. The upstream weir is used for irrigation and also used to stabilize water level, which is utilized for water tourism activity. But, this activity can no longer continue following the 2010 eruption. Although the RBO had dredged the riverbed in 2011, the lahar still flowed, and no dredging activities were done up until the fieldwork in 2016 commenced (see picture below):

Dragon boat practice as pictured from a 0% condition in a normalization project for Tegal Weir (BBWS SO, 2011)

Boat docking location is filled with lahar sedimentation up to 100m to the river (Fieldwork 2016)

Figure 5.10 Comparison of Opak River in 2011 and 2016, Kebongagung, Bantul

Here, the role of BBWS SO is known for river normalization or irrigation maintenance. The same goes for PUP-ESDM. Although for the irrigation operation, the weir is handled by the DSDA Bantul or the municipal water resources agency. The farmers' group within the WUA or Poktan also handle the irrigation in daily practice.

For hazard control, the village is also equipped with the Tagana. However, as this village has no experience with flooding, except from the 2011 flood due to the riverbed siltation, the Tagana is not as expert the Tagana in sub-case 1 and 2. The Tagana orders for an evacuation order after first consulting the village officials.

5.3 Interaction Attempts

The implementation of IWRM calls for interactive actions all around, across sectors-domains (formal) and public-private partnerships (informal). Within the national level, interaction attempts are formed into guiding recommendation. More attempts exist within the regional level. Within the municipal level, for the case of Opak Sub-Basin is non-existent, as the rivers in this case study are inter-municipally crossing, the lowest level of coordination is within the regional level. The municipal level has to use the regional agency or regional mechanism to address their water-related problems. The diagram (figure 5.11) is based on what is known up to this stage of the research. Later on, the diagram will be used as the base diagram and be completed in the next chapters (6, 7, and 8). The diagram indicates the interaction attempts found and are themed for each of the levels. Based on the findings, these are based on themes, which located in each hierarchy of governance. Budget (A) for utilization and conservation pillars, water (B) for general utilization and conservation pillars, and disaster (C) for hazard control pillar. Meanwhile, the interaction can be formal (initiated by the government) and informal (initiated by non-government). They are located in each of the levels of governance hierarchy (horizontal), also inter-level/hierarchies (vertical): national (1), regional (2), and municipal (3). The lines are color-coded based on themes (A, B, and C). The X sign is used for failing interaction attempts, while the dots signify the connecting actors.

5.3.1 Budget Attempts: Water Conservation, Utilization, and Hazards Control

The formal budget attempts (A) are available and exist in the horizontal arrangement at each level: national (A1), regional (A2), and municipal (A3). In the budget attempts (A), there are two types of meetings that are held: Rakorbang (government coordination meetings) or Musrenbang (public-private-society representative meetings). The names of the meetings are corresponding to the level of governance. The ending '–pus' and '–nas' refer to the national level (A1), the ending '–da' to the regional level (A2), and the ending '–kot/kab' to the municipal level (A3). These attempts relate directly to the annual national budgeting (APBN). It continues throughout the year and usually consists of a smaller budget team: technical ministries (either KemenPUPR or KemenLHK), Bappenas and the Ministry of Finance (KemenKeu). The person who coordinates this limited attempt is termed as 'the broker,' functioning as to bridge the inter-ministries relations and operating at each level of governance, especially with the budget mechanism.

> Yes, only one (broker), which change each year. Later needs to find who, that's to boost (the budget), but we have to ready stock of program. (Respondent, BPSDA DIY, 2018)

The type of budgeting is through the APBN (National Government Budgetary System), comprising of all national agencies situated in the regional level. All the budgeting has to go through activities or project-based, which are proposed to the main office at the ministries within the national level.

At the regional (A2) and municipal level (A3), similar arrangements exist for the budget interactions. The names for these interactions are Musrenbangda and Rakorbangda (A2) and the Musrenbangkot/kab and Rakorbangkot/kab (A3). These formal attempts are also related to the regional and municipal budgeting proposal of the APBD (Local Budgetary System). However, the natures of these meetings are still 'ceremonials,' and sectorial ego exists between ministries. It implies that interaction is available, but it is not integrated, rather focus back to the 'boxed' budgeting for each sector.

> Not yet (integrated), well the bad thing in Indonesia, especially at the national government, sectorial ego still exists. In front of the President, things look good, but afterward, everyone goes back to their offices, each back on their own works. (Respondent water expert, 2016)

While with those in the regional and municipal level, the budgeting goes through APBD (Regional Budgetary System), which comes through the Ministry of Home Affairs. Essentially, these two budgeting systems are almost the same. Both are fixed budgets proposed to the national level. However, the first goes directly to the ministries, while the second has to come through one ministry. For a project or activity to be listed as a priority, it is based on readiness criteria.

5.3.2 Water: Water Utilization and Conservation

The formal attempts take the forms of water councils and irrigation commissions (B). All these water councils have 50%: 50% of governmental and non-governmental representatives. Within the national level, this is called the DSDAN (B1). The DSDAN focuses on national coordination between ministries and non-government organizations, consultations TKPSDA, regional level water councils (DSDAP) – located in B2.

Although the DSDAN (B1) holds national meetings annually, the consultations are not done regularly. The meetings discuss issues in policy settings, water-related problems, and orientation of Indonesian water management. The DSDAN's products range from recommendations to regulations. The Minister of Coordination chairs the DSDAN and vice-chaired by the Bappenas, although the daily coordinator is the Minister of Public Works and Housing. The members have all related the ministers in water resources management. Therefore, mandated by the Presidential Decree no.83/2002, the coordination function is not for everyday problems, but more to the policy decision.

Meanwhile, the informal attempts are done through the River Jamboree (B1) and have been held twice in 2016 and 2017 (Endang, AKSY, 2018). The aim is to raise awareness of river restoration movement, especially for urban rivers in Indonesia. The Jamboree was held in 2017, and in this time Yogyakarta had national attention. In the Jamboree, the activities consist of direct observations for waste, understanding the ecosystem, and River School for young adults to monitor water quality with river transect walk. (https://satunama.org/4205/siaran-persjambore-sungai-2-indonesia/). The targets of the Jamboree were national-wide river communities, government actors, and youngsters' participations.

Meanwhile, within the regional level, it translated into TKPSDA (hosted by BBWS SO based on WS), DSDAP (hosted by PU-P ESDM based on provincial administration), and Forum DAS, (catchment conservation hosted by the BPDAS-HL SOP) – B2. The meetings of these water councils are also 'ceremonials' in nature. Many of the results became general recommendations to the head of government (governor, regent/mayor, and minister). However, there is no mechanism available to use these recommendations into action planning or budgeting by each of the members. Aside from them at the regional and municipal level, there is also the Komir or irrigation commission. The coordination form within the municipal level is more technical, which serves, as a day-to-day basis of irrigation practice, while within the regional level, is more on water allocation. The coordination in Komir works better than in other water councils as it offers direct benefits on water allocation of farming activities.

> Even if as the (water council) head, I never had time to dwell on (problems). What I feel is, as a bureaucrat, there are too many meetings, so that we don't have time about what we necessarily have to do, many things are not accomplished. With the Komir the work is more technical. (Rani, TP5 DIY, 2018).

The Komir (B2) is hosted by the Balai PSDA DIY (under the PU-P ESDM). The coordination is also held for inter-municipal interaction. This condition is different from the water councils, as they directly decide on the water allocation for irrigation and not merely giving recommendations. More coordination is done through the TKPSDA WS POS (Coordination Team of Water Resources Management in Progo Opak Serang River Basin Territory), which has the same members as the DSDAP (Provincial Council on Water Resources) - (B2).

The difference between the two located in the spatial unit they are working on. The TKPSDA WS POS coordinates all stakeholders in the WS POS, which includes the Central Java Province and Yogyakarta Special Region. Meanwhile, the DSDAP only works with stakeholders within the province. The TKPSDA WS POS is funded through the BBWS SO, as it works with the same spatial unit (WS), while the DSDAP through the provincial budget. It is not mandatory to have a TKPSDA, which operates on the WS level. Although the DSDAP and TKPSDA exist as ways to coordinate better between government and non-government stakeholders, there is yet no direct mechanisms between the recommendations to problem-solving. Their role is important but has not been used to its maximum potentials.

> Yes, DSDAP's (Provincial Water Council) and TKPSDA's role are limited to giving recommendations. The authority is with the RBO. The management of the rivers authorities from up to downstream, from Serayu until Opak yes indeed BBWS. It is so hard. It is based on the Minister Decree. It was the baseline; there is nothing below it. (Gunawan, BBWS SO, 2016)

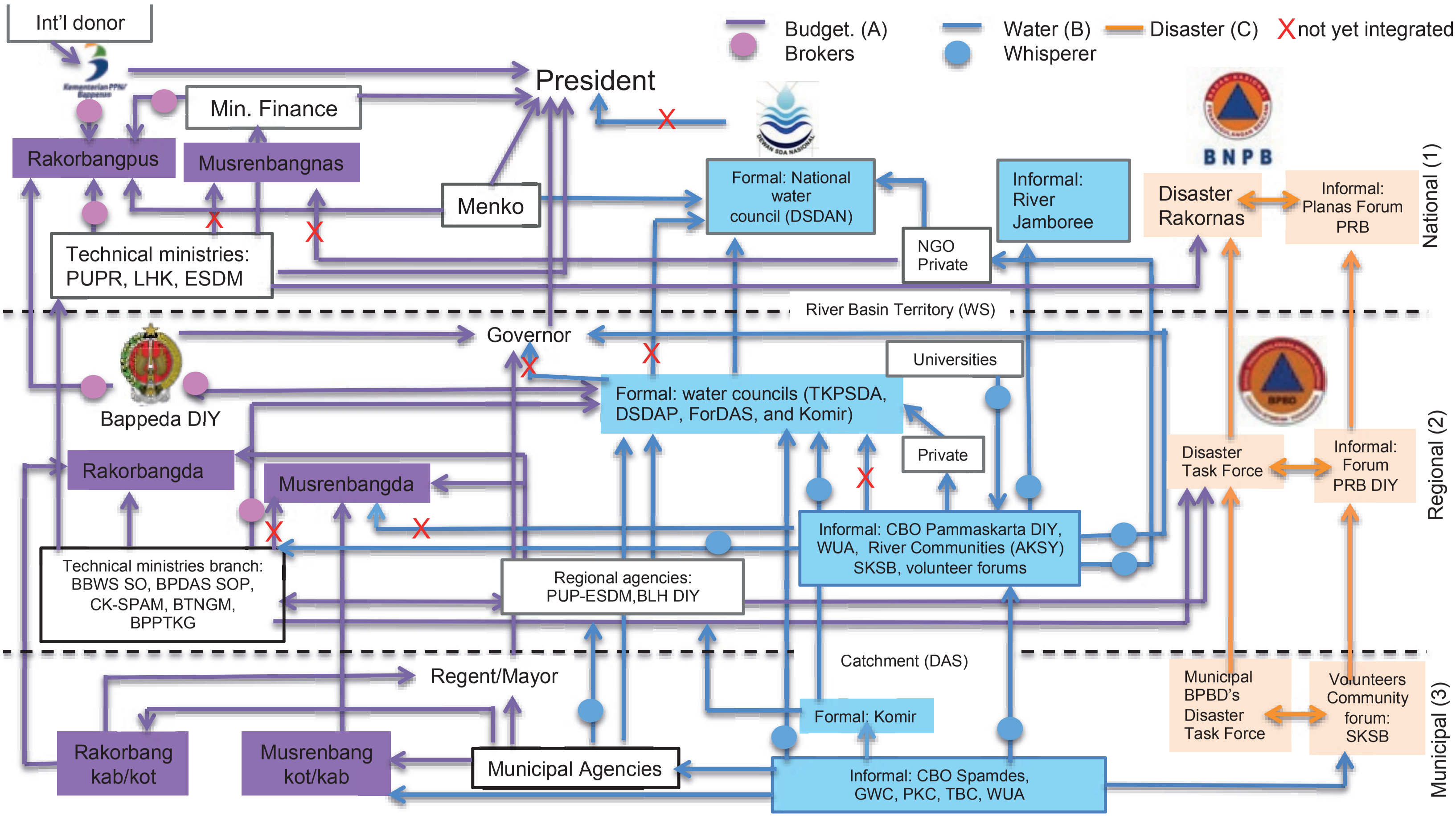

Figure 5.11 IWRM Interaction Attempts

For the time being, the disaster management agencies are not included in the council. But, it is a matter of urgency that they are included, especially relating to water hazards coordination. Also is the inclusion of BPPTKG in the TKPSDA, which is a way to be more aware of the volcanic hazards.

The main task of TKPSDA is to legalize the Pola and Rencana PSDA, below were pictures taken in 2013 on one of their meetings on finalizing the Rencana PSDA (figure 5.12). The BBWS SO prepares both of these documents. The Pola presents its targets with three economic scenarios: low (<3%), medium (3-6%), high (>6%). The scenarios are based on the rate of the regional economic growth. The TKPSDA should choose one of these scenarios. Based on the chosen economic scenario the Rencana will be prepared. In the case of WS POS, the TKPSDA chose the high economic scenario. This condition is the reason for the economic growth of the region, which at the time the Pola was legalized was higher than 4%. The proposed Rencana document was presented and discussed in 2013. During this meeting, usually, it will take longer than regular TKPSDA meeting. The pictures show the example in 2013, how the meeting took two days to complete the agenda. As the draft Rencana was presented, read together, discussed in smaller groups and reconvened in the plenary session and was finally agreed upon, with minor changes.

1st Day Discussion was lead by the PUP-ESDM, with BBWS SO as the facilitator

The group was divided into smaller groups based on the three pillars of IWRM: conservation, utilization and water hazards mitigation.

Figure 5.12 TKPSDA meeting 2013 (BBWS SO, 2013)

Although the fragmentation of the IWRM implementation is robust, during hazardous conditions, the interrelations of water-lahar play an even stronger role, especially in the field of coordination. This condition is somewhat related to the norms and values of the Yogyakarta Javanese and not solely be based on the nature of the IWRM approach.

> Something with culture is always challenging. In the past, it was underestimated. Our experiences showed that it is what we need. The application of local wisdom appears compelled by nature to emerge. For example, in *gotong-royong* (collective action), the rise was because of being forced not to use contractors. (Bayudono, an expert on water management)

This quote explained after the 2006 earthquake experience, the dormant collective action spirit, the *gotong-royong* was again active. The 2010 eruption was still a call for this action. This time again, not only the communities but also organizations joined hands to help the faster recovery of normal living conditions in the region.

Another forum in which the stakeholders meet each other is the Forum DAS Serang Progo Opak, hosted by the BPDAS HL SOP.

> Yes, there is a River Basin Forum (Forum DAS) for the Yogyakarta Special Region is also facilitating the cultural-based watershed. (Nardjan, BPDASHL SOP)

The members of this forum are also selected based on 50% government and 50% non-government representatives, where a Letter of Degree from the Governor legalized the members.

The aim is similar to that of the TKPSDA as the coordination team, to draft watershed management policies and align the inter-sectoral, inter-municipal, and inter-stakeholder interests in integrated watershed management of Yogyakarta Special Province and provide input to the Governor. Note that this is regional oriented than the TKPSDA as the latter provides feedback to the Minister. Also, it aims to facilitate cultural integration into watershed management. In practice, the meetings were attended by a majority of government officials; there is a limitation (code of conduct) in voicing one's problem. The results of the meeting as a recommendation are rated as not enough. There is also no room for evaluation on how things were developing based on the recommendations. Another problem is the attendees were elderly from WUA, who were coming for voicing their local issues, not on WS or catchment level.

> TKPSDA is talking only. Yes, we were actually pushing to there (voicing problems on the catchment or WS level). TKPSDA can bring an action, while DSDAP cannot. For example, in terms of river setback, why wouldn't TKPSDA dare decide directly? This condition is because the setback is an imaginary line, but TKPSDA can call it floodplain or (flood) line, for the community education. From my observation, even the DSDA and TKPSDA have never connected. (Endang, AKSY, 2018)

In summary, within the regional level, the informal attempts consist of two attempts: meetings of Pammaskarta DIY and AKSY meetings (B2). In these informal attempts, the government sometimes provides support either in budgeting, collaboration in action in normal meetings (B2). For example, the BBWS SO as the RBO got invited into AKSY meetings to discuss matters on rivers. This condition is seen as a two-way discussions forum, which is more useful to bridge between government and non-government actors.

> We may not have the (formal) 'umbrella.' But, we are the responsible party for the entire rivers. They always discuss things related to rivers with us. (Respondent BBWS SO, 2016)

The Pammaskarta DIY (B2) convenes its meetings not as part of government initiative activities but as part of their way to organize the Spamdes (municipal and village water supply communities). With the Pammaskarta efforts, the water supply coverage for the whole region acquired national acknowledgment as 80% of the target for piped water supply are achieved. The region has become the first to attain this target in Indonesia, due to the Pammaskarta's efforts. This initiative starts at the village level and will be explained further on the municipal level.

On the other side, the AKSY (B2) has more efforts on river restoration objectives, but not limited to the scopes. It provides support for coordination of 21 river communities within the region. The AKSY activities consist of conservation of catchment, river setback enforcement, river eco-tourism, involved in regulations consultation meetings, member of formal interaction attempts in DSDAP and TKPSDA, advocating between community-government, early warning system, water quality indicator using fishes types (*bio-tilik),* etc. However, the respondent from AKSY sounds her frustration with these formal attempts, as the results of the meetings are only recommendations, not real actions. These frustrations were explained in the formal attempts above.

These river communities are smart, and the government within the regional level is aware of their importance.

> For me, things like this are for the government officials; we have to have the spirit, that they have community partners. These partners need to be held. So, when now, the River Task Force of River Communities have been founded, Mr. Tri (BBWS SO Chief) needs to couple with them. The CK should partner with the Spamdes. (Rani Sjamsinarsi, TP5 DIY, 2018).

The formal meetings for the municipal level are held at the Komir (Irrigation Commission) – (B3). These meetings discuss the technical aspects of water allocation within the irrigation area under the municipality. Both formal and informal attempts are filled with 'whisperers,' persons who have good networking contacts and located either as part of the community, as part of the institutions, or as an independent entity. These people have the function as a trusted persona to convey an important message and at times, hints priorities in actions. These whisperers are characterized as boundary spanner and will be elaborated later in chapter 7.

> Precisely whispered it, (better than) submitting a proposal, as it will just be stacked. Respondent, Sub-case 3, Argomulyo, 2016.

Meanwhile, in the informal municipal attempts, the river communities (CBO) (B3) are more organized within the urbanized area of Yogyakarta, in comparison to the rural area. As the rivers are crossing municipalities, there is no municipal level river community. They are based stronger within the regional level. The main river communities or CBOs located in this case study are named after the name of the tributaries in Opak, such as PKC (Code), GWC (Gadjahwong), and TC (Tambakbayan). However, their collective actions are stronger and voiced in the AKSY. The municipal level government does support their activities, but as all rivers are under the authority of the BBWS SO, the permission of activities are diverted to them.

This informal attempt for water supply works up to the hierarchies level, gathering more significant impacts. As mentioned within the narration on the self-organized water supply, the communities arranged the water community at the village level (Spamdes). Initially, all water initiative is given a pump, but the operation and maintenance do not work, due to incompetence, and no one feels responsible, as explained below:

> It does not work; then the CK changed their mindset. Now, when you need water, the first form so (the CBO). Continue then, with what do you have? It turns out to be more *handarbeni* (feeling of ownership). Later, in Jogja there is a form of cooperative by *Ngerso Dalem* (the Sultan) is sworn here (at *Kepatihan* or the regional office complex). The

cooperative of Pammaskarta, *Paguyuban* (community) under them is the Spamdes, at the village level. (Rani, TP5 DIY, 2018)

This feeling of ownership requires a partnership with the communities. Now, the community has to be ready before the pump is given for the village.

5.3.3 Disaster: Water Hazards Control

The formal attempt collaborates with informal attempts (C). The formal is called the disaster task force (Satgas Bencana), while the informal attempt is called disaster management forum (Forum PRB). Both are located at each level of governance. In the national level:

> "So far, as I know, hazard prediction with us, in water resources is more on flood or other water-related hazards. That is included in the EAP (emergency action plan). What I did at the Dam Safety Center is the EAP. We did that as we know the volume, what if dam failure happens, and how we can simulate that." (Tri Bayu Adji, BBWS SO, 2016).

These are hosted by the BNPB within the national level (C1), BPBD at the regional and municipal levels (C2 and C3). The KemenPUPR as a technical ministry (A1) and their branch office (RBO) (A2) has to report water hazards monitoring data to the disaster management agencies as the base for evacuation decision. During the onset of the flood, the task force (C2) is always in close collaboration with the RBO also the PU-ESDM, but the community recognized the PU-P ESDM, and the integration attempts are close to cooperation. The community-government attempts are even suggesting the active role of the people as a volunteer to disseminate hazards information.

> We are included, people even know us, not the RBO. (Respondent PU-P ESDM DIY, 2018)
>
> Maybe (name omitted) understands, as he is also a member of River Taskforce, also for technically he is responsible. (Endang, AKSY, 2018)

Within the regional and municipal level (C3), the role of community in the interaction attempts are felt more. The interaction is high towards cooperation and is based on cultural cooperation.

> Jogja's *gotong-royong* is still good. The (social) capital is incredible. (Rani, PU-P ESDM, 2018)

The *gotong-royong* is known as a Javanese cultural value and exists still, during an eruption, which eliminates the boundaries' boxed' management. It activated the people's latent cooperation spirit, both in the governmental and community. The explanation about Pammaskarta Gunung Kidul for water-related hazards control in transporting water to the upstream impacted of the Mt. Merapi eruption is an example of how the government-community cooperation is working.

Meanwhile, for a volcanic eruption, the responsible technical ministry is the KemenESDM with PVMBG (C1), as the monitoring center for the volcano within the national level. During onset eruption, the BPPTKG under this ministry is in close collaboration with the task force (C2). The task forces at all level are the command center and prepared at the corresponding disaster management agencies (C). More information on this interaction attempt will be explained in the next chapter, as it deals more on lahar management. Aside from this Satgas Bencana during onset disaster, for pre and post-disaster, the inter-ministries coordination (BBWS SO-BPPTKG-BPBD) is non-existent between the different management (water, volcano, and disaster). This statement clarified this information:

> When there is no disaster potential, the term pre-hazard. It is the term of disaster management. Later, during onset, we are the commander. (Heri, BPBD DIY, 2016)

The interaction attempts also used all kinds of the medium on the ground (C3): walkie-talkie, cellular phone, traditional music instrument, etc., whatever which can get the message across faster.

> (We are accustomed to used) *bendhe* (small gong). Aside from alarm EWS, the community also us walkie-talkie. So, there are some communities in our area, SKSB, AMC, for flood is from SKSB, especially for rain lahar. Thus, the hamlet chief or other stakeholders mostly have the walkie-talkie, so all can hear the information. When the walkie-talkie is crowded, we anticipated with *kenthongan* (bamboo gong), when three times, with three interludes, it means flood. But, not all community members understand. It can also be informed through the mosque's sound system. Those are anticipation to minimize disaster risk. (Semprit, Argomulyo, 2016)

The quote also explains the sizeable community-based organization in this information network, which at times become overwhelming. Therefore, for hazard control, alternative mechanisms are used to spread the information other than the walkie-talkie.

The Forum PRB has better influences and flexibilities in disseminating information and supporting coordination, collaboration, even cooperation as they work without boundaries of ministries. The following quote about flood explains the cooperation between the village apparatus with the Forum PRB:

> Yes, when the village has a threat. It is more about flooding; then the river is part of the threat. They have to take this as notice; then we support the Forum PRB. It combined with the village's core, where it has autonomy. (Respondent, BPBD, 2018).

The disaster attempts (C) are more 'condensed' with actors for a short amount of time (during onset hazard), and it is only related to the water-related hazard control pillar. They cease to exist when the onset hazard is no longer available. The disaster task forces members dispersed into their daily tasks into managing the water conservation and utilization pillars. This arrangement will be explored more in chapter 6 on lahar management, also in chapter 7 on the interrelations of water to lahar management.

As a summary, the budget attempts (A) do not have informal interaction, but based on the information in this chapter, the water (B) and disaster (C) attempts do. The following table (5.3) presents the difference in characteristics between formal and informal attempts, which is valuable in determining the main actors for each interaction:

Table 5.3 Difference of Formal and Informal Attempts

Difference	Formal	Informal
Who initiates it	Government organization	Community
The budget source	Government organization	Community
Meetings atmosphere	Ceremonial, one way presentation	Relaxed, two way discussion
Agenda	Annual agenda has been determined before	Focused on immediate problems
Membership	50% government, 50% non-government (community-private), strict membership based on letter of decree	More than 80% community, loose membership, can be for everyone
Activities	Meetings	Meetings, training, education

5.4 Integration Level in IWRM Implementation

This haphazard arrangement of collaboration works (societal integration) existed between stakeholders and even fully cooperation (non-formal institutional integration) during the 2010 eruption. All stakeholders were able to integrate and coordinate their aims and resources. Full integration towards achieving better good is during an eruption, where safe human settlements and drinking water supply are priorities. Even though overlapping occurred, it relates not to integration level, but lack of coordination. The integration levels are not the same for each governance level. Based on the findings, there are progressing integration levels. The levels are (1) coordination, where data are shared, but no shared vision is established, (2) collaboration, where projects are synchronized, with no shared vision, (3) cooperation, where projects are synchronized with a shared vision, which entailed budget sharing.

Although interaction attempts mechanism exists, integration does not automatically heighten. The integration depends on the willingness of actors to work together. It is still some distance for the Indonesian IWRM to be fully integrated. At the moment within the national level, the integration level is still at 'baby step' towards coordination, which exists in the budget (A1) and water (B1) attempts. Despite their efforts to coordinate, there are still overlaps between ministries. Even if overlapped, each of the ministries also has their ego not to work together. This condition is shown that each has its own set of regulations, which are managing the same thing, which is water resources, but from a different way of thinking.

> Not integrated, because what I saw from past experiences. Usually, when something happens, then people just "throwing hands" [Indonesian term for not my responsibilities]. It (IWRM) does not yet happen. (Respondent, BBWS SO, 2016)

As for the integration level in disaster attempt (C1), the level is only high during onset hazards, which does not support the daily practice of the other two attempts (A1 and B1). As explained in the previous section, the disaster task forces are where the high integration level is happening.

As explained earlier, the IWRM implementation within the national level is highly fragmented into specified tasks division and diverse priorities. Thus, the coordination from each of the stakeholders at most of the time is still only an idea, but not adequately done. As volcanic river basin condition is not yet acknowledged, it is not a priority to be addressed, and the interrelations between the KemenPUPR and KemenESDM are not yet established.

Within the regional level, both seeds of collaboration and cooperation exist, but on the other hand, overlapping is a common trend in the water management patterns at this level.

> When we talk about the regulation of water resources management is talking about who did what, whether it can overlap, yes, it may, but there is mandate for coordination. (Respondent BBWS SO, 2016).

An example of the MoU for the SPAM Kartamantul is ranked as 3rd level integration (cooperation). Based on the formal attempts, there is still a low trace of the level of integration. It means, partial integration exists, but not as a total. This arrangement indicates that the main stakeholders aware of their roles in the IWRM implementation, but they seem to work on their own 'box.' During the water-related disaster, the integration level is better at ranging from collaboration to coordination within the disaster task force. The regional level proposes many interaction attempts, but its level of integration is not yet as high.

The coordination of water management within the regional level are arranged in table 5.4 as follows:

Table 5.4 Main Actors and their Roles in Opak River Basin Management

<table>
<tr><td>BBWS SO: the main actor in utilization, conservation, hazards control</td><td>BPDAS-HL SOP: partner in conservation (catchment)</td><td>PU-P ESDM: partner in utilization, hazards control, conservation</td></tr>
<tr><td>It is like this, as RBO, we must conserve water resources, utilize and develop water resources, but also protect from the damaging force of water. (Respondent BBWS SO, 2016)</td><td>Nature's characteristics, geology, spatial data, temporal data, those are normative. (Respondent BPDASHL-SOP, 2016)
(Respondent BPDASHL-SOP, 2016)</td><td rowspan="2">They (PU-P ESDM) are the minor stakeholders, the main is us. Just like this, all the primary drainage is returned to us. (Respondent BBWS SO, 2016).</td></tr>
<tr><td colspan="2">For example, BBWS only manage the water body of the river, but outside the river already belongs to the forestry sector (Respondent PU-P ESDM, 2016)</td></tr>
</table>

Within the municipal level, the integration level is mostly at the 2nd level, collaboration. With the active role, the community is more engaging with the informal form of attempts. Although the attempts are not as many as within the regional level, the integration level in the informal attempts is higher. The hosts of these attempts have stronger access to the budgeting scheme, which should aim at better collaboration, even cooperation. Outside of these attempts, there are countless sporadic discussions and meetings throughout the year, to coordinate different needs in annual programs. At times these occasional meetings work more effectively than the ones mentioned in the formal attempts. The focus is narrower and relates to the current budget, where actions are ready to be taken. As an example is the MoU for SPAM Kartamantul or Regional Water Supply System for the urbanized area of Yogyakarta Special Region. It aligns the budgeting scheme and timeline, between the national government (BBWS SO, CK-SPAM), private water company (PDAM), and regional (PU-P ESDM).

5.5 Conclusions

This chapter presents the IWRM implementation in a volcanic basin, which is characterized by (1) the requirement of integrated policy setting between water-volcano at its core, but still not occurred, (2) a multilevel governance conditions of current water management, and (3) the actors are interacting through existing mechanisms. The result of the analysis shows that the integration level is not as high as anticipated, which is the result of combined attempts in regional level, between formal and informal ways.

First, on policy setting, the required integration correlates the water and volcano management. Let alone on integrating policies to the types of geological conditions for each basin, the annulled water law is still struggling its 'come-back'. This circumstance supports the claim that the integration is not yet achieved. The tone of more 'centralized' approach in managing the water resources is also no longer appropriate with the changing times and current society's condition, which demands on more autonomous solutions in the regional and national levels (WS and DAS included). The IWRM implementation in Indonesia at the policy setting is not at a promising at the moment. A new law for water resources management needs to be established with more sensitivity to privatization issues of water, better guidance to different characteristic of river basin, support to partnerships between stakeholders in levels of governance, sectors, and public-private.

Secondly, table 5.5 shows the summary of multilevel governance condition as Indonesian IWRM implementation for the case of Opak Sub-Basin. This multilevel condition was peeled layer upon layer: national, regional, municipal, and themed accordingly based on the water management pillars: conservation, utilization, hazard control. Between the national and regional, the river basin territory as the current unit of water resources management exist, also between the municipal and regional, the catchment as the unit for conservation exist.

Table 5.5 Actors of IWRM Implementation in Multilevel Governance Setting

Pillars of IWRM Level of governance	Conservation Actor (activities)	Utilization Actor (activities)	Water-related hazard control Actor (activities)
National (Policy orientation)	KemenLKH (policy on forest and catchment conservation)	Bappenas (policy on water budget supply)	BNPB (Policy on disaster response)
	KemenPUPR (policies on water conservation: reservoirs; utilization: DMI-domestic municipal industry water supply, and hazard control: on mitigation with technical sides - flood, drought, landslide, lahar)		
Regional (WS: national-regional)	BPDAS SOP (catchments) BNTNGM (national park radius 4km from summit)	Satker CK SPAM (manage water supply in reservoirs) PU-P ESDM (irrigation, small dams)	BPBD DIY (disaster response for flood, lahar, drought, landslide)
	AKSY river communities	Pammaskarta DIY	Forum PRB regional
	BBWS SO (infrastructures form of conservation: small dams, check dams, utilization: weir, small reservoir, dams, Sabo dams.)		
Municipal (DAS: regional-municipal)	-	DSDA (monitoring of discharge in weir, irrigation maintenance) PDAM (water supply company)	BPBD municipal (disaster response)
	River communities (PKC, TB, etc.)	Spamdes	SKSB, Paguyuban RW, Tagana

The table shows specific actors deal with the pillars of IWRM. An actor cannot work alone, as there is just too much to handle in the different aspects of water. All IWRM pillars are handled through the KemenPUPR within the national level and BBWS SO or RBO within the regional level. They have partners in the corresponding level to aid the specifics of each pillar. The institutional arrangements show mixed actors from government and communities, but still low involvements of private companies. Many community actors exist in the regional and municipal levels in each of the IWRM pillars. Better communication strategies are needed and specifically targeting the organization for each level.

Multilevel governance on water management is hierarchically structured and fragmented. The most superior integration level is seen in hazard control pillar implementation, during an onset hazard through disaster attempts, where sectorial ego and hierarchical ego are diminishing. This condition is based on the *gotong-royong* and other local values in the region during the times needed to overcome all coordination barriers. Using the river basin territory (WS) as the unit for water management is a wise decision made by the Indonesian government, as it combines the river basin concept with the existing inter-basin infrastructures on the ground. However, to implement IWRM, the Indonesian government's attempts have not been successful. The varied level of integration supports this claim.

The IWRM does not provide theoretical guidance on adapting it in volcanic river basin settings. Thus, the Indonesian government performs a 'trial and error' for managing the volcanic river basin. The volcanic characteristics are taken into account in the water resources management plan. However, it does not include awareness of the hazardous condition with volcano activities as a holistic picture. At times, many actors related to volcano management are not aware that their roles are needed in water management. Also, the RBO is not sure how to involve them in the interaction attempts.

Thirdly, on the interaction attempts, better communication is established mostly through informal meetings (B, C) and 'skill of whisperers' for water interaction attempts (B). Learning from this experience, identifying these 'whisperers' for each of the actors is important. The use of communication technology is lessening the bureaucracy hassles and geographical distance problems. Another important finding is that during hazard occurrence, the interaction attempt is increased strongly. The overall integration level for the IWRM is still poor. Even though existing interaction attempts mechanisms (water councils) are installed. The integration level varied on each governance level, the highest is located within the regional level, where most of the water councils do exist, but not yet on the cooperation level. In summary, the regional integration level is some way towards coordination. This fact indicates the regional level as 'the priority playing field' for IWRM implementation in a volcanic river basin.

CHAPTER 6

LAHAR (RISK/RESOURCES) MANAGEMENT IN A VOLCANIC RIVER BASIN

6 Lahar (Risks/Resources) Management of a Volcanic River Basin

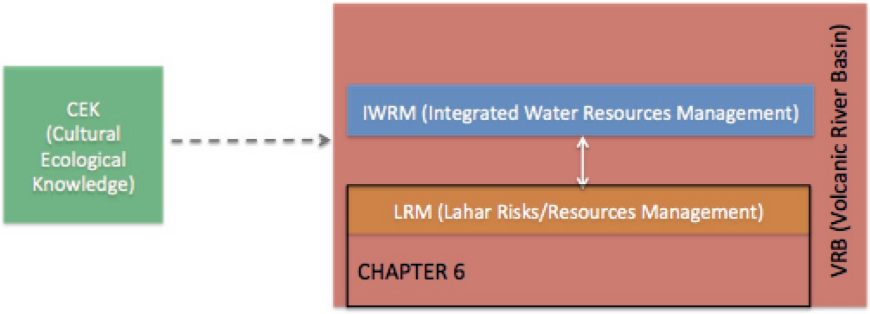

Figure 6.1 Addressed LRM Concepts within the Research Framework

6.0 Introduction

This chapter focuses on the LRM concept, to answer the sub-question of "What constitutes lahar management, and how is it being implemented in a volcanic river basin?" The LRM is located in the lower half of the conceptual framework on the VRB concept (as seen in figure 6.1) as the dependent variable. The structure of this chapter is based on the previous section with small adjustments fitting to the characteristics of lahar risks management. The title suggests to understand lahar as a type of resources; one has first to understand its risks to manage it. The secondary data (maps, planning documents, regulations, etc.) are also used to support interviews. These secondary data are the result of recommendations by the respondents or as it is referred to by other document or regulations.

This chapter addressed the sub-RQ by answering the first part of what constitutes lahar management. Therefore, the concept of lahar, which is under scrutiny relates to the definition of rain lahar as "the mudflow, which contains volcanic materials transported by water, including "debris and angular blocks of volcanic origin" (Bemmelen 1956, 20-36). Thus, the phase of DRR stages based on the literature reviews incorporated in this study are the stages of eruption: pre, onset, post, and also related to lahar production. This chapter also provides proof of how lahar management consists of lahar risk and resources management. Lahar may directly connect to the eruption. For Mt. Merapi it is associated with high precipitation after an eruption, which can occur up to several years post-eruption. This kind of lahar is also known as rain lahar, which relates to the existence of volcanic materials combined with the rain.

As for the second part of the sub-RQ on the implementation of lahar, management is answered using a similar structure of the earlier chapter on the multilevel governance used as the analysis framework. The lahar management is explained within policy settings, managerial contexts, interaction attempts, and integration level. Within each of the level, the lahar management is presented in the stages of eruption: pre, onset, and post, also by referring to administrative governance level: national, regional, and municipal.

6.1 Policy Settings

The Indonesian policy sets the boundary of a river basin based on geomorphological characteristics, in which rivers drain in its catchment toward the sea. However, a volcanic river basin is characterized by a volcano at its upstream as defined in the literature review. Thus, the volcano policy setting relates specific natural characteristic of lahar in the river basin. However, Indonesia does not have a single regulation specializing in lahar management. The lahar is mentioned in many rules, but no specifics are given in how to handle it. The primary regulation defining lahar is found in volcano management. However, the lahar is perceived as a type of hazard, and this is mentioned in the National DRR framework. Aside from that, the lahar is included as part of the water-related control in the water resources management law and spatial planning law for disaster-prone areas for river basin management.

6.1.1 Volcano Management Policy Setting

On the volcano management, the Indonesian policy setting belongs to the Ministry of Energy and Mineral Resources (Kemen-ESDM) and to be exact under the Geological Agency at the Centre for Volcanology and Geological Disaster Mitigation (PVMBG). It is legalized as Minister's ESDM no. 15/2011 on Guidelines of Disaster Mitigation for Volcano, Land Movement, Earthquake, and Tsunami. Overall, the guideline gives definitions relate to the management, as explained in the following. The definition of a volcano is a hill or mountain with a crater where magma and volcanic gases released to the earth's surface. Meanwhile, a volcanic eruption is a process of escaping magma and volcanic gas from the earth to the surface, which produces a loose variety of sizes or effusive that produce lava or incandescent rock. The KRB or the Disaster Prone Areas are areas that have been affected or identified as potentially threatened by volcanic eruption either directly or indirectly. Also on the types of hazards of a volcano are divided into primary and secondary hazards. The primary hazards are immediate danger caused by volcanic eruption products, such as lava flows, pyroclastic flows, incandescent stone and ash rain, poison gas, and lava. The secondary hazard is indirectly caused by volcanic eruption products, namely lahar and avalanches volcano. The status of volcanic or Volume Activity Rate is the level of activity reflecting potential threat of eruption. It is classified from low to high levels, i.e., Normal, *waspada*/alert, *siaga*/standby, and *awas*/beware. However, during pyroclastic flow (*awan panas*), lava flow, and lahar, all these materials flow into river valleys, especially those in the upstream area. Also, the volcanic activities tend to promote heavy rain as the particles were flown into the atmosphere. The volcanic ash rain can also decrease surface water quality.

The main duty of volcano management is monitoring the volcanic activities, which falls under the Ministry of Energy and Mineral Resources. This guideline stemmed from Law no. 24/2007 for Disaster Management. Based on these policies, the main duty of volcano management is monitoring the volcanic activities, which falls under the PVMBG. The above mentioned minister's regulation states the 127 active volcanoes in Indonesia. They are divided into three types: (A) still erupted after the year 1600, (B) no longer have any magmatic activity after the year 1600, but still has some mild activities such as the Solfatara crater, (C) those with remnants of mild volcanic activities, such as solfatara field. Mt. Merapi is categorized as type A, along with 75 other volcanoes are actively affecting the river basin they located on.

6.1.2 Lahar in DRR Framework: Hazards Control

The DRR policy is based on the Law no.24/2007 explained the framework of disasters risks reduction (DRR) as both human and natural caused. However, it is a general law for all kinds of disaster. The law calls for the implementation of disaster management:

> "A series of efforts covering the establishment of development policies at risk of disasters, disaster prevention activities, emergency response, and rehabilitation."

Some important points in this law are on terminologies related to disaster management, the acknowledgment of international agencies. They represent the United Nations, international organizations, foreign NGO, and the establishment of disaster management agencies. The national and regional BPBD coordinate the implementation of disaster management activities in a planned, integrated, and comprehensive way.

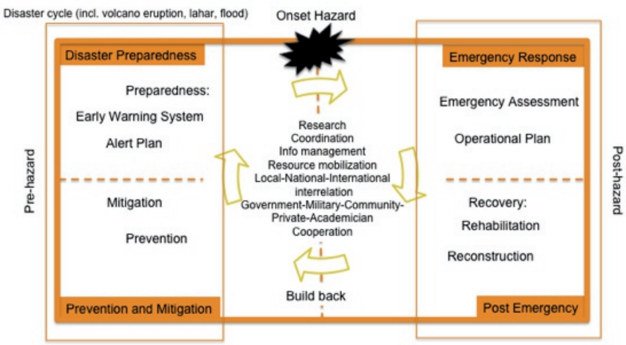

Figure 6.2 Model of disaster management with the author's adaptation (BNPB, 2011)

The law no. 24/2007 on disaster management gave a similar attitude, as it only refers to lahar is a type of flood. The implementation of this law also needs synchronizations with other law, especially concerning lahar as part of water-related hazards control in law no.7/2004. Although the second law has been revoked, the components of this law were taken as Minister's Regulation of PermenPUPR no.13/PRT/M/2015 for each of the stages of water-related hazards. Regarding disasters, mostly in flood and in this case lahar, the Law for DRR does not directly refer to KemenPUPR. Instead, it puts 'all related ministries,' but the Law for Water Management does this relating.

Another relevant law on lahar management as a water-related hazard is referred to in Law no.7/2004 on water resources management. This law is the Indonesian version of the integrated water resources management (IWRM). It appoints ministers and departments related to water management to control water hazards. Under this responsibility, the disasters referred to are:

> "Floods, lahar floods, landslides, ground surface sink, drought, and change of characters chemical, biology, physical of water, threats of endangered species and animal, the epidemic of a disease; intrusion; and seepage."

Although not explicitly pointing the Ministry of Public Works and Housing to be in charge. This formal language is commonly used in Indonesian law, as changes of names and merging or splitting of ministries are likely to happen throughout transformations of the Presidency. Thus, the law refers to the mandate to "the minister who is in charge of water resources," and to be more exact, it also explains:

> "Ministers or heads of non-regional government agencies, which are those whose field of duty relates to the field of water resources, including the functions of forest management, groundwater, agriculture, fisheries, water transportation, spatial planning, meteorology, environment and weather modification technologies."

This ministry is responsible for coordinating with the BNPB and BPBD to decide the status of disaster. This condition is a broad undertaking that one ministry is hoped to be addressing and already signals the expectations of collaboration between ministries and agencies. This ministry builds most of the water resources infrastructures. The way to mitigate disasters using a technical approach is handled through the same ministry.

6.1.3 Volcanic River Basin and Hazard Zone

Apart from the two mentioned laws above, no policy in Indonesia addresses the volcanic river basin specifically. On account of a volcanic river basin, there are two kinds of threats: direct and indirect. The direct threats are addressed as protected areas, and the indirect is addressed as limited function areas. The water resources in a volcanic basin underwent these two threats, which affects both the physical and chemical condition of the water. However, the concern of this research focuses on the second threats; namely, lahar, as the lahar flow occurs further downstream into urban areas and devastates all areas along with its ways.

The law, which addresses general river basin management, was the law no.7/2004 followed by government regulation (PP no.32/2012). This law abides by the river basin territory (WS), which addresses all kinds of river basins. It only discusses lahar as a form of water-related disaster, with no additional information on how to manage it. This fact is interesting. Either the law was being flexible, creating space for creative implementation or whether it merely neglects the importance of managing lahar. Again, although not specifically pointing to a stakeholder, the law no.7/2004 implicitly expressed the KemenPUPR as the primary stakeholder to manage with lahar, as it is considered as a water-related disaster.

The spatial planning law no.26/2007 addresses the spatial arrangement of any river basins. Concerning the volcano, this law acknowledged Indonesia's potential for natural disaster and proposed demarcation of disasters zones.

> "Geographically the Republic of Indonesia located in the disaster-prone area. Spatial planning is needed to be based on disaster mitigation as an effort to improve the safety and comfort of life and livelihood."

In regards to natural disaster-prone areas, these include the following disasters: volcanic eruptions, earthquakes, landslide, tidal, and flood. This prone area boundary is based on the work of the municipal disaster management agency (BPBD) together with many other stakeholders at the regional level, which is discussed in the sub-chapter.

This cycle type of work is where one side decides the zoning, and others take this as a ground-rule. However, after an occurrence of disaster occurred or after five years, a review on the work is done. Based on the review, a new hazard map is proposed.

However, based on Law no. 26/2007 on Spatial Plan, the upstream area, is included as conservation zone of a volcano. Especially on the upstream areas, the volcanic river basin is becoming national parks (radius 4km from Mt. Merapi Summit), which falls under the authority of the Ministry of Environment and Forestry. Although, the conservation zone delineation is based on the data by the Geological Agency, under the Center for Volcanology and Mitigation of Geological Disasters (PVMBG). As also the hazards zones or KRB's is determined by the PVMBG in collaboration with its regional level office. The KRB's states, which areas area impacted with direct and indirect threats of a volcano.

Another interesting fact is the level of immersion of JICA (Japan International Cooperation Agency) through its Engineering Consultant (Yachiyo) in the lahar management of Indonesian volcanic river basins. This strong collaboration between the Ditjen SDA and the JICA in the study and implementation of the Sabo Dam System throughout Indonesia has been prevalent since 1976 with the field study of Merapi (JICA 1976). Based on these data, JICA's involvement in the Mt. Merapi Sabo Dam has been cemented. Carefully thought plans had been drawn since then. Although most of the reports are technical engineering-based, they also include social study. However, the results of the latter are not apparent, aside from the master plans, which were socialized with village communities and meetings were held. Hence, the lahar management has a special place in Indonesia-Japan relationships.

However, based on this condition, there is no special attention being given to the volcanic river basins. The policies address the fact of volcanoes as a natural phenomenon. It is embedded as a national park for the volcano as recommended in the Law of Spatial Plan, the Minister's ESDM regulation on volcano mitigation, Disaster Mitigation, and Water Management Laws for lahar management. This partial approach in the policy context highlights the current condition of lahar management.

6.2 Managerial Context

The implementations of policies are carried through many stakeholders, which are located in layers of management. As in the previous chapter, this chapter unfolds into three layers of management context: national, regional, and municipal. However, there are also international actors' involvements in this context, located at any level of the management. This condition might be related to the nature of lahar as a hazard, potentially creating disaster threats. Therefore, when it happens, any stakeholder in any level of management will find its way to address it through any available resources. International actors in lahar management mostly are concerned about the condition of the region under threat of volcanic eruption. In general, during any hazard, international aids operate at any level necessary for them to support.

6.2.1 National

The BNPB and the ministries were involved in 2010 Mt. Merapi eruption, as its hazards areas consist of the whole Java Island. On the week of the eruption, all flights in Yogyakarta were canceled, as the ash flew from east to west of Java, limiting visibility. The hazard area covered two provinces; thus, inter-provinces authority belongs to the national government. Based on the disaster cycle, the managerial context is presented into three stages: pre, onset, and post-eruption. In each of the stage, the actors or the management units are explained.

National Pre-Eruption: Volcanology Monitoring

The volcanology department at the Ministry of Energy and Mineral Resources (KemenESDM) is the main actor for the volcano monitoring. This ministry has the responsibility to monitor the geological activities, which is implemented in the form of Geology Agency (Badan Geologi). Geological Agency performs the following functions: conducting research, investigation, and service in the fields of geological resources, volcanology and mitigation of geological, groundwater, and environmental, geological disasters, as well as geological surveys.

The Center for Volcanology and Geological Disaster Mitigation (PVMBG) performs the following functions, (1) prepare the formulation of technical policies for mitigation, (2) conduct research, (3) map hazard zones, (4) disaster risk analysis, (5) provides guidance of volcano observers, (6) monitoring, evaluating and reporting on the implementation. It has many branches in Indonesia, but lahar management is put under the Center for Research and Development on Technology of Geology (BPPTKG) at the regional level.

However, the most related to the actor of the lahar management at the national level is the Directorate General of Water Resources at the Ministry of Public Works and Housing and also the involvement of JICA. The JICA's participation on the DRR of volcanic basin management is grounded on the experience cooperation, between the two countries: Japan and Indonesia. For the case of Merapi lahar, the JICA has been Indonesian's partner since 1976. Based on the JICA master plan for volcano disaster mitigation plan (figure 6.3), there are two types of hazards against rainfall (secondary impact) and volcanic eruption (direct impact). The master plan directs the direct impact to be managed with non-structural measures (evacuation plan, land use plan, early warning system, disaster response training, etc.), while the secondary hazards have structural (lahar management infrastructures) and non-structural measures.

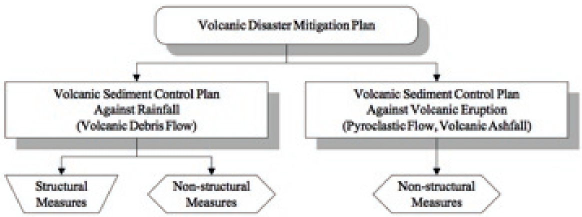

Figure 6.3 Volcanic Disaster Mitigation Plan (DGWR, Yachiyo Engineering Co.Ltd., and et.al. 2001)

Aside from these activities, the Bappenas run ‘its business as usual,’ the budget activities. The budgeting for the disaster fund is also proposed to the Bappenas as a way to prepare for any disaster. The component of the disaster fund at the national level is used to support lower government level. Based on this explanation, the Bappenas has a role in funding for all kinds of disaster, including for lahar disaster.

> BNPB has his own ‘on-call’ funds because it has funds at the time of the disaster, but the BPBD also has a budget. Every year, the DIPA budget at the national level has a reserve fund for disaster. So the reserve is transferred over to the next year. (Rani, TP5 DIY, 2018)

National Onset Eruption: Lahar Risks Management

At the national level, as presented in the policy setting, the BNPB is the main actor. Although not specifically related to lahar, this actor is the commander in times of disastrous conditions. Using the law on disaster management, the implementation of this law requires the establishment of BNPB and the Renas PB (National Plan on Disaster Management). Under this law, the implementation is seen during the 2010 eruption, where the BNPB took over the command line collaborating with BPBD DIY established orders in the emergency condition. The earlier is in charge of monitoring and coaching the later, while the second is more active on the ground. The most common disasters in Indonesia are flooding (46%), but the most taken toll on human lives is volcano eruption (147,000) between 1982 and 2012 (BNPB 2015). The BNPB functions as the command center during disaster occurrence, which involves all stakeholders under normal condition to be under its authority. Figure 6.4 shows how this function made the BNPB as the hub for management.

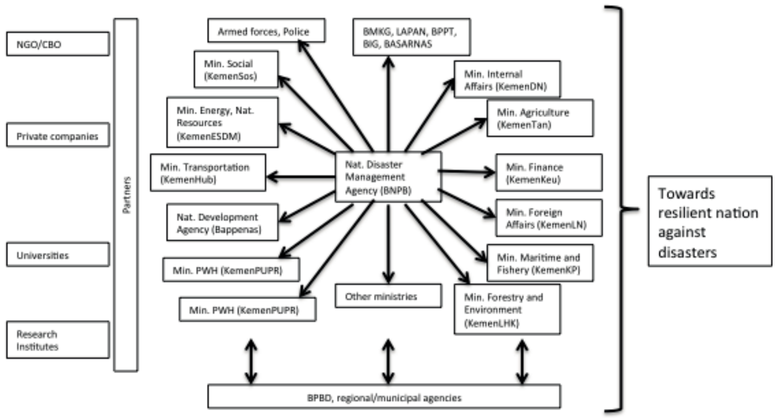

Figure 6.4 Implementation of Inter-organization synergy in Renas PB 2015-2019 (BNPB 2015)

In the occurrence of a disaster, the Bappenas is also a part of the coordinated stakeholders by the BNPB, while in normal condition is vice versa. Based on the figure above, the number of stakeholders in each of the disasters may differ. For example, in the case of flood, the KemenPUPR have more roles than during an earthquake. Using this overarching framework, the BNPB operations’ are limitless as long as the main idea is to maintain safety and order during disaster events. The Indonesian policy on DRR encompasses all types of disasters in their Renas PB. Based on the law on disaster management, there are channels for international aids to reach the locations. The national government is acknowledging these aids in the form of grants or loans. Another ministry, which relates to disaster management, is the KemenPUPR or the Ministry of Public Works and Housing. This situation has to do with their tasks in mitigation of water hazards (pillar no. 3 of the Indonesian IWRM). The way this is done is through coordination with the BNPB. Only when a flood has national impacts, between two or more provinces or in trans-boundary locations, then the BNPB manages it.

National Post-Eruption: Lahar Sediment Management

The JICA proposes lahar sediment management through Yachiyo Engineering. Co. Ltd. JICA is partnering-up with the Ditjen SDA (DGWR). The Master Plans of JICA calculated the size of boulder size and tests models in the laboratory before actually building the Sabo. Recent issues covered by the JICA studies: (1) general condition of Mt. Mt. Merapi, sedimentation related problems, proposed countermeasures, project cost and implementation, and evaluation (including environmental study), 2001; (2) public participation in disaster management (including sand mining management), 2008; and (3) handbook for sand mining, 2010. Even if these studies are general on volcano disaster, Mt. Merapi has been their focus since the 1980s, and the Sabo facilities become a natural laboratory. The models of Sabo dams are part of responsibility belonging to KemenPUPR through its own Research and Development Center (Puslitbang). Based on its structure, there are one related to each specific subject: water resources, road, and settlement. The one associated with the Ditjen SDA is called the Water Research Center (Pusair). However, their branch office for the Sabo dams test models is located in the regional level is called the Balai Sabo and introduced later at the regional level. Aside from JICA, the UN-Habitat also helps with the re-establishment of better housing in urban areas impacted by the lahar in 2010, while the World Bank aids through the rebuilding of settlements in the upstream Mt. Merapi, especially in direct impact zones through Rekompak JRF Program from 2010-2013. These international agencies are the most prominent players and work collaboratively through the Ministry of Public Works and Housing (KemenPUPR).

6.2.2 Regional

The regional level is where the main 'playing field' of lahar management occurs, as the location of lahar occurrence crosses over many municipalities and even regional boundaries. Also, main actors on the ground operate more engaged instead at this level than at the local or national level. The regional level still has the more significant authorities than the municipal, and it is also a bridge to connect international donors giving aids through national government or direct aids to the communities during onset disasters.

Moreover, being the most active volcano in Indonesia, Mt. Merapi has a special office: BBPTKG (Centre for Investigation and Development of Geological Disaster Technology for Mt. Merapi or Volcano Centre for short). Mt. Merapi is a Strato-volcano (a cone-shaped mountain), with effusive-lava flow and eruptive-sudden burst type of activities. The policy sets to manage a volcano includes the monitoring and prediction of the volcanic activity status.

The BPBD DIY (Regional Disaster Management Agency) also has strong onset hazard cooperation and post-hazard collaboration attitude for reconstruction, but not for post-hazards activities, such as sand mining, which become a contested authority, between the BBWS SO (RBO), PU-P ESDM (Regional Agency For Public Works). Especially, in the 2010 Mt. Merapi eruption, during the emergency response, it worked not only with BNPB in the national level and the municipal BPBD's but also with direct relief of international organizations and community-based organization. However, based on an interview, the part of pre-hazard, are not yet as integrated as the post-hazard. This condition is explained more in detail in the coordination attempts and integration level.

Regional Pre-Eruption: Lahar Infrastructures

The authority of the BBWS SO in terms of lahar is more on the river channels, which have been studied thoroughly by the JICA as mentioned at the national level. Thus, the results of their studies proposed the Sabo Dam System, with a series of consolidation dams and sub-dams in all rivers originated at Mt. Merapi. The concepts of Sabo Dams are adapted in the Indonesian context adding multi-functions (temporary bridge and irrigation intake) and use the sand mining activities as sediment management. These Sabo dams were prepared based on the calculation for 100 years return period of lahar (DGWR, JICA, 2001), however, as proven in 2010, the calculation may have not properly predicted the amount can reach up to 140 million m3. There are two types of Sabo dams implemented at Mt. Merapi: closed and open (see figure 6.5). The closed type is used to completely stop the lahar sediment flow, at which the dead storage condition can happen. Meanwhile, the open type has the conduit/slit pass, which still let pass smaller rocks and sand up to 50% of the discharge.

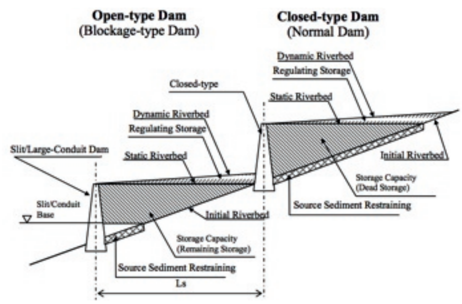

Figure 6.5 Sediment Control by Sabo Dam (DGWR, Yachiyo Engineering Co.Ltd., and et.al. 2001)

Based on the above concept of lahar management using Sabo Dams system, the current implementation is the combination of the open and closed type dams. This combination is performed to filter the size of the volcanic materials flowing in the river. The Sabo dam system in Mt. Merapi works in managing lahar using the filtering strategy. Bigger boulders use open type and sand pockets for upstream Sabo; closed type with holes between up to midstream with the help of diversion channel; embankments for midstream, throughout downstream areas where needed.

During 1986.1991, there were not many Sabo Dams that were built. This number rose during 1986.2001, adding in the groundsill and consolidation dams. More Sabo Dams were constructed during 2001-2011, which totaled up to 144 dams (BBWS SO, 2011). These dams were built based on a 100-year lahar recurrence interval. But, since the 2010 eruption was a 100 years cycle, the magnitude is not what these dams were designed for. Out of the 144, around 70 of them were demolished by the lahar flow in 2011. These Sabo dams were reconstructed, and more were added after the 2010 experience. Up to now, there are 259 Sabo dams based on the 2011 Master Plan by JICA. In total, these dams can hold up only to 20 million m3. The BBWS SO also perfected the Kali Putih Diversion Channel as part of protection to Jalan Magelang – Yogyakarta (Provincial Highway) in 2010 and disconnected the city from the northern part of Java Island. Although, as the experience told them that diversion channel is not functioning if the magnitude of lahar is as enormous as it was in 2010. Those understudy for the Opak sub-basin is located in the tributaries: Kuning, Boyong, Gendol. Out of the 102 Sabo dams, 58 have other functions, either as intake or Oprit (bridge) or both. The following data summarized the extent of Sabo dams in the study area:

Table 6.1 Sabo dams in Opak Sub-Basin 2016 (PPK PLG Merapi 2015)

Tributary's Name	Code Name	Catchment (DAS)	No. of Sabo	Status 2016 Volume Capacity (m3)	Multifunction oprit/intake	With water intake	With Oprit	Both
Boyong	BO	Opak	56	2,338,668	33	33	6	6
Gendol	GE	Opak	22	1,161,379	11	1	10	0
Kuning	KU	Opak	18	2,745,167	11	5	7	2
Pabelan	OP	Opak	6	75,521	3	0	3	0
TOTAL			102	6,320,735	58	39	26	8

This situation also means that lahar management, although having a high priority comes second to daily needs of water and transportation. These other functions are established, as there are similarities of dam function for water and lahar, which is a cross-river body infrastructure.

> It is converted into multifunctional, the main function is the sediment control, but the second function is an intake for irrigation. It has the same principle form, only with a gate (water intake). We do have a vision of a direct impact on the community. If it is that (a bridge-described with hand movements), it has a direct impact, the public could directly benefit from it. (Heri, BBWS SO, 2016)

The multi-function favors permission from the villagers, as many protests were drawn after the 2010 eruption when the BBWS SO proposed to rebuild the Sabo dams. However, after discussions with the community, all of them want the Sabo dams to be rebuilt.

> Oh yes, if there is anything like it. It was after the 2010 eruption that's also a lot of community leaders anyway, of which several community leaders say, who 'heat the situation.' But after I talked to them, no, they want it to be rebuilt, especially with the multifunctional form like that. (Heri, BBWS SO, 2016)

In this sense, the BBWS SO accommodates several interests, which, according to the organization, is an acceptable role. Especially, as the rivers are under their management, where the lahar hazard is taking place. The following quote supports this condition:

> Although this lahar is only on its destructive power, not on how much potential, it is [under] the ESDM volcanology. According to me, indeed it's okay that the BBWS is positioned as the connector between several interests. (Hanugrah, BBWS SO, 2016)

Plans on lahar management aside from the extensive network of the Sabo dams are as follows:

> "For bigger sediment volume, it is recommended to build the SRD (Sediment `Retention Dam) with 5-10million m3 capacities, we will need 10-20 SRD's to hold off the sediment flow, which is at the moment residue at 100 million m3." (BBWS SO, 2011 from pu.net)

But, there is no location for such SRD, as most of the river basins are highly developed. The RPSDA WS POS does sound this plan, as there was no potential location to put this. Alternatively, more sand pockets are used, if a massive SRD cannot be provided. As long as the plan is sounded to the community, the needed relocation and buffer zone for lahar is delineated based on direct calculation.

Aside from them, the BPBD DIY roles in this stage include:

> So, what needs to be prepared within pre (eruption) is in my division, prevention, and preparedness, by preparing the risk studies, five-yearly disaster management plan, regional action plan, also socialization, EWS installment, etc. Within the pre-disaster process is when we do the studies on which zones are hazard-prone, where the villages and their inhabitants potentially also might get impacted by the disaster. What we have to do there include mitigation, prevention, study, education, training, socialization, and early warning. (Heri, BPBD DIY, 2016).

So, even though at this stage, the BPBD DIY is passive, they are also responsible for the preparation activities for future hazards. It is done collectively with the municipal BPBDs. The regional level instructs, provide the modules for training and education, but the implementer is at the municipal level.

It is evident in figure 6.5 that the lahar is controlled using the Sabo dam system throughout the river systems, which is located in Mt. Merapi. Thus, the volcanic river basin characteristic management in this case study is quite developed and anthropogenic controlled. The infrastructure damaged the natural condition of the rivers to secure the settlement and agricultural area. It is also clear that the upstream suffers for the benefit of residents who live in the mid and downstream. This information is not disseminated, as it is considered as a sensitive matter to the upstream village communities, but they do deserve to know this risk. By presenting this figure, the perception of lahar management is based mostly on the technical solution, while in reality; the most important thing is the readiness of communities to evacuate. The system is explained as follows (see figure 6.6): (1) sediment retention dam: to stop big boulders using open type Sabo (upstream), (2) guiding dam: to filter smaller boulders using smaller size closed type Sabo, also known as Sub-dams (up to midstream), (3) consolidation dam: to stabilize the riverbed after series of Sabo using bigger size closed type Sabo (up to midstream, (4) sand pocket: to park some lahar sedimentation on the sides of the rivers (up to midstream), (5) guiding channel: to steer the lahar flow to specific locations, useful in a location where the river was diverted to give way to roads (up to midstream), and (6) dikes/embankment and channel: to steer the lahar flow and secure settlement areas (mid to downstream).

This figure 6.6 also visualizes the authority of management in the whole river basins. During pre- and post-, the Bappeda DIY has the highest in the hierarchy as coordinator. But, during hazards, the BPPBD DIY took the main command at the regional level.

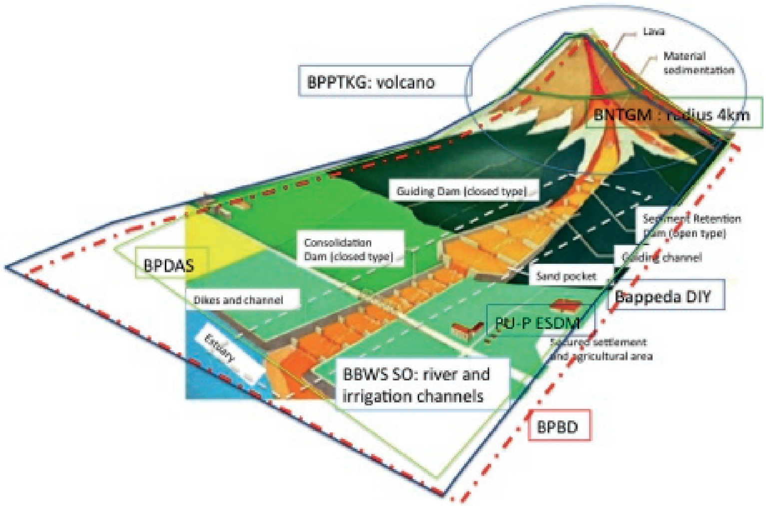

Figure 6.6 Sabo Dams system and authority of management in Mt. Merapi and its River Basins, elaborated (BBWS SO 2011)

In summary, the stakeholders are presented in the diagram and arranged as follows:

(1) Bappeda DIY: all space in regional administrative during pre and post-disaster

(2) BPBD DIY: all space in regional administrative during onset disaster

(3) PU-P ESDM: all infrastructures belonging to the provincial government and management

(4) BBWS SO: under the KemenPUPR for all the rivers, lahar and flood, including floodplains and the Sabo Dam infrastructures

(5) BNTGM: under the KemenLHK, the national park of Mt. Merapi– scales of management: 4 km radius from the summit

(6) BPPTKG: under KemenESDM on the Mt. Merapi's volcanic activities are monitoring – scales of management: the whole mountain up to its flank and the rivers where the volcano channels its debris flow.

(7) BPDAS SOP (Catchment Management of Serayu Opak Progo): under the KemenLHK, for all catchment managements especially for water retention inland

Regional Onset Disaster: Volcano Eruption and Lahar

At the regional level, the BPBD DIY is the regional partner of BNPB. Although not established in one roof, the BPBD is a true regional actor. The command line goes through the Ministry of Home Affairs, and the highest commander is the Governor or the Sultan. The BPBD is Chief, and it uses the RPB to address all disasters potentials that are belonging to the region, either natural or human-made. The document is valid for 20 years from 2013 to 2017. As the BPBD was newly established in 2011, there is only one RPB. The priority for Opak Sub-Basin consists of everything, but the focus of this chapter is the volcanic eruption and its relation to lahar flood and water management.

Moreover, out of the following potential disasters in the next table, the reports of disasters (1995-2011) in the region that claimed the greatest number of lives were due to volcano eruptions and earthquakes. The flooding happened more often than the volcano eruptions, but this also included lahar occurrences, which means that the lahar flood was not specified as a special form of a flood. The data below illustrates the disasters, which occurred (BPBD DIY, 2013):

Table 6.2 Type of Disasters and Impacts in Yogyakarta Special Region (1995-2011)

Type of Disasters	Occurrence	Died	Wound ed	Missing	Suffered	Evacuated	Heavily Damaged Houses	Slightly Damaged Houses
Flood	34	2	5	-	3.090	869	139	-
Epidemic of disease	1	16	-	-	-	-	-	-
Abrasion/tidal wave	1	-	-	-	-	-	-	29
Earthquake	10	4.923	22.406	-	-	1.403.617	95.903	107.048
Tsunami	1	3	3	-	-	-	-	-
Technological Failures	2	75	119	-	-	-	-	-
Drought	34	-	-	-	-	-	-	-
Volcano Eruptions	7	4.249	186	-	-	10.759	2	-
Extreme Weather	24	16	83	-	-	790	226	1.417
Landslide	12	32	5	-	-	589	47	500
TOTAL	127	9.316	22.807	-	3.090	1.416.624	96.317	108.994

Based on the data provided above, the seven eruptions dating back from 1995 still ranked second, with thousands of people have died. Also, as the BPBD DIY was just established in 2011, the role for training and education on disaster during those years were neglected or maybe partially addressed. During onset eruption, the studies prepared by the BPBD DIY in the pre-eruption stage is hoped to develop the people.

> When it (hazard) happened, the studies we prepared for are supposed to protect the people from disaster potentials. Secondly, we prepare the people becoming resilient people in facing it (hazard). (Heri, BPBD DIY, 2016)

The BPBD uses the feed of data from the BPPTKG to decide the status of the volcano. Generally, the BPPTKG is responsible for conducting research, investigation, development of technological and instrumentation methods, facilities management and infrastructure of geological disaster laboratory and mitigation and study of Mt. Merapi. The monitoring there uses International standards and observation posts, remote sensing, and UAVs (unmanned area vehicles):

> Monitoring, for Mt. Merapi the standard is international, it is seismic, deformation, geochemical, visual. Yes, the visuals are represented by observation posts of our volcanoes. Depending on each volcano. In Mt. Merapi, there are 5, because it (the eruption direction) moves around and active, but if the direction is the same, once is enough. (Dewi, BPPTKG, 2016)

This situation explains that sophisticated and remote sensing technology and international standards are used by the PVMBG to monitor their volcanoes. However, there is also the need to visit the sites (observation posts), when the device is not working or cannot be remotely accessed from the office or when they need to crosscheck measurements directly. The morphological condition of Mt. Merapi has changed drastically since the 2010 eruption (see figure 6.7). A big crater as deep as 200m formed due to the eruption. An interview with the BPPTKG personnel reveals that Mt. Merapi's cycle is continually changing. Thus, the natural dimensions of the volcano-related to the temporal cycle of volcanic activities.

Figure 6.7 Mt. Merapi Summit Condition before and after 2010 Eruption, the new crater depth is 200m (Jousset et al. 2012, 121-135)

Using the precursors of the Mt. Merapi Eruption by BPPTKG, an expert knows whether the Mt. Merapi volcano is active or at normal condition. Surono was a key person in BPPTKG (earlier called PVMBG) in monitoring these precursors, published his findings in a scientific journal with his international colleagues. The office has a kind of sophisticated control room, where live feeds and different types of sensors are located. Although this control room is based on scientific knowledge, the intuition of the person is based on experience, and this is what the decision-making process is about.

Based on this excerpt, even if the volcano is under detailed monitoring, there is a need for experience to decide the status of the mountain. It cannot be simply based on the reading of the data presented by all sensors. Here, the expertise of a leader in deciding the status is an essential aspect for the safety of many. The picture below explained the onset of Mt. Merapi 2010 eruption with its pyroclastic (seen as a cloud) and the lahar, which inundated the Gendol River up to its flank and even pirated other tributaries and the villages nearby the rivers. The indicators they used for the eruption cycle is the production level of SO2 flux. Based on the reading of this flux, the phase volcanic is enduring to the timeline as shown. The following figure 6.8 describes the 2010 eruption during *'awas'* (beware) status:

Figure 6.8 Condition of Mt. Merapi during November 2010 eruption (left) and Gendol River (right) (BBWS SO Documentation, 2010)

Based on the interviews, the intuition of experts also guides them, and the data presented above was done through the monitoring of volcanic activities using remote sensing and satellite data by the BPPTKG. Based on the interview, the intuition of the expert in predicting volcanic activities is also an important part of the 2010 eruption experience:

> But that recommendation was from us. Need to evacuate or not. In standby status, all warnings were given and that we've been there with them if something happens to evacuate them, the Mt. Merapi does not have a clock (it can be anytime). This (intuition) is based on field experience (predicting), not foretelling. (Dewi, BPPTKG, 2016)

Another interesting piece of information is about the 2010 Mt. Merapi eruption and lahar, and the early warning provided by the Sultan. Even the BNPB has agreed jokingly that the Sultan is better than modern technology. However, the EWS (early warning system) using the Sultan's premonitions (*wangsit*) is not to save lives, but more to help the people aware and be ready when the disaster struck.

> Yeah, so our colleague at the National Development Agencies said, "You don't need EWS, your King has exceeded our EWS." But He would not be able to save, those who are supposed to die must die, but He prepared his people, to become more vigilant. When it happened, I just called the Natural Resources (Management) Agency in Sleman Regency, "Brother, step aside; His Highness had spoken to us." (Rani Syamsinarsi, PUP-ESDM, 2016)

Here, it is also clear that there is a system of communication that is held during a disaster, which is special and through the direct command line with the Sultan. This situation was a different approach during normal volcanic conditions when all correspondence was mostly dealt with using formal letters. The emergency status helps to fasten the information dissemination and provides a better condition to collaborate, and even cooperate between stakeholders. This situation is perhaps due to the philosophies, as explained in the Local Regulation on DAS or catchment management:

> The uniqueness of the spirit of mobilization of all resources (*golong gilig*) in integrated (*sawiji*) in the persistence and dynamic hard work (*greget*),

accompanied by confidence in action (*sengguh*), and will not retreat in facing any risk whatsoever (*ora mingkuh*). (Rani Syamsinarsi, PUP-ESDM, 2016)

The perception of *sawiji* is also presented as the region is seen as becoming one, where all are helping one another, especially during difficult times, like during onset disaster.

The outreach of lahar in 2010 is presented in the BNPB's map (figure 6.9) on the lahar risks is used, with the lahar's fan flow is pictured to reach to 25 km with inundated zone up to 300 m to each side of the river (lahar buffer zone). The map illustrates the lahar flow to Opak Sub-Basin consisting of the Boyong, Kuning, and Gendol Rivers. The lahar at Gendol River, as shown in the following figure, pictured the characteristics of Mt. Merapi lahar: volcanic materials with high temperature combined with rainwater and speed of maximum 100km/h. The flow dispersed downstream from Mt. Merapi to locations where the opening of the crater exists to East and South.

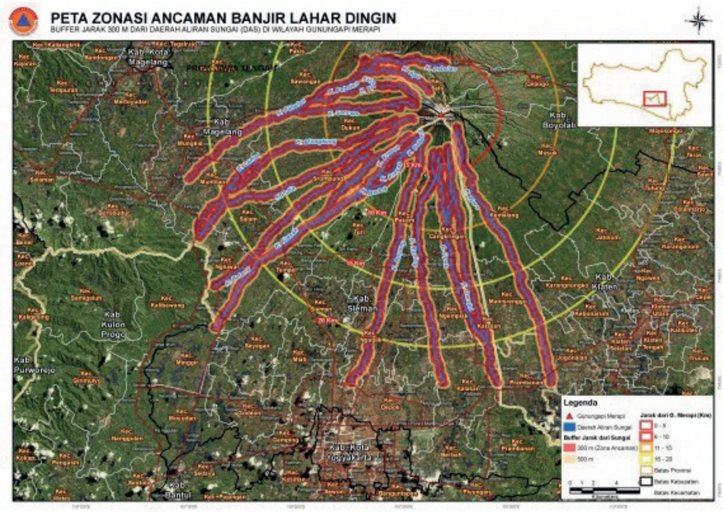

Figure 6.9 Lahar prone zones (BNPB 2010)

The BNPB made this map for the BPBD DIY, which presents that for many villages, this distance to the rivers meant their villages are completely violating the buffer zone. Therefore, the further investigation becomes the mandate of the BBWS SO and BPPTKG. The buffer zone is especially important to locations nearby Sabo dams and flat river channels. As explained in the following quote:

> We do not know who gave them the information of 300 meters (river setback), lahar delineation is depending on its channel. The cliff's width there will be overload, we do not have to wait for the 300 meters, and all will be filled. (Dewi, BPPTKG, 2016)

Based on lahar formation process, on its composition and speed, the term of lahar are High concentrated Stream Flow (HSF), Debris Flow (DF), and Stream Flow (SF). This monitoring does not belong either to BBWS SO or BPPTKG. Both organizations denied their role in this. The BPPTKG is more concerned about the volcanic activities, in general, to pinpoint when an eruption happens. However, the BBWS SO concerns are more to the lahar flows and the infrastructures they build to control damages to urbanized areas and human settlements. There is a missing communication link between the two organizations, but the lahar is however managed under these two organizations.

> Well, let alone the speed that is not our function at all. Our task is the connection between the primary and secondary of Mt. Merapi (impacts). Well, we only want a small (information), to know the potential lahar volume. (Dewi, BPPTKG, 2016).

The monitoring of lahar flow uses EWS, which is installed by the Balai Sabo with its signals copied to a receiver at BBWS SO. During the rainy season, the EWS can provide data required for evacuation in all rivers connected to Mt. Merapi. However, the BBWS SO is only responsible for the provision of the infrastructures, while the mitigation plan is the authority of BPBD DIY. Many stakeholders have EWS for lahar.

Another interesting fact related to the cultural ecological knowledge is the way the 'Sultan's EWS' works for lahar as part of the *wangsit* or premonition. He does this through rituals in the river that comes down to Yogyakarta inner city.

> "At the time of the eruption (2010), His Highness used his royal clothing with his spear aimed at seven rivers, he speared (the riverbed). He (the Sultan) asked for some sort of protection, "You (lahar) should not disturb my people"' (Rani, PUP-ESDM, 2016).

This *wangsit* and ritual are a clash of tradition and the modern era. But, by giving signs on the seven rivers as lahar channels, the people are aware of the dangers of the river and how to stay safe from a lahar, especially for communities living by the rivers.

The lahar composition and speed do not belong to either the BPPTKG or the BBWS SO; it belongs to another organization since the type of Sabo is supposedly based on these data.

> Composition and speed of lahar supposed to be the authority in designing the RBO for the Sabo. Our Sabo design conditions may not be fundamentally based on the lahar calculation. The form of Sabo designs, some striped like a sieve, but this design is not used. Here, most of them look like, a big hole and small holes. It seems to be based on the design of the composition of the lahar, which flows. (Gunawan, BBWS SO, 2016)

This role belongs to the Balai Sabo, as mentioned earlier, at the national level; it is the Water Resources Research Center (Pusair) branch office. This center develops research and development in the field of Sabo dams. It is aimed at providing technical advice in the area through surveying, investigation, review, physical and mathematical model testing and Sabo infrastructure planning (http://www.pusair-pu.go.id/organisasi/balai-sabo-5-1-7). However, when asked about the availability of the speed and composition data, the respondent from this office explains that the office does not have them. Therefore, the Sabo design is not designed based on these data but based on the size of boulders and rocks that flow with the lahar (DGWR, Yachiyo Engineering Co.Ltd., and et.al. 2001).

The design of Sabo dams apparently is solely the work of JICA's consultant: Yachiyo, but it is tested on Indonesian research center: Balai Sabo and then implemented by the BBWS SO on the field (in all rivers originated at Mt. Merapi). Thus, the lahar management is somewhat belonging strongly more on the KemenPUPR side; then it is on the KemenESDM authority. It was explained in the previous sub-chapter of the study on the design of the Sabo dam system in Merapi.

> Yes, because in designing the sabo dam infrastructure we have to pay attention also on sediment capacity, so it can still flow downstream. I do not let it flow, degradation (of riverbed) will happen. (Gunawan, BBWS SO, 2016)

As rivers are morphologically deeper than their surroundings, the lahar with its fluid nature flows through them. There are nine tributaries of Mt. Merapi flows. Five streams are belonging to Progo and three to Opak river basins, while one belongs to Woro River Basin under the BBWS Bengawan Solo. However, Mt. Merapi Lahar Management Project Office (PPK PLG Merapi) by the BBWS SO manage all of these rivers. As the lahar cools off, the sedimentation stayed and filled the riverbed to the brim, even to pile up to the sides and produced extra height. At the onset of lahar, the only way to survive is to evacuate. Also, if the Sabo dams system is installed, there is still a possibility that the lahar may inundate the buffer zones nearby the rivers.

During the onset of lahar, clean water becoming scarce in the rivers, and the wells are too hot to be used or flooded with the lahar. The only way to get water was from water tanks dropping from related stakeholders, especially PUP-ESDM and BBWS SO. It is specifically related to the up- and mid-stream locations, where the villagers are also provided with plastic water tanks for domestic usage. The practice of water dropping is common to remote areas in Gunung Kidul Regency (Karst region) during the dry season, so these stakeholders are prepared with the trucks and its tanks. Alternatively, the village communities use existing springs, which was not impacted by the lahar. More about this is discussed at the municipal level.

Regional Post-Eruption: Lahar Prone Area and Sand Mining Management

For floods, including the lahar flood, the BBWS SO is mandated to form a Satgas or a Task Force on Disaster Management (internally). The members of this Task Force are also the members of the Fast Technical Review Team, which is responsible for determining the disaster status together with BPBD. This Team consists of structural personnel (the Division Head or Section Head: someone with authority to decide), a PPK (project leader), a BBWS SO staff, and the task forces of the related organizations. The workload of the BBWS SO as the primary technical reviewer is for the status of the water-related disaster. The historical eruption and lahar on Mt. Merapi (1911-2010) illustrated the 'fan' pattern of the lahar and hot cloud changes from time to time, which made the Mt. Merapi being observed from 5 posts, with the current main direction to be Southeast. Thus, the BBWS SO's also focuses their work on these rivers, mainly to mitigate the risks of lahar flow. Out of these rivers. However, this study pays more attention to the tributaries of Opak, Boyong-Code River, Kuning-Gadjahwong River, and Gendol-Opak River.

In the case of Mt. Merapi, there are three areas divided (see figure 6.10): KRB1 for direct impact, KRB 2 for combined direct effects, and KRB3 for indirect impact. The Mt. Merapi disasters map is a collaborated work between the Kemen ESDM under the Spatial Plan Directorate General (previously under KemenPU, the same ministry as the BBWS SO).

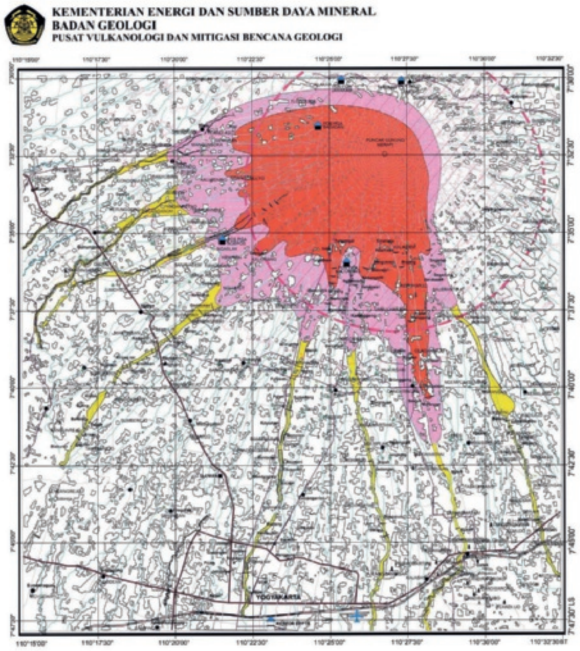

Figure 6.10 Hazard Zone (KRB) Map (KemenESDM, 2010)

The policy for the spatial plan based on this disaster location is as follows:

Table 6.3 Hazard Zone (KRB)

Zone	Zone characteristics	Spatial plan policy
KBR 3 - Red (most dangerous) approx. 4 km radius	Very close to the summit of Mt. Merapi volcano direct impacts by threats: pyroclastic flow, lava, rock avalanches, incandescent stones hurls, and heavy ash rains. Recommended use as a non-fixed residential area. When volcanic activities escalated, prioritized to evacuate.	Direct volcanic activities impacts, land use, recommended: conservation area or limited cultivation. Non-direct volcanic activities impacts recommended as zero growth zones. The infrastructures are used only for the existing residential and limited farming, research and community's safety The local Regents assign directly impacted zones up to hamlet scales
KRB 2 - Pink (dangerous) approx. 4-15 km radius	Areas with the pyroclastic flow, lava, lahar threats. The community has to take care of evacuees from KRB 3 when escalated volcanic activities. Based on 2010 eruption the hurls of incandescent stones reach up to 10 km of the Mt. Merapi summit	Recommended as limited cultivation zone, by related regency's RTRW
KRB 1 - Yellow (less dangerous) Approx.>15km radius	Areas with potential lahar flood, lava, and pyroclastic flow. During high precipitation, lahar inundates settlements, agricultural land, and infrastructure. During the lahar flood in big scale, the community has to be evacuated — safety strategy to move away from the catchment (wrongly used terminology, supposedly river channel).	River boundaries are made in segments, not generalized for the whole river channel. The segment is based on the river morphology and with regards to lahar impacts. The budget for relocation to directly impacted areas (non-urban) includes compensation for land by the National Government. Urban area policy needs further studies.

This map shows the disaster zone of Mt. Merapi divided into three categories. Under these categorizations, the locations under study mostly fall under the KRB2 and KRB1, between 10- 30km away from the summit (BPPTKG). The map above explains the future prediction of volcano eruption impacted area. It shows the area of KRB 3 or the most dangerous area (less than 4 km from the summit) and also the designated conservation forest called the TNGM (Mount Merapi National Park). The Balai TNGM under the Ministry of Environment and Forestry managing it since 2011 manages this location. However, the Balai TNGM does not have the authority to give volcanic activity status; this responsibility falls under the BPPTKG. Based on the status, the Mt. Merapi is not only a provincial level threat but also a national concern, where two provinces were involved: DIY (Yogyakarta Special Region) and Jateng (Central Java). Thus, the BNPB (National Disaster Management Agency) has agreed the 2010 Mt. Merapi disasters map produced by the BPPTKG to be used as the main reference.

The BPPTKG explains that in a way, sharing the role in calculating the potential lahar volume at post-eruption is better, as it was done in the '90s. But, it is no longer available, and the BPPTKG feels that the collaboration is lost.

> Our sharing was good, in the '90s, about four times. It happened with the collaboration with the ProMer (Merapi Project under BBWS SO) to calculate the lahar (volume potential). (Respondent BPPTKG, 2016)

Potentially, the Opak Sub-Basin up to 2016 has a high vulnerability for lahar flow, as the summit of Mt. Merapi opens directly to the south flank, where the Opak and its tributaries are located. However, the two maps presented here come from different organizations, show that there are differences in the way calculations were made and the potential quantity of lahar. However, the one made by BBWS SO is easier to be understood as it shows the potential magnitude of lahar in each river, which for the Opak Sub-basin totaled at 50 million m3 (2015 status).

When the fieldwork was performed in 2016, there was a moment when the letter of research intent got lost at the BPPTKG. The personnel showed some letters from BBWS SO, asking for lahar potential for 2016. It occurred to the researcher, this formal letter is the only way the BBWS SO is making any coordination between two organization. They go back and forth through letters, because they too do not have any direct order from the law or regulations to organize this. But, the BPPTKG does have the responsibility to provide data to all who enquire. Based on an interview, the BPPTKG feels that potential lahar quantity calculation belongs to BBWS SO, as the BPPTKG works more on the volcano. In 2010, the BPPTKG did the lahar calculation as they feel the need to help all the people to count the volume of lahar flowing downstream. Aside from that occurrence, they feel that BBWS SO should continue doing it, as the river channels is the responsibility of BBWS SO. The interviewee even plea that this calculation was worked collaboratively as what was done in the 1980s.

The approaches done to calculate by the BPPTKG was based on satellite imagery data combined with fieldwork, while the BBWS SO based their calculation on satellite imagery only. By this comparison, the more reliable computation is made by BPPTKG. The BPBD is as a main agency disaster management plans, including a disaster map for

Mt. Merapi. However, the disaster map of Mt. Merapi is a pure work BPPTKG. The BPBD does not have a Mt. Merapi disaster map, but they have many thematic maps on the volcano with detailed scale.

Meanwhile, especially after the lahar occurrence settled into sedimentations, either on land or in the river channel, the lahar become a type of resources. The materials are used as construction materials: sand, boulders, stones, gravels, and as fertilizer. The BBWS SO needed the sand mining industry for the maintenance of their Sabo Dams' capacity. The sand miners are supposed to dredge or dig up to the pre-2010 eruption conditions. In some locations, there were Sabo facilities obstructed by the mining activities, as they bulldozed the dikes that were part of the Sabo and collapsed the side facilities. This condition is difficult, as even BBWS SO does not the workforce to monitor the sand mining. The BBWS SO is the sole authority in all river channels, but they do not own the mandate to stop over mining. The BBWS SO may only give the technical recommendation on safe locations to mine nearby the Sabo facilities. The safe distance is determined in Minister's PUPR Regulation on setback from infrastructure, which are 500m upstream and 1000m downstream, while the safe depth depends on the natural morphology of the river channels. However, the respondent's from BBWS SO explained that for the case of Sabo Dam, it is only 50m to the upstream and 100m to downstream. This condition is permitted because the Sabo needs a clean capacity to function effectively. It also gives the main recommendation to ask for Sand Mining Permit, while the regional government produces the permit. It is problematic, as the permit last for five years, while the lahar sediment may already run out and the BBWS SO cannot stop the sand mining activities.

Figure 6.11 Sand mining activities at Gendol River (BBWS SO documentation, 2016)

The JICA, with Yachiyo in collaboration with the KemenPUPR, DitjenSDA have developed a handbook for community-based sand mining management. In this handbook, the community can easily assess whether the sand mining activities are following the allowed permits or not. It also calls for Sabo dam facilities monitoring. The BBWS SO as the implementer agent with more than 250 Sabo dam and there is not enough workforce to watch over this. The recommended flow for sand mining management is as follows (DGWR, Yachiyo, 2010): the sand is monitored quantitatively at survey posts, located by the entry of the access road to the river site.

The method of calculation is by counting the number of trucks and the load height (by the local community). The monitoring is done manually, with community members as the operator for the truckload measurements. A survey form is equipped in the handbook, which also explains how the measurement is taken. The information required to fill in survey form is (1) source of the material (name of mining site) and (2) type of material, such as sand or stones (figure 6.12). The results are reported to the local government. It provides support in the community's monitoring activity, calculating the actual mining volume and taking measures for controlling the amount of mining. In this context, the local government is the regional level government at the Income Office Agency (Dispenda).

Figure 6.12 Load Truck Measurement - Photograph taken from the sand mining handbook, (DGWR and Yachiyo Engineering Co.Ltd. 2010)

During the observation in the upstream sub-case 1, it showed many numbers of trucks with sand mining materials throughout day and night. However, the survey posts are not located in this location, as the sedimentation volume is no longer as much, the upstream. In addition to sand mining monitoring, the local community also has a role in the maintenance of Sabo facilities. The recommended flow for Sabo dam monitoring is as follow (DGWR and Yachiyo Engineering Co.Ltd. 2010); the local community monitors the condition of Sabo facilities and reporting the result to the government. The government's role is to enhance public awareness, about the function of Sabo, detailed inspection and repairing the facilities, but also in providing the funding. In this context, the government is not the local government, but the national government through the DGWR, KemenPUPR at the BBWS SO. The things to be monitored on such structures are not foreign to the locals, but they do not know the technical terms for the parts. Thus, the handbook introduced the components of Sabo through schematic and pictures. The figure below is also taken from the handbook to give the illustration for the community.

During the observation in the upstream sub-case 1, it showed many numbers of trucks with sand mining materials throughout day and night. However, the survey posts are not located in this location, as the sedimentation volume is no longer as much, the upstream. In addition to the monitoring of the sand mining, the local community also has a role in the maintenance of Sabo facilities. The recommended flow for Sabo dam monitoring is as follow (DGWR, Yachiyo, 2010), the local community monitors the condition of Sabo facilities and reporting the result to the government. The government's role is to enhance public awareness, about the function of Sabo, detailed inspection and repairing the facilities, but also in providing the funding. In this context, the government is not the local government, but the national government through the DGWR, KemenPUPR at the

BBWS SO. The things to be monitored on such structures are not foreign to the locals, but they do not know the technical terms for the parts. Thus, the handbook introduced the components of Sabo through schematic and pictures. The figure below is also taken from the handbook in order to give the illustration for the community.

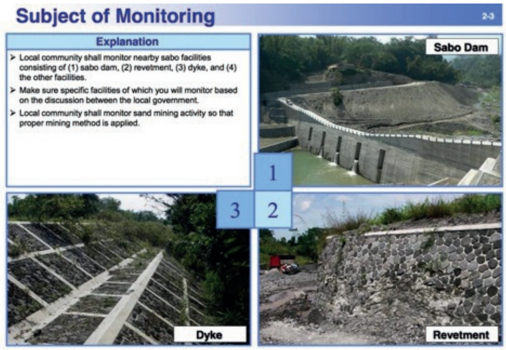

Figure 6.13 Photograph taken from the sand mining handbook (DGWR and Yachiyo Engineering Co.Ltd. 2010)

This monitoring handbook is developed on a technocratic approach but used by the local community. The book is still too difficult to be understood by the locals. Especially, on the components of a Sabo dam, let alone to judge if anything wrong is happening to it. This handbook needs further socialization from BBWS SO, as they are the sole responsible agent for the infrastructure construction and maintenance.

6.2.3 Municipal

At the municipal level, there is not much to be done when it comes to lahar, except for evacuation plans. Interestingly when it comes to the excess of lahar (which became river sedimentation and boulders obstructing the river channels), this is the most prominent level of governance. This sedimentation excess is ‘blessing in disguise’ as the sand and rocks from the lahar materials are high quality for construction materials.

Municipal Pre-Eruption

The training for preparation of the pre-eruption phase is dealt with readiness training of the CBO with the local BPBD. The training more often took place in upper stream areas, than the midstream and downstream. The training is more intense in the upper stream due to the impact of the hazard are greater there compared to other locations. More focus on Sabo Dam training is also given to the villagers by the RBO in collaboration with the community-based organizations (CBO). The CBO in the upstream area is focuses their awareness towards safety during hazards. About the training, evacuation routes, and meeting points are also prepared for each location. Especially for lahar, the hazard zone is mapped based on a historical review of earlier lahar. However, even if the safe lahar zones are not yet implemented, the ‘sister village’ program is already established between the upstream and midstream villages. Accordingly, as one interviewee noted:

> A sister village program exists between villages. Like here, in Argomulyo, we have Glagaharjo as our sister village.” (FGD Argomulyo, 2016).

With this sister village program, whenever an eruption happened that extends to a certain radius, the upstream villagers evacuate to their sister village location. This program is supported by the municipal and regional BPBD using the disaster fund. The fund is used in establishing evacuation tents, providing food, emergency supplies, and other helpful tools for individuals in the disaster region. Therefore, this support from the BPBDs is for these sister villages.

Municipal Onset Eruption

The local BPBD's main tasks at onset eruption, during lahar occurrences, are to evacuate as many people as possible from the riverside. The BPBD at Sleman Regency is more actively engaged, as the lahar potential in the upper stream up until now is still an imminent hazard potential. Most of the time during rain lahar, the victims were sand mining trucks and their teams. The EWS alarm sometimes is not regarded, as it makes too much sound, when visual on the lahar is seen, it is usually already too late to evacuate from the river. The Tagana is the disaster response personnel at the village level. Its role is to maintain safety in the village in the case of hazards occurrence. For this study, the hazards are related to lahar flood.

> At Adem Stream (upstream Opak), there was already there. Here, (in Argomulyo), we have the SKSB (Shared Social Communications Channels). If there were victims, those were breaking the rules. (Respondent Argomulyo, 2016).

During the onset of the eruption, the river channels are filled with volcanic materials. Depending on the locations, severities of impacts differs based on the distance from the volcano, the closer the range being the most severely impacted. The BPBD at the municipal level works together with local communities regarding monitoring the lahar. In the Opak Sub-Basin, the municipal includes Sleman Regency, Yogyakarta City, and Bantul Regency. Although each municipal has their disaster management agency, they relied heavily on the aids from the national (also international aids through national government) and regional level. Especially for locations on the riverside, the BBWS SO aid for heavy equipment is needed all around. During the onset of lahar, there are no activities relating to water resources management conservation and utilization.

The experience with the 2010 eruption for sub-case 1 was so intense, as many people died due to the pyroclastic flow. They were more concerned about the direct impact than the indirect. They remind the researcher time and again about the danger of this pyroclastic flow. The experience includes when the authorities (BPBD) did ask them to evacuate hours before the eruption, which they did not heed. It was because old experience taught them otherwise, that the eruption never reached their village (almost 15 km from the summit). What happened was beyond imagination, not only the village was drowned in volcanic ash and mud; balls of fires were scorching everything on its way. The village was on fire. The respondents in this research were witnesses, either through luck or caution.

> As long as what the elders know, he never knew about the history of Mt. Merapi eruption except the biggest was of that day (in 2010). Most did not evacuate. (Sudirman, Argomulyo, 2016)

The pyroclastic flow took the villagers by surprise, as there were no experiences in the past where their village got direct volcanic eruption impacts.

Also, when one lives too close to a Sabo dam in this sub-case in GEC Bronggang, it can cause death tolls during a pyroclastic flow. A safe buffer zone around a Sabo dam has to be drawn and socialized correctly to communities to heighten safety standards.

> The reason is this. If Sabo were to be built higher-up, the blast would go out, so like this (description with hand gestures from bottom to top). So if it were not strong to hold back, it exploded. The Sabo is powerful; so, the pyroclastic flow) came out. To the west, there were 48 deaths, including 36 here, which are my children, wife, and parents. (Kasur, Argomulyo, 2016)

They are now ready with the community-based information sharing system using a walkie-talkie and the mobile phone though Tagana Desa (Disaster Fast Response Cadets/Personnel), a voluntary based informal community organization. The communities in upstream areas are more ready when it comes to this as they were trained and socialized by different agencies and institutions. The workflow is described in the FGD Argomulyo in 2016 fieldwork as follow. The walkie-talkie radiofrequency has all kinds of members, including the hamlet chief. So, any information being shared in this frequency is directly heard by the chief. When the onset of lahar flow happened, the line is held, not accessible for all members; it becomes an emergency line. The essential post is the one most upstream, which is now held by the TNGM (national park authority). The communities inform the chiefs, but the decision for evacuation remains with the hand of officials (village chief and BPBD). The information can also be disseminated through phone calls, and it is being delivered for all communities downstream.

Meanwhile, for the upstream village (sub-case 1), the initiative relates more to the disaster information with the Forum SKSB. Although training for Sabo Dam monitoring does exist, the setbacks of rivers in the upstream area are unknown for sure. Hence, people living in this area do not know for sure what is the safe distance from the river. Aside from the location of the Prince Jayaningrat Tomb, people do not know. Another attention is given to the awareness of residents in the midstream area (sub-case 2), as post-eruption, by delineating the riverside setback to 3 meters from the current dike. Although this is not a safe zone from the inundation of lahar, it can give some buffer time to evacuate the riverside residents. The residents have also developed an informal gathering through the *paguyuban RW* to address riverside Kampong's issues, especially concerning the river and flooding*.* Its location by the riverside characterizes the kampong in this sub-case. Typically, a village consists of several hamlets, where each is composed of several RW (community), and under this, there is also RT. However, the RW does not usually form a gathering. This midstream village presented an example of self-governance using formulating the *paguyuban.* The downstream village (sub-case 3) is more active in tourism, especially agro-tourism, by forming community-based organizations of the secretariat of tourism village initiative and the agricultural museum. The river setback is based on the river's embankments with buffer zones of farmlands up to 100 meters. Based on historical experience, this distance is safe for flood and lahar zones.

Municipal Post-Eruption: Farmland and Sand Mining

The condition during the fieldwork in 2016 was considered as the post-eruption condition. The municipal government seems to have an eye on the profit of this sand mining industry, rather than the sustainability of the river regimes. More permits than necessary were given to gain access to the lahar materials. The river channels were dug up, deeper than the original condition pre-2010 eruption. The municipal government is responsible for declaring permits for sand mining or the C type mining. In the Opak Sub-Basin, the municipal government includes; Sleman Regency, Yogyakarta City, and Bantul Regency. Although each municipality has their disaster management agency, they relied heavily on the aids from the national (also international aids through national government) and regional level. Especially for locations on the riverside, the BBWS SO aid for heavy equipment is needed all around.

For the sub-case 1, the condition of post-2010 eruption is presented in the map below (figure 6.14). It explains that the riverbed is filled with the "wedi kengser" or the lahar sedimentation materials, which in this case is sand. Based on the site visits in 2016 fieldworks, the location of the bride stones indeed benefited the locations downstream and behind them. It functioned as a natural barrier from lahar flood for the hamlet nearby. The lahar filled up the river channel and submerged existing spring, except for one by the Sabo GE-D, upstream of the village. As the lahar sedimentation was dredged, the underground water channels were cut off, and the post-eruption hot spring water stops producing. Even if lahar cannot exist without water, apparently water can also be interrupted by the lahar. This situation is related to the quantity of water diminishing and hot temperature. Also, the water quality changed with the volume of volcanic materials submerging the wells, such as iron and sulfur. The Eastern side of the river is residential areas, which were not directly impacted by the 2010 eruption. Although, at Pak Kasur's house in proximity the Sabo Bronggang (GEC-Bronggang), all residents were casualties, except Pak Kasur. He became a respondent of this research. He explained that he is not afraid to live there, as now he knows when to evacuate:

> So, don't need to (think), the mountain is scary, I am not afraid, as long as I can run, roughly. When being too bold, then obviously dead, (even) Mbah Maridjan was afraid. (Kasur, Argomulyo. 2016)

His quote also refers to the known Mbah Maridjan, Mt. Merapi's famous gatekeeper. He was the survivor of 2006 eruption even if his village is only 4km away from the summit. However, he died in the 2010 eruption, due to either stubbornness or feeling of responsibility that he did not evacuate. All residential areas North of Sabo dam were emptied before the 2010 eruption occurred. Now, the residents are relocated to a nearby site called Kuwang, as all houses were burned and destroyed. The following figure 6.14 shows the current sub-case 1 condition of post-eruption and utilization lahar sedimentation as temporary farmland (6.14-1) and the existing sand mining activities (6.14-2 and 6.14-3):

1

2

3

Figure 6.14 Locations of Sabo Dams (blue dots) and Conditions of Sub-case 1

However, since the Gendol River does not have a continuous flow, but a braided type river, there was no water seen in the river channel during the dry season. Most of the riverbed is filled with the lahar sedimentation. If not dredged due to its low quality of aggregate by the sand mining industry. The sedimentation or *wedi kengser* is used as seasonal agricultural land as seen in the following picture near Sabo dam GED11 (figure 6.14-1).

The post-lahar sediment becomes sand and stone resource for locals to build back their homes, by mining their lands. Even the lands were also dug, as lahar materials like sands, stones, and gravels, totally overflowed many people's lands. Since the land has private ownership, one cannot control the over-mining. During the FGD, the researcher presented a short video (paused and presented as figure 6.14-2) from the field observation on a person who is mining on a plot of land. The response was clear; it was done on private land, so, and the owner has all the rights to do as he pleased. A respondent reminded that the mining activities in this village are proven by the existence of sand and rocks depot by the Gendol River when normal volcano status is recognized.

> Well, it is, as usual, those who have a business, do their business, farmers doing farming, miners mining. When there is still something to mine. Now, they mine the field (the rivers are already too deep). (Mrs. Jaka, Argomulyo, 2016)

Another important fact is that the locals are involved in the monitoring of sand mining and Sabo dam facilities condition. This involvement is done through the socialization of a handbook, which was mentioned at the regional level. The BBWS SO role is the agent on the ground for recommending this collaboration with the municipal government and local community members. However, it seems that the communities are not sure to whom they report when these activities are happening. The sand mining activities are happening here without monitoring, as shown by the Sand Depot (figure 6.14-3). The community monitoring belongs to other locations; even though, there were trucks loaded with sand and stones throughout the roads to get to sub-case 1 location. The locals are aware that these sand mining influence the groundwater supply in their village. They seem helpless in this situation as there seems to be 'mafia' at play when it comes to the sand mining sector. These 'mafia' are the ones controlling the municipal governments. The role of BBWS SO needs enhancement in this matter.

Aside from this fact, the so-called sacred location was not inundated by the 2010 lahar: the tomb of Jayaningrat (the pioneer of the village). This tomb was discussed earlier in the CEK chapter, where myths of how the *tambak kali* celebration came into being. The tomb is located on the east riverside of Gendol, between two Sabo dams: GEC Bronggang and GED 10.

> Particularly, citizens of Bakalan Hamlet. In the tomb, there was no sand, not even a little, not at all affected. Well, (it is) close to Gadingan (GED10), considered as the sacred location. (Eko, Kuwang-Argomulyo, 2016)

The following logic came into place, as certain morphological conditions protect the location. These did not change, even if the river channel was obstructed with the Sabo dams. It is due to rock formations north (upstream) of it, called the "*Batu pengantin*" or bride stones.

> His (the Hamlet Chief's) mother used to say; there are those three stones, the bride stones, she said. "As long as there are these stones, everything will be fine." Yeah, it was safe, no problem. Apparently yes, keep safe. Even though compared to the embankment there was no distance, empty its contents there's nothing, coupled with the embankment. (Mrs. Jaka, Gadingan-Argomulyo, 2016)

For sub-case 2, the lahar in 2010 devastated the homes of the communities who live on the riverside. The lahar filled up the homes up to 1 meter deep. As the Code River has been built with the fixed embankment, people felt safe to live by the riverside. But, during that occurrence, all was affected, and the lahar is tackled momentarily, using temporary dikes (gabion-mesh), which seem to last longer than temporary as of during the fieldwork in 2016, this still existed.

> Here, all are affected. If the embankment, my comparison is I am like this, before the (2010) flood I wanted to go down to the river, I held the embankment I could not reach. So at least the height was 2.5 meters. Now, after the eruption of Mt. Merapi, when I go to the river is only like this ma'am (stepping). So it's automatic the sand deposition existed 2 meters. (Atok, Gowongan, 2016)

As seen in figure 6.16, the level of water in the river is about 3m deep in comparison to the dike, but this is after massive dredging was done. Before that, all the river body was blocked with lahar. The dredging of the lahar material out of the river is used to elevate the whole Kampung to +60cm of its original elevation (figure 6.15-1). It is done through the initiative of the community members and using the aid from BBWS SO (back-hoe and other heavy equipment). The lahar materials have good sand quality and were also used by the community as construction materials to heighten their houses to the second level. The following pictures also show the river condition with dikes (figure 6.15-2) and the community well (figure 6.15-3) dredged and reused post-2010 eruption:

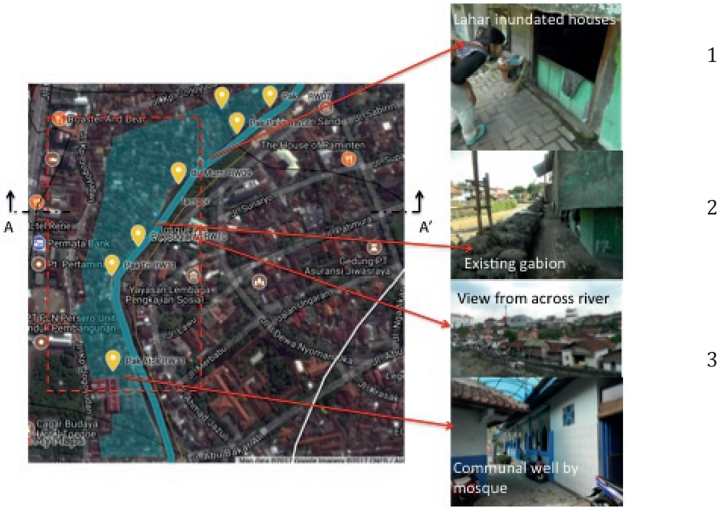

Figure 6.15 The condition of Sub-case 2 (fieldwork 2016)

Figure 6.16 Sketch Section A-A' of Sub-case 2: Kampung Jogoyudan, Gowongan

In this sub-case, the locals make use of the aids from BBWS SO (regional stakeholder) and UN-Habitat (international):

> At that time, the solution of BBWS when (lahar) flood was to give the gabion. Here who has the gabion is BBWS, but does not have stones, so the stones are from Kimpraswil. So at that time, the solution from BBWS was to save people but to reduce (risk). The embankment was given gabion. (Atok, Gowongan, 2016)
> From the Balai Besar (BBWS SO) they help in excavating the sand, but the communities' houses were submerged of at least 60 cm. Then with the (UN-) Habitat project, the houses were lifted, the floor was above the zero flood point, at the meeting hall it stayed the same. (Andi, Gowongan, 2016)

Here, the international donor can directly access the community, but it was not through proper channels. The fund supposedly went through the national government first, and then given to the village using the budgeting of APBD (Regional Budgeting System). However, during disaster time, it is an urgent situation that shortcuts were made, although this is not the 'right' way.

> At the time there was from an NGO, the (UN) Habitat entered, they helped if until now there are maybe 250 houses. Help from the UN-habitat is seen from their roof with asbestos. District Head and Sub-district Head at that time said, "I closed my eyes because if I open eyes to existing bureaucracy, (this aid) does not work. But I

pity my communities; all right I pretend I do not know." (Respondent Gowongan, 2016)

This information is a revelation that although multi-levels of governance exist, it does not hamper the opportunity to gather aids from international agencies. But, this is only happening when a 'wise' leader is at hand.

In sub-case 3, lahar impacts are not as severe as the first two locations. The locals were more concerned about the sedimentation of the Opak River, especially near the Tegal Weir, as the villagers used to use the river for water tourism attraction. This location is just before the fork of Opak and Oyo meets, therefore the lahar concentration is not diluted with the water from the other sub-basin. Even if the villagers consider the volcanic activities in sub-case 3 as a danger and sad occurrence for the victims upstream, this area had advantages as the ashes are considered as a natural fertilizer. The lahar sedimentation also made good fertile land for the non-irrigated crop. This knowledge is also considered as cultural ecological knowledge, as it is a knowledge passed down from their ancestors.

> Yes, it is fertile from the river (lahar) sedimentation. (Martadi, Kebonagung, 2016)
> So if Mt. Merapi explode, Mbah Blondo (will say prayers) amen, amen. (FGD Kebonagung, 2016)

The sand mining industry is not as burgeoning as in the upstream. It is due to the quality of the sediment is not as good as those in the upstream area for construction material. However, there are some reported sand mining activities downstream and observed nearby the Tegal Weir. This activity uses simple tools such as bamboo boat and human diver with a bamboo knitted container, which can drain the sand as soon as it gets to the surface. Figure 6.17 is showing the condition of the Opak River along the Kebonagung village, where the water for the irrigation channels is originating. The pictures show the high sedimentation, which created the *wedi kengser*. This condition is the result of 2010 Mt. Merapi lahar flow. Thus, the sedimentation is considered as a bad condition for the village, as it caused siltation to the riverbed (figure 6.17-1 and 6.17-3). It hampered the water tourism and also created flooding during the rainy season to the upstream-irrigated area near the dikes, it is used for limited agriculture. Most of the villagers are plotting the "*wedi kengser"* or this temporary river sedimentation by the adjacent landowners.

The lahar sedimentation in Opak River channel is used for grass cultivation for cattle, temporal farming for corn and banana trees nearby Tegal Weir (figure 6.17-2).

> Pak Bachroni: The residents adjacent to the w*edi kengser* plot it first.
>
> Mbah Prapto: Plenty, most of them are my grass. But if dredged, I will be happy because the possibility of added crowds, the problem faced by village tourism can live again, i.e., paddle race. But, the grass is just for me. (FGD Kebonagung, 2016)

Figure 6.17 Location and condition of Opak River in Sub-Case 3 Kebonagung

The Tegal Weir stops the sediment, making the nearest resident's plot to it have the most significant plot (figure 6.17-4). This sedimentation is used as farmland to grow grass for cattle food and other non-irrigated plants. The villagers asked BBWS SO several times to dredge the deposition near the weir, as it may lead to ineffectiveness of the irrigation and hinder the boat tourism activity. There was a dredging project installed right after the eruption in 2010, but sedimentation from lahar still flowed after the dredging project.

An active tourism community member claimed that he used to visit the BBWS SO to ask for the dredging project, but now no one does that. He also explained that personal communication is always better in this kind of thing, rather than sending a proposal and letter about the condition of the Tegal Weir after lahar sedimentation. He even proposed to hold a focus group discussion (FGD) inviting the surrounding villages, including the Regent of Bantul, to discuss this matter with the BBWS SO. The initiative of this sort comes from years of experience in active communication with different stakeholders in different layers.

The following pictures (figure 6.20) are taken from the normalization project:

Figure 6.18 Normalization Project on Tegal Weir (BBWS SO, 2010)

The BBWS SO built the Tegal Weir in 1997. Then, the BBWS SO was called Mataram Irrigation Project Office. The irrigation area is only 700ha, the weir authority for operation and maintenance is transferred to the municipal government, which in this sub-case falls to the DSDA Bantul. The DSDA Bantul has a branch office that takes a record of water level in the Tegal Weir, called the UPT Opak Hilir. They were also unsure to whom they report to on the sand mining activities, which took place in the location.

> Just recently, the sand miners are accumulating; then I went to the village with Tegal Weir, they have the extraction machine. I went to report this to the conservation office in Bantul, but they say it's the RBO's jurisdiction. Until now, there has been no follow up. (Respondent, UPT Opak Hilir, 2016)

The daily manager of the Tegal Weir is the municipal government. However, as the eruption and lahar was a force major, it is evident that the dredging of rivers belongs to the BBWS SO.

During a flood, the village disaster fast response (Tagana) also works with the walkie-talkie to pass-on information from up to downstream. However, post-eruption 2010 during the rainy season, only average stream flow or water flood is happening. The fact that it is not life threatening (only inundates paddy fields) and the unclear status of authority made it a non-priority. In the meantime, the sedimentation is considered as a natural process the Opak River has to face post-eruption. The river needs dredging to give room for future lahar flow, yet, the focus of BBWS SO is at the upstream area: the Sabo dams reconstruction. The villagers think the sand mining industry can help dredge the sedimentation from upstream of the weir. However, the lahar sedimentation found there has similar characteristic to mud and unfeasible to be used for construction.

6.3 Interaction Attempts in Lahar Management

The diagram on the findings of the interaction attempts themes in chapter 5 (budget, water, and disaster) is used as the basis for this chapter's interaction attempts. However, as this chapter pays more attention to lahar, the disaster attempts are put under focus more than before. This diagram (figure 6.19) is then completed with more actors and their interactions in the disaster theme. The interactions are still arranged through the national, regional, or municipal level, but the role of interaction attempts changes throughout the stage of the hazards using the existing mechanisms in each theme.

The interaction attempts in figure 6.19 show the same order as the water attempts. They are divided hierarchically into national (1), regional (2), and municipal (3), also horizontally into themes of budget (A), water (B), and disaster (C). This numbering system is used to read the following diagram (figure 6.), which visualizes the interaction attempts happening in lahar management. However, in this chapter, the focus is shifting more to disaster attempts. Furthermore, the arrangement is based on eruption stages, rather than on the themes, as explained in chapter 5. The interaction attempts to focus on the disaster (C) relating to the other attempts (A and B). The interaction between the budget (A) and disaster (C) are stronger due to this line of fund and policy support.

Meanwhile, between the interaction attempts of the water (B) and disaster (C), there is no direct line. But, there are non-direct lines through the actors, who are involved in the disaster task force (C). Within these interaction attempts, the connecting actors are located and indicated by the dots, as explained in the earlier chapter on brokers on budget interaction attempts (A), they also exist here. Meanwhile, as the focus of this chapter is on the disaster interaction attempts, the author paid particular attention to the contact person (CP) as the boundary spanners existence. These contact persons exist between agencies or coming from the actors outside of the government structure.

Interaction Attempts Pre-eruption: Budget and Water, Less on Disaster

For the pre-eruption, the interaction attempts are made using the budget (A) and water (B). In this context, no lahar sediment management are spotted directly; the focus is on the preparation, such as education, training, EWS re-installment, or lahar infrastructure reconstruction for the next eruption. This education and training are happening at the community level (C3) by the BPBD, NGO, or universities. The interactions are not at the disaster task forces, but more on the informal ways directly at the community. It is not done in the interaction attempts, as there is no actual onset disaster, and the task force is no longer active. The BPBDs do have the authority to address this training.

Additionally, for lahar, the JICA (international agent) collaborates with the BBWS SO, as they are responsible for the Sabo Dam systems. The BBWS SO trains the communities near the Sabo to learn when to evacuate, how far, and to which direction. It is also done directly at the community level in the budget (A3), not through formal attempts in water (B3) or disaster (C3).

The re-installment of the EWS is located in different institutions in the regional and municipal levels (A2, A3, C2, and C3). Also, in the meantime, there is no EWS interaction attempt from the members of the disaster task force (C2). The BPBD DIY at the regional level (C2) is trying to facilitate this coordination; this is a difficult task. Yet, it is more rewarding to have all of the available data under one center as the quote explains below: "This is what we are going to do: EWS integration. So far, this is working separately. Then we want to integrate." (Heri, BPBD DIY, 2016)

The existence of a contact person in coordinating the data of the EWS is highly essential, as there is no formal form of interactions for pre-eruption. The communication line is held between the designated contact persons between institutions. Having the EWS scattered in different institutions also gave difficulties in deciding. The data is used for lahar in what river, and this decision need to come from the BPBD DIY (C2), rather than the municipal BPBD (C3). Therefore, the interaction attempts are still based on the initiative of the BPBD DIY.

Meanwhile, for the lahar infrastructure reconstruction as preparation for the next eruption, as explained earlier, the BBWS SO (A2) is taking a lead role in this. The interaction attempts are made informally and directly between the BBWS SO (A2) to the community (B3 and C3). The attempts have no names, not through the water councils (B2), irrigation council (B3), or the disaster tasks forces (C2 or C3), as it instead happened organically, depending on the project locations. Based on informal attempts, the BBWS SO decided to make Sabo Dams as multifunctional.

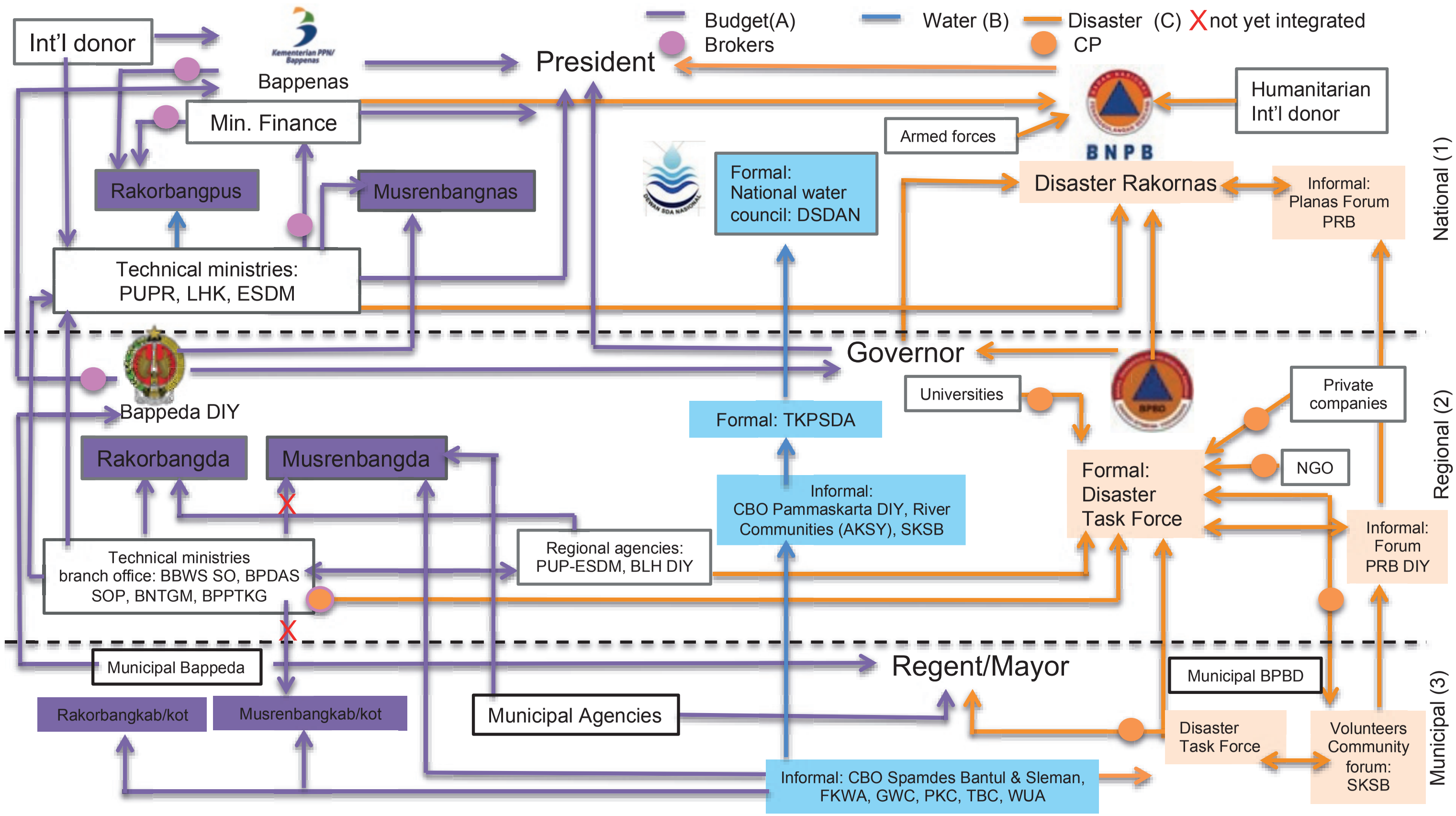

Figure 6.19 LRM Interaction Attempt

Interaction Attempts Onset Eruption: Focus on Disaster and Budget
For these attempts during onset eruption, it is termed as the disaster interaction attempts (C) in this thesis and called the Disaster Task Forces for each level of governance. In these task forces, the members are ministerial level. At the national level (C3), the coordination attempts for lahar risk management are dealt at BNPB, the national disaster management agency. For the case of Mt. Merapi 2010, the eruption was of a national scale priority as its ash also impacted the whole Java Island's flight routes. Also, as the KRB's are inter-regional or inter-provincial delineation, the attempts are collaborative works across vertical and horizontal levels.

The water attempts (B1) do not have a direct link to disaster attempts (C1) but exist through the technical ministries. This missing interaction proofs that water-lahar interrelations are non-existent. The disaster attempts (C1) do have support from budget attempts (A1) due to the existence of funding schemes, which interlinked with the national fund into the annual budgeting structure. The law on DRR also supports this mechanism of budgeting as 'on-call.' The budget allocation for disaster management is in the form of ready use budget, for all kinds of disasters, which include lahar floods. The core of disaster management coordination lies heavily on the BNPB. However, the collaboration works are no longer integrated at post-reconstruction phase. As the coordination is not as frequent, the command line goes back to the Development and Planning Agency (Bappenas).

Within the regional level, the BPBD DIY (the Provincial Disaster Management Agency) acts as the leading actor for the commander in disaster response implementation (C2). For the case of Mt. Merapi 2010, the eruption was of a national scale priority as its ash also impacted the whole of Java Island's flight routes. Even as the KRB's have an inter-regional or inter-provincial delineation, the attempts are collaborative works across vertical and horizontal levels. However, the fund helps within the interaction attempts from BNPB at the national level to the regional level (C1 to C2) is not always appreciated.

> Just by the end of 2017, we got it (lahar), BNPB is ready to help us. 'Please contact us; the fund will be ready.' In my heart, (I said), 'No, enough, thank you.' That is what I thought. Because of them (BBPB) we got hit (by problems with the auditors). (Respondent, BBWS SO, 2018)

The disaster fund, although very 'liquid' with its 'on-call' status, is also not so easy to be accountable for. This condition is due to the proofing mechanism having to show tangible results, which for the case of the BBWS SO meant the construction of water infrastructure. During the lahar flood, for example, the rock-fill embankments built can easily get swept away by the next lahar incoming. Thus, the photographs from an earlier condition of the location with the embankments already constructed so different with what the auditors found with the next post-lahar, as the embankments are already gone by the next rainy season.

Another important fact is the existence of contact persons in the interaction attempts in the municipal level (C3) being embedded in the village or even hamlet level, as explained in the excerpt:

> This is special for lahar. The hamlet chief is mingled in this community (SKSB). So, the information line is fast; without any report, he knows the condition. They just started with disaster communication management. Several months ago, we simulated here. (FGD Argomulyo, 2016).

Also, the people listen more to the riverside communities contact persons, when to evacuate from the area.

> But, we are more (trusted). When the colleagues from the riverside communities said to run." (Semprit, Argomulyo, 2016)

The sub-case 2 focus group discussion (2016), also used the contact person in the river communities to contact the people for flood and lahar using the walkie-talkie. The communication line is through the relayed walkie-talkie. There are many communities along the river, and they are joining together. All of them monitor the water level and river conditions. However, the contact persons for the sub-case 3, for onset eruption are not as active as the other two, as the eruption impacts are not so severe in downstream. Aside from them, the informal disaster interaction attempts to use religious figures as contact persons from the regional level to the municipal and community level (C2 to C1).

> From what I know, in Mt. Merapi, they have an inter-religions community. It is what I used. I carried the message (about the eruption) from the Sultan to them. They spread it to the people. (Rani, PU-P ESDM, 2016)

The BBWS SO supports this quote also, as follows:

> In the lower level, they lean more to the Ulama (Islamic religious figure). Make this as a note. So to say, the religious figures more trusted than those (hamlet chiefs). (Tri Bayu Adji, 2016)

However, the onset of lahar is intersecting two main actors of the budget within the regional level (A2): the BBWS SO (rivers) and the BPPTKG (the volcano). Both actors have the sound technical expertise needed to decide the lahar status and when to evacuate for the disaster task force (C3). During an eruption, both works under the BPBD DIY (C3), which coordinate and collaborate data towards cooperation in deciding the status. The coordination meetings during the eruption are held and led by the BPBD DIY, which aiming all sectors cooperation.

Interaction Attempts Post-eruption: Budget and Disaster, Lesser on Water

The interaction attempts during this time are the budget (A) and the disaster (C) interaction attempt is active. This budget attempt through the Bappenas (A1) proposes the annual budget as preparation for disaster fund (C1). This mechanism of budget preparation is commonly known as the disaster funds. In each of the level, the funds exist, but the higher level of government can support lower levels, through transfer mechanism. These attempts exist in all levels of government (A1, A2, A3).

Within the national level, the budget attempts (A1) are experiencing fragmentation across domains of ministries. The attempts are known as the Musrenbang (government-people meeting) and the Rakorbang (inter-governmental agencies meeting), which existed in all level of governance. This fragmentation is due to the limited time to focus on one subject and specified just for lahar management, but also for other development-related issues, such as education, export, and loans, among other topics. The meetings (A1) have several preparation meetings occurred throughout the year. However, the process was through plenary sessions; the condition does not support two-way discussions intended to take place in the meetings.

> This (Bappeda) has to voice out stronger to the higher level, because here (the Governor) it is impossible (to create impact). Here (the President) only attend for the important ones or something significant for national impacts, that is all fine. (Rani, TP5 DIY, 2018)

The regional's budget attempts (A2) are also experiencing the same fragmentation. This fragmentation is again based on the inexistence of apparently responsible actors to manage the lahar. Yet, coordination works better through direct communication during eruption and rain lahar occurrence right after the eruption, which heightens the integration level. As quoted from the following:

> (The) Musrenbang is, I'm sorry to say, it is just formality, now, where do you want to target, it is a problem of coordination to the Bappeda (DIY). (Respondent, BPDAS DIY, 2016)

In other words, at the regional level, two-way discussions are non-existent between the government and the people. It is only a mere formality, but it is done annually, also starting from the municipal level.

The municipal's budget attempts (A3) have a different approach, as it sounds from the community and is built upon a bottom-up approach. It started at the hamlet level to the village, then to the municipal. The communities have understood for the post-eruption condition, on how to propose their ideas. However, not all of their ideas become priorities to be developed.

> Through the Musrebang, we would like to know, how did our concept in reality being developed, has it been what we hoped for, whether or not it is accommodated. (Endang, AKSY, 2018)

However, as reported above, the Musrenbang in the regional level (A2) does not always pay attention to what the lower level has prepared (A3). Other community level respondents in this research also gave similar accounts, even though the attempts exist their wish does not always come true. Another way of the lahar risk management is done through the Disaster Task Force in the interaction attempts (C2). Each of the regional agencies and the branch of ministries send their representatives to validate the data provided by both the disaster management agencies of the regional (BPBD) and the national (BNPB). The national level does not function in post-eruption aside from legalizing the KRB map (figure 6.10).

Within the regional level, the interaction attempt is through the disaster task force (C3), which highlighted the role of BBWS SO (A2) for lahar flood. This condition is also when sand mining activity takes place. In this regards, rain lahar happens during each rainy season. The RBO is the sole organization created to address the rain lahar management. However, they also coordinate with BPBD's at municipal and regional levels through the disaster task force headed by the BPBD.

The main tasks of the PPK PLG Merapi are actually to operate the Sabo dam system. Due to the limitation of personnel, the PPK PLG Merapi cannot monitor the 259 Sabo dams on the whole Mt. Merapi slope. For this task, the JICA used the budget interact attempts at the national level (C1) through the Ministry of Public Works. The community-level monitoring approach is suggested for lahar resources management. Direct coordination between the local communities to PPK PLG Merapi is done informally (A3 to A2) through calls, walkie-talkie report, or chat apps. Still, this points out that along the rivers, the management belongs to BBWS SO, through the PPK PLG Merapi for those related to Sabo and the main office for the whole river regime. In this sense, the coordination is crossing levels of regional-municipal coordination (A2-A3).

Within the municipal level, they work directly with the disaster task force (C3) and community organizations (for example the Tagana or the Forum SKSB in C3). The informal attempts between BBWS SO and BPPTKG in budget attempts (A2) are missing. There is a need to create a mechanism, where they can coordinate providing their expertise and prepare the technical recommendations, also in normal condition. This attempt is also made through municipal level BPBD's by the disaster task force (C3). More ongoing works are done for lahar management in the upstream and midstream areas. For the downstream region, the Tagana does not work with lahar, but more with the flood, which there silted the river's channel. At this level, local communities are more active to reach out for aids at any level of the management.

Another interaction attempt is termed as the water interaction attempt (B). Within the national level (B1), this is done through the meetings of the Water Council (DSDAN). However, the council does not often discuss lahar management. This is because its chief concerns are water, even though lahar is part of the water-related hazard. The attempt is not relating directly with the water development fund but hosted by the General Directorate of Water Resources in KemenPUPR. This attempt handles general water management, which is active during pre and post-hazards. However, within the regional level (B2), one of the water councils' MoMs has proven less interested in the lahar risk or resources management. It was only mentioned once in June 2014 of the regional level water council (DSDAP), throughout the MoM data from 2010-2015:

> "Decided on adding the substances of materials potentials and problems related to water resources relating to flood and lahar flood, including the minerals resources."

It does not refer to define the lahar and mineral resources, how, when, and also by whom. The rest of the MoM's are also in the same tune; they are not detailed in giving information. Perhaps, this is just the way; the water councils made non-specific recommendations. Even though, in reality, the meetings last at least a half-day (for any kinds of the councils: TKPSDA, DSDAP, Forum DAS). This fact proves that there is no direct relation between the different water interaction attempts, aside from the members of the councils are also the members of the disaster task forces (C2 and C3).

6.4 Integration Levels

Based on the narration of interaction attempts, the integration level is decided, as in IWRM, this is divided into three levels, starting with the lowest: coordination, collaboration, and cooperation. The integration levels also differ based on three conditions: pre-, onset, and post-eruption, and they are presented within each of the interaction attempts (A, B, C) of each level of governance (1, 2, 3). However, the most prevalent integration is taking place at the regional level (2) within the disaster interaction attempts (B). The integration level is pre-determined following the order of chapter 5, like coordination, collaboration, and coordination.

However, the BBWS SO (RBO) in the regional context, is aware of the fact that there is yet no integration of concept in managing the lahar, as mentioned below:

> We are separating, when thinking about making disaster rule, then only about the disaster itself. So the relationship with the water resources with sediment they wouldn't want, right. I said when disaster is not viewed, merely as a disaster, but it should also be seen with its benefit. If you do not see it (because), people only see this through one "lens." It is as if we (want to) relate lahar and water resources. It is not yet related until it is managed through the post (eruption); it is not however ordered. (Sigid, Head of Implementation Division, BBWS SO, 2016)

The shifting of roles and the stages of eruption continuum as a cycle is not yet recognized. There has been no order in this awareness. This reason explains the varying levels of integrations throughout the stages of LRM.

Integration of LRM Pre-eruption: Low Coordination or Non-existent

The integration of LRM for pre-eruption is based on the findings in the budget (A) interaction attempts, through the formal budget preparation for lahar control. The interaction attempts at the national level are aimed indirectly to lahar management through the budget (A1) and water (B1). It is done through the budgeting of the Ministry of Public Works and Housing (A1) concerning Sabo dam development. Meanwhile, the Bappenas (A1) provides the budgeting 'brokers.' It is due to the inexistence of lahar management-focused regulations, and the directive position of the BNPB is not the focal point in this stage. This condition approaches disaster management as reactive and not pro-active. Based on this, the national integration level is ranged as partial coordination only. Within the regional level (2), the tasks of the BPBD DIY is actually to study the possible hazards and coordinating EWS. During the fieldwork, coordination between these different agencies for EWS has not been established (see explanation on pre-eruption in the earlier sub-chapter), but meetings to discuss this possibility is ongoing. The case in the 2016 fieldwork shows that the almost normal condition of the Mt. Merapi river basins proposes no secure connection between each actor who has the EWS. The attempts in coordinating are still at the beginning. They seem to be just always at the level of discussion, and no concrete actions have taken place. So at this stage, the integration level is still non-existent. The same happens for the municipal level (3), there is no integration for lahar management, as the river belongs to the regional level.

Integration of LRM Onset Eruption: towards Cooperation for all levels

During the onset of the eruption, the integration level for national, regional and municipal are high towards cooperation through the disaster interaction attempts or the disaster task forces (C) involving both formal and informal ways. The many 'contact persons' located in the regional and municipal level signals this cooperation. The reason is the urgency of saving as many lives as possible and the volunteerism values towards one another. All actors in the disaster attempts are aware of the importance of integration and work collaboratively. They are aiming at the same target and cooperatively sharing their resources. Based on the experience of 2010 eruption, the interaction is busied with the BNPB (C1) organizing the expertise of each institution, government, private, or community organization and either from international, regional and municipal levels. The integration within the regional level under the BPBD DIY (C2) is also towards coordination as the attempts are cohesively merged. It is not due to any regulation, but because of people characteristics in Yogyakarta. As explained before, the *gotong-royong* spirit is almost gone, but due to the 2006 earthquake, this spirit regained the momentum. However, this may not be the case in another part of Indonesia. During this stage, the municipal task forces (C3) are also working at their best. The disaster task force at this level is very reactive:

> Our experience, there was a village being flooded, we didn't contact the BPBD, but suddenly the BPBD already came. (FGD Argomulyo, 2016)

This proofs that the BPBD has a high cooperative capacity to tackle the information and help the communities.

Integration of LRM Post-eruption: Non-existent for all levels

In the post-eruption condition, the interaction attempts shift to budget (A) focus on the regional level (A2), as the lahar sediments are located all over the rivers from up, mid, and downstream. In the national level, the integration has no trace, as the sand mining is managed under the budget attempts (A1), but for the benefit of the regional income (A2). The sand mining permission process is done previously (up to 2014) through the municipal agency of water and natural resources DSDAEM Sleman (A3). However, after the Law no.23/2014 on Local Government, the task for giving permit is at the regional level by the PUP-ESDM DIY (A2). The integration for post-eruption at the municipal level for lahar resources management is not yet established, especially as the transferred responsibility like this requires implementation mechanism. During the process between 2014-2015, all of the rivers belong to BBWS SO (A2), where the sand mining locations are located. This condition is where one acquires technical recommendation, whether specific areas permitted for mining or not. But, since 2015, the permit is processed is by the Licensing Office (Dinas Perizinan) at the regional level under the Bappeda DIY (A2), with the technical recommendation by BBWS SO (A2). In the municipal level, the use of lahar sediment in the river channel into farmlands or personal sand mining quarry. As the level of integration is also still non-existent, it is not being contained in any of the existing interaction attempts. Thus, the integration level is at with the current fragmented institutional framework.

6.5 Conclusions

This chapter presents the LRM implementation in a volcanic basin, which is characterized by (1) inexistence of lahar policy setting, (2) a multilevel governance conditions combining disaster and water management, and (3) the actors interacting through the same mechanisms in water management, but focusing more on the disaster attempts. As a summary, the following table below presents the main actors and their activities for the LRM within each of the level of governance are presented as follow:

Table 6.4 LRM actors and activities

Stages of Eruption / Level of Governance	Pre-eruption	Onset Eruption	Post-Eruption – Lahar Resources Management
	Lahar Risks Management		
National	Bappenas (policy orientation on budget). KemenPUPR-DGWR and JICA (Volcanic Disaster Mitigation Plan)	BNPB (policy on disaster response on volcanic hazards, pyroclastic flow, lahar)	KemenPUPR-DGWR and JICA (policy on lahar sedimentation management)
	KemenESDM (policy on volcano activities monitoring, throughout all conditions of LRM)		
Regional	Bappeda DIY (disaster fund proposal)	BPBD DIY (disaster response on volcanic hazards)	BBWS SO (dredging of lahar sedimentation in rivers, reconstruction of Sabo dam ,water infrastructures)
	BNTNGM (national park catchment management radius 4km. BPDAS (catchment management)		PU-P ESDM and Dispenda (sand mining permit process)
	BPPTKG (monitoring of Mt. Merapi activities, throughout all condition of LRM) BBWS SO (pre: Sabo dam infrastructures, onset, and post-eruption: decide on lahar status, post-eruption: technical recommendation on sand mining)		
Municipal	Lahar Risks Management	BPBD Municipal (disaster response on volcanic hazards within the scale)	ESDM agencies (sand mining permit process) Sand miners (volcanic aggregate mining)
	Sister village (up to midstream- pre-eruption: prepared, onset: hosting villagers during evacuation time, post-eruption: stay alert for the continuous eruption) Forum SKSB (upstream monitoring and info sharing throughout all LRM condition) *Paguyuban RW* (midstream-communication initiative for all LRM conditions, pre: monitoring, onset: evacuation command, post: disaster fund transfer)		
	Tourism village secretariat (downstream: agriculture tourism)	Tagana at all sub-cases (disaster response and evacuation)	Tourism village secretariat (downstream: agriculture tourism)

The interaction attempts for lahar risk/resources management are located in each of the governance level and similar to the earlier chapter. However, this chapter highlights the shifting roles that the interaction attempts have during pre-, onset, and post-eruption. Also, as lahar does not own a specific council as what water has, it is being discussed through the three existing themes: budget, water, and disaster. More attention is given to the disaster attempts, as lahar is more engaging when the onset of eruption is happening.

The result of the analysis shows that the integration level is high only during the eruption, which is the result of combined attempts in regional. First, implementation of the LRM in a volcanic basin proposed alternatives of combinations of policies, as there is no fixing one referring directly. Here, the shifting roles in the management and interaction attempts are based on the eruption stages. Secondly, the multilevel governance in water is also presented in the lahar management, although there is a shift within the management priority based on the stages of eruption. This priority shift impacted on the shift of command role. For example, during the pre and post-eruption, the RBO has the command for the river, but during eruption and lahar flow, the disaster management agency became the commander for all aspects.

CHAPTER 7
VRBM: INTERRELATIONS OF LRM AND IWRM

7. VRBM: Interrelations of LRM and IWRM

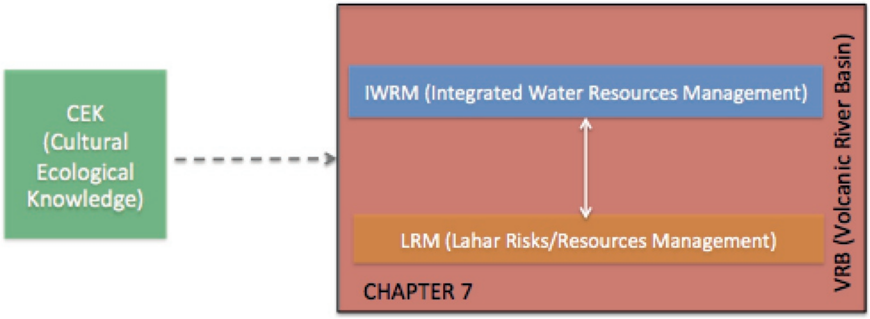

Figure 7.1 VRB concepts addressed within the research framework

7.0 Introduction

This chapter is the first meta-level analytical chapter of this research. Earlier chapters have answered each of the components of the 'bulk' concepts regarding IWRM and LRM implementation. The sub-question on what LRM is about having been answered, the next stage was to configure the answer to the next sub-question: How and why does lahar management relate to integrated water resources management in a volcanic river basin? The aim of this chapter is to merge the empirical findings of the IWRM and LRM chapters into a conceptualization of volcanic river basin management (VRBM). Figure 7.1 visualizes the position of Chapter 7 in the research framework as the summary of the dependent variable. The VRBM phases proposed in this chapter describe how the two interrelate. There are five possible ways of interrelating (Goldstone, 1996), but in order to focus on water–lahar integration in a volcanic river basin (VRB), this chapter highlights only those that overlap. Therefore, the chapter unfolds in an order similar to the two earlier chapters: policy settings, managerial context, interactions attempts, and integration level. The interaction attempts evidence the existence of CEK and how it is used in the VRBM phases. The new conceptual interrelations presented at the beginning of the chapter explain the 'how' part of the sub-question, and the boundary activities in the later sections explain the 'why' part, to give a full-cycle account of the interrelations between IWRM and LRM in each VRBM phase.

7.1 How Does LRM Relate to IWRM?

As explained in the earlier chapters, policies are determined at national level, as also, in the managerial context, the guidelines and the establishment of regional level branch offices. At regional level, both the river basin territory and the catchment are part of the IWRM unit of management. The catchment is managed at municipal level. The dotted lines between the levels suggest that the boundaries are not fixed and that it is possible to cross levels. All of the actors in each level address the four dimensions of IWRM-LRM and even directly impact the natural dimension, by building infrastructures that are both water and lahar related. This structure simplifies the way in which the four dimensions are managed within the governance levels. The multilevel governance

(MLG) concept is used to explain the conceptual interrelations of LRM in IWRM, as shown in Figure 7.2.

Figure 7.2 visualizes the overlapping of governance levels and dimensions. The dimensions are based on the initial theoretical IWRM framework (human, spatial, temporal, and natural), to which is added infrastructure as the incision dimension between the human and natural dimensions. As the dimensions are intertwined, the MLG structure is used, with the human dimension as the starting point. The study found that the management levels are national, regional (DAS and WS), and municipal. However, the boundaries between the levels are flexible, as the WS is connected at the regional and the municipal level, and the DAS also crosses municipal and regional boundaries (dotted lines). The types of management contexts are also based on the volcano's status: pre-eruption, eruption onset, and post-eruption, and on the water resources management pillars: conservation, utilization, and hazard control. Later, interaction attempts and the integration level connecting the management contexts are explained. However, to simplify the IWRM-LRM concept, this research proposes the term 'volcanic river basin management'.

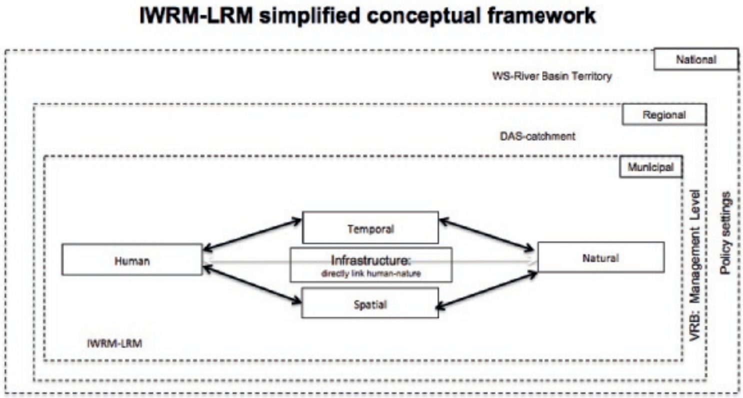

Figure 7.2 Adapted Conceptual interrelations of human-nature diagram

The author adopts the framework discussed in Chapter 2 (Goldstone, 1996) for the five possible ways in which the two types of management (LRM-IWRM) can be interrelated in the river basin: (1) isolated: not related to any aspects or dimensions, (2) coherent: consistent in forming the same aim, (3) juxtaposed: two things being seen or placed close together with contrasting effect, (4) parallel: two things being side by side always touching, although never converging, (5) overlapping: extending over to cover partly.

As juxtaposition effects are contradictory, and parallel and isolated are neutral or have no influence, these interrelations are not meaningful for this study. A coherent interrelation means that integration has only partly been achieved, and this is included in interaction attempts. Therefore, it only makes sense to discuss the overlapping interrelation. This approach is used to propose the VRBM in this research as a way to cluster the interrelations of IWRM and LRM activities. In doing so, VRBM is defined as the management of a catchment originating in an active volcano, in a context that includes water, lahar, and volcano.

This definition is used to investigate the links between water and lahar management. In the governance context, lahar is not addressed by a specific organization; the existing actors 'make do' with the condition. This is where the overlap is located, when the water-managing actors sometimes have other jurisdictions in lahar or volcano, or vice versa. The main actor is the river basin organization (RBO), with other organizations having a role, such as the volcano center, catchment management authority, national parks authority, disaster management agencies, and community-based organizations (CBOs).

There is a shift in the IWRM pillars' focus on implementation (conservation, utilization, hazard control) in each LRM stage (pre-, onset, post-eruption), and this consequently impacts the shift in command role. For example, during the pre- and post-eruption stages, the RBO has command of the river, but, during eruption and lahar flow, the disaster management agency becomes the commander for all aspects. The findings show that there is currently little proof that integration exists between water and lahar management. As explained in two earlier chapters, 'boxed' management occurred according to the IWRM pillars and the LRM stages. Figure 7.3 portrays how these overlapping constructs exist in VRBM.

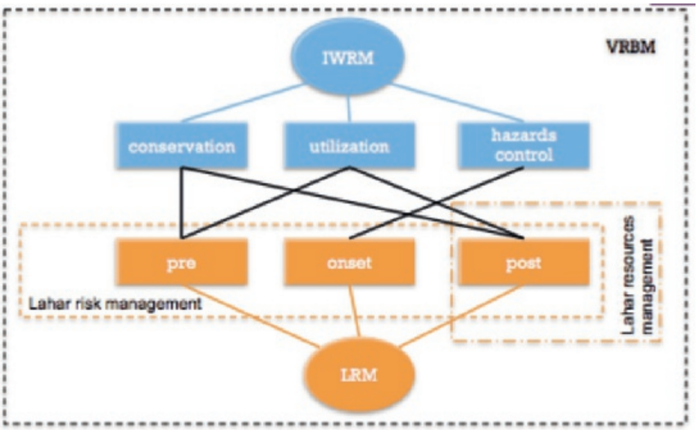

Figure 7.3 Interrelations of WRM-LRM in VRBM

First, note how the IWRM pillars are clustered: conservation, utilization, and hazard control have connected activities within LRM pre-, during onset, and post-eruption. This arrangement is explained as follows:

- Conservation at pre- and post-eruption. The upstream area as water catchment is delineated as a conservation zone managed by the national parks authority (TNGM), whereas BPDAS SOP manages midstream and downstream conservation areas. River forums monitor water quality and the conservation of rivers.
- Utilization at pre- and post-eruption. Post-eruption, water is harvested after lahar sedimentation is dredged from Sabo dams by the sand-mining industry managed by Local Mineral Resources Agency, CBOs, and private companies. After some years of no eruptions, the condition reverts to the pre-eruption

phase, the rivers are normal again, supposedly with no more sand mining. Here, water intakes and a multifunction Sabo dam are used to supply water for irrigation and DMI (domestic municipal industry) water supply, which are handled by BBWS SO, CK-SPAM, and PDAM. Communities also directly utilize springs or wells for drinking water.

- Hazard control at eruption onset. All water intakes from the infrastructures are stopped. Water for the upstream area cannot be used, so BBWS SO, PU-P ESDM, CK-SPAM, and Pammaskarta DIY send water tankers. BBWS SO has to maintain all water infrastructures. Activities focus on disaster mitigation and evacuation plans led by disaster management agencies (BPBD DIY-BNPB) and a variety of volunteer forums. Water in the mid- and downstream area is still utilized, but disruption takes place.

Second, LRM is termed as lahar risk *and resources* management. In this context, risk management is always involved pre-, during onset, and post-eruption, whereas lahar resources management applies to post-eruption only and deals with lahar sediment extraction or sand-mining activities.

Third, these overlapping interrelations are termed VRBM phases, where the LRM stage and the IWRM pillars come second in order of priority. Figure 7.4 presents the VRBM phases.

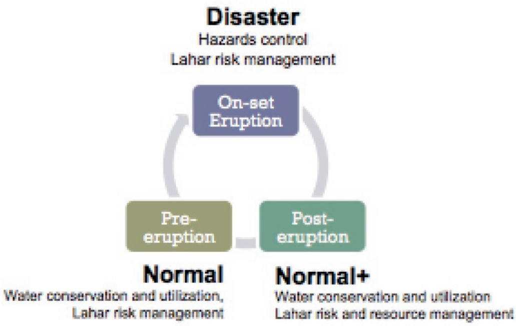

Figure 7.4 VRBM phases: Normal, Disaster, Normal+

In the Normal phase, water utilization and water conservation are fully implemented, and lahar risk management is at the preparatory stage. During this phase, water utilization is fully optimized, and water conservation relates to both land and water. The water discharge into the rivers and springs is at average capacity, not being interrupted with volcanic activities. The lahar sediment has already been removed, and no sand-mining activities are allowed. This condition arises because the riverbed requires a minimum amount of sediment transfer for ecological functions. The RBO and the catchment authority take control of management.

Disaster VRBM includes both water-related hazards under normal volcanic conditions and water-related hazards during a volcanic eruption. The primary hazards (pyroclastic flow, lava, hot flames, and ashes) and the secondary hazard (lahar flow) may occur according to the severity of the eruption. In this phase, the function of volcano and lahar risk management is activated to reduce risks. However, as the focus of this research is more about water-related hazards, the primary hazards are not part of the main findings. Nonetheless, they still play a role in Sabo management. The disaster management agency takes control with the help of the RBO and the volcano center.

Normal+ occurs when the eruption stops, but the lahar flow may still be taking place, in the form of volcanic materials triggered by rain. This phase is where the lahar risk and resources management overlap and may already include water utilization from river, wells, and springs. Implementation of the conservation pillar may still be delayed until the Normal condition is re-established. An additional function during Normal+ is the extraction of lahar sedimentation in the form of sand-mining activities. This condition arises from having Sabo dam systems in the river; dredging is required to re-create the pre-eruption condition to restore capacity in the dam. The RBO takes control for determining the volume of extraction and the distance from the Sabo facilities at which extraction is allowed.

7.2 LRM Interrelations with IWRM in the Multilevel Governance of VRBM

Conceptually, the interrelations are found in the overlaps between LRM and IWRM practices. This section therefore focuses on the implications of overlapping in the MGL context of VRBM. VRBM is described in terms of similar structures in Chapters 5 and 6, first regarding the policy settings and second regarding the managerial contexts, but this chapter focuses more on the overlap between the two management sectors. The results of these overlaps are presented in the order of the VRBM phases: Normal, Disaster, and Normal+. Each result points to the overlaps in the main actors' jurisdictions and authorities in each phase.

7.2.1 Policy Settings Overlap

The main policies relating to water resources and lahar management are the revoked law no.7/2004, the DRR law no.24/2007, and the ESDM Ministerial Decree no.15/2011 on Guidelines of Disaster Mitigation for Volcano, Land Movement, Earthquake, and Tsunami. The derivatives of these policies are also used at national level as the guiding policies.

Normal

During the Normal phase, the policy overlaps happen between the water resources, the natural conservation, and the volcano management decree managing volcano monitoring. In reality, the overlaps continue to take place in the VRBM phases. These overlaps arise because, in the managerial context, the spatial authority of a river basin coincides with that of the volcano region. Water utilization in this phase is guided by several ministers' PUPR regulations on the development and management of irrigation systems, water sources utilization, dams, water infrastructures, the setback of surface water and irrigation channels, water source exploitation permits, irrigation operation and maintenance, and water system planning.

The revoked water law briefly mentions lahar as a water-related hazard, but without describing how to cope with it. The old irrigation law that is currently in force does not mention anything about lahar or any other water-related hazards. Within the extensive series of ministers' PUPR regulations used to support the irrigation law, only one – PermenPUPR no.13/PRT/M/2015 on Countermeasures for Disaster Emergency due to Water Damage – comments on lahar risk management, but without further explanation about how this hazard is to be managed. It does mention hazard control, but not water conservation and utilization. Furthermore, it does not indicate the eruption condition in which this lahar develops.

Furthermore, the water law hints at the existence of the catchment, which falls under the Ministry of Environment and Forestry's (LHK) natural conservation law no.37/214 on Land and Water Conservation. The overlap takes place as the river basin territory consists of one or more catchments, including water. However, the water law applies to water, and the conservation law applies to both land and water. This complication emerged, for example, when the upstream area became a national park under the Ministry of LHK; Mt. Merapi is included in this.

Disaster

Another overlap occurs during disaster onset; based on Law no.24/2007, BNPB (disaster management agency) takes command, and whatever the disaster is, flood, volcano eruption, or other, the command line is switched to that agency. The other ministries in this condition take the role of supporting BNPB. This condition signals the transfer of authority between organizations.

The Ministry of ESDM's (energy and mineral resources) decree for volcano management explains the existence of lahar. Further, it describes two types of lahar occurrences: eruption lahar and rain lahar. Both are mentioned in the context of rivers as lahar channels. Moreover, it suggests alternatives for infrastructures to manage lahar. However, the building and maintenance of infrastructures are not the responsibility of this ministry; rather, they fall under the Ministry of PUPR (public works and housing). The Ministry of ESDM gives technical recommendations, whereas the Ministry of PUPR constructs, operates, and maintains lahar control infrastructures in river channels. This arrangement gives a greater lahar management role to the latter.

Normal+

In this phase, both water conservation and utilization are already taking place. The overlap comes with the extraction of lahar sediment by the sand-mining industry. The Ministry of ESDM is responsible for the policy on extraction under Law no.4/2009 on Mining on Minerals and Coal. The law highlights the importance of other related government institutions and also the local government in deciding the delineation of the mining area. Also, control of mineral extraction permits is delegated to the regional or provincial level, as the national government cannot supervise the whole the country.

For minerals located in the river, recommendations are required from the related government institution that is in charge of the rivers and the administrative location. As stated in Law no.4/2009 on Mining on Minerals and Coal, the policy also covers those mining locations in the river where: "(The river) has a reserve of secondary minerals (sand, stones, or gravels) located in the river or between the embankments of the rivers." The policy aims to address community-owned mines, but the condition in the case study is that sand mining is a massive industry conducted by multiple actors, private and communities alike, supported by strong investors (politicians or high-ranking military generals). This situation is discussed in the lahar management chapter, Chapter 6. Most sand extraction locations are in the river channels near the Sabo dams built by the RBO and BBWS SO, which also 'owns' the rivers. This condition is at variance with the regional government's control function. In this instance, the regional level asks the RBO for 'technical recommendations' on safe distances from the Sabo dam facilities to conduct mining activities and whether the location has lahar sediments. The overlapping policies are summarized in Table 7.1.

Table 7.1 Policy settings overlaps

Overlaps	Normal	Disaster	Normal+
Policy settings	Water conservation and utilization (KemenLHK, KemenPUPR)	Eruption, volcano, and lahar management (BNPB, KemenPUPR, KemenESDM)	Water conservation and utilization Sand mining (KemenPUPR, KemenLHK KemenESDM)

7.2.2 Managerial Context Overlap

The overlap in the managerial context at national level occurs in all VRBM phases. The national actors play the role of giving guidance and policy orientation (KemenPUPR, KemenESDM, BNPB). International agencies (UN-Habitat and JICA) are also involved either during eruption onset or post-eruption. Their roles diminish when the emergency status changes to the normal condition, except for JICA. Since 1976, this organization has been investing funds and researching Mt. Merapi. JICA has a role in determining decisions on lahar risk management using the Sabo dam concept and design. Its role is one of research and consultancy in planning and managing different aspects of lahar in collaboration with KemenPUPR at the Directorate General of Water Resources (DGWR).

These phases are visualized in Figure 7.5, which presents the Normal and Normal+ phases containing the water conservation and water utilization pillars, and the Disaster phase focusing on the water hazard control pillar:

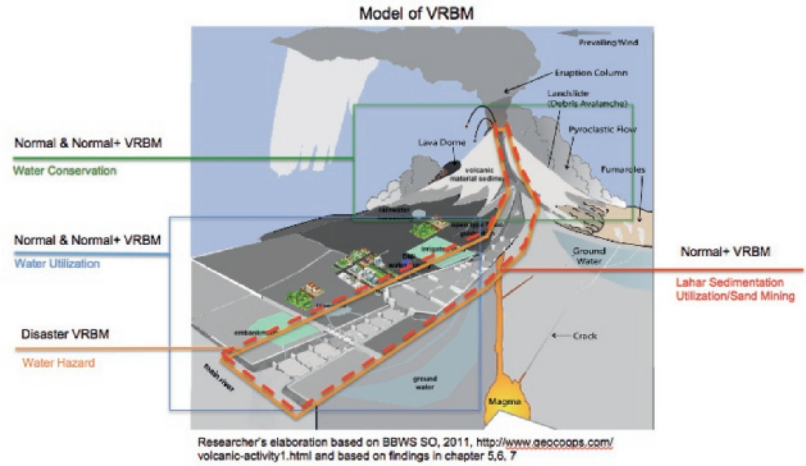

Figure 7.5 VRBM model (overlapping of VRBM phases with IWRM pillars)

Normal

The Normal VRBM phase focuses on water conservation and water utilization with lahar risk management in the pre- and post-eruption phases. At national level, during this VRBM phase, the activities are coordinated by Bappenas. The Ministry of Public Works and Housing, under DGWR, implements water management with a combination of water conservation and water utilization. The essence of its approach is still technocratic and default. The focus of this management is water utilization for irrigation, for drinking, for the municipality, and for industry. Provision is made through dams, weirs, and direct extraction from river intakes, calculated on the needs of the river basin territory. Water utilization is based on the supply and demand functions of water (Asian Development Bank, 2016, Ditjen SDA, 2015).

Water conservation, under IWRM implementation, takes form in collaboration with other ministries. Since 2015, this collaboration has included eight ministries or persons representing the ministries in the National Movement of Water Safeguarding Partnership (GNKPA): the Ministry of Internal Affairs (Kemendagri), National Budget Agency (Bappenas), Ministry of Public Works and Housing (KemenPUPR), the Ministry of Agriculture (KemenTan), National Government-Owned Companies (BUMN), the Ministry of Environment and Forestry (KemenLHK), the Ministry of Agrarian Affairs and Spatial Planning (BPN), and the Ministry of Village, Disadvantaged Regions, and Transmigration (Kemendesa). http://birohukum.pu.go.id/berita/113-Kesepakatan-bersama-GN-KPA.html.

Their Memorandum of Understanding (MoU) is an intergovernmental joint effort to encourage community participation through a national community movement. This joint effort is in line with Law no.23/2014 on Regional Government focusing on the hydrological cycle in watersheds (DAS). The MoU targets 108 priority catchments, 15 priority lakes, 29 priority dams, and 17 rice centers. GNKPA asked each ministry to engage collectively to provide the facilities and infrastructure according to their duties and function. However, the stakeholders' implementation of these tasks required assistance from regional and municipal actors, who proved too difficult to engage given the fragmented condition of the IWRM approach as explained in the IWRM chapter, Chapter 5.

At regional level, the foundations of a water conservation partnership can also be found. However, the Opak river basin does not fall under the priority catchments addressed by Law no.23/2014, which voids GNKPA's existence. Therefore, conservation is undertaken on land by the forestry and agricultural agency in collaboration with BBWS SO and PU-P ESDM on water bodies. The activities carried out using a non-technical approach relate either to planting in degraded catchments or around water bodies or to terracing the steep slopes of ravines. A technical approach is applied to dams, to check dams and embungs (retention basins). PU-P ESDM helps to apply the latter approach and to maintain the Opak sub-basin. As mentioned in Chapter 6 on lahar management, because of the volcanic activity and sedimentation problems from lahar flow, the sub-basin does not have big dams. The water utilization for irrigation is also managed by the RBO and BBWS SO, PU-P ESDM, and the agricultural departments.

Meanwhile, for the water supply, BBWS SO provides and prepares the source, but distribution is by PDAM (local government-owned company) or community-based organizations: Pammaskarta DIY. Problems arise because BBWS SO has authority over rivers and springs, or any water body, and BPPTKG monitors volcanic activities, but, when it comes to Mt. Merapi, the national parks authority (BTNGM) limits others' access, even though there are river infrastructures in the location and all the water bodies at the summit, such as river sources, are BBWS SO's responsibility.

Aside from the two focuses explained in the lahar management chapter, lahar risk management is still ongoing during Normal VRBM, as preparations are made for lahar flow in this condition also. In this case study, the preparation includes hazard maps, training, education, early warning systems (EWS), and the Sabo dam system. It is segregated based on the duties and functions of the actors, although there is a coordinator in the form of Bappeda DIY or the regional development agency. Therefore, a loose structure is in place: Bappeda DIY knows who is doing what, but does not interfere in the progress of the preparations.

Water conservation is not as strong at municipal level as it is at regional level. The agency at this level also is supported by the regional level agencies. Therefore, initiatives do not tend to be taken in this regard. On the other hand, more initiatives are taken regarding water utilization, as explained in the IWRM chapter (Chapter 5) on the river communities and Spamdes (village level Pammaskarta).

All of these actors are part of the IWRM water conservation and utilization pillar, but the involvement of the private sector is missing. Both RBO and community actors attest to this claim.

> Yes, from the private sector, I haven't seen. I see the community's (involvement). (Tri Bayu Adji, BBWS SO, 2016)
>
> They (actors in river basin management) are the government, community, (and) university. But (from) private (sector) are not so many, only one or two, not yet massive. (Agus Maryono, River Communities, 2016)

As also explained in earlier chapters, the involvement of private actors, although noted, is not so much detected. Some water companies engage in water distribution, but these are still government owned. Furthermore, water resources management for water supply is not as significant as water resources management for irrigation. In the VRBM Normal phase in this case study, the river basin territory bridges the national and regional levels, and the water catchment bridges the regional and municipal levels. In addition, water conservation and utilization are managed on a sectorial basis. The key to how this condition is bridged is explained in the interaction attempts section of this chapter.

Disaster

During the Disaster VRBM phase, all water conservation and utilization activities are immediately stopped. This phase consists of both the eruption and the lahar flow condition as the continuity of the eruption, and it focuses on hazard control. At national level, this means that BNPB takes the lead, as explained in the lahar chapter in the onset eruption condition. BNPB has almost unlimited jurisdiction and even funding supports within its 'on-call' budget when the onset condition occurs. The other ministries still 'guard their posts' or fulfill their roles as managers of each water sector, but Bappenas is no longer the commander or coordinator. However, the national government only gives guidance, with the mandates being issued at regional level.

From the findings it appears that the regional level focuses on minimizing the victim numbers and impacts on infrastructures. The regional government through BPBD DIY organizes coordination and a rapid-response team during any disaster, depending on the type of disaster. In the case of volcanic eruption, BPPTKG is the primary source of information, whereas for lahar BBWS SO and Balai Sabo are the primary sources. Victim numbers is minimized using the EWS, evacuation routes, and meeting points. The Sabo dam system addresses the second aim of minimizing impacts on infrastructures (roads, bridges, and settlements) in combination with the hazard map and land-use control. As a reminder, the Sabo dam system consists of consolidation dams, sub-dams, guiding channels, sediment retention dams (SRDs), and sand pockets.

Regarding the other two pillars, water conservation and utilization, the findings in Chapters 5 and 6 explain their implementation. First, water conservation is completely stopped during this VRBM phase. No respondent has referred to water conservation activities during eruption or lahar flow. Second, because the water utilization process is inactive, the water for the victims of eruption is brought in from somewhere else. Pammaskarta DIY's (regional level) role is invaluable in sending water tankers to the impacted locations, as described in Chapter 5 regarding IWRM. The initiative for providing water tankers is based on volunteerism and a collective spirit (*gotong royong*), which flourish during all disasters in the Yogyakarta Special Region. Thus, the conceptual interrelation, as presented in the earlier part of this chapter is proven: both pillars – conservation and utilization – are stopped during Disaster VRBM in the case study location.

Normal+

The Normal+ VRBM applies in the post-eruption condition, where the normal VRBM phase is accompanied by lahar sedimentation extraction (sand-mining activities). The first two pillars of water management – water conservation and water utilization – have been explained above in the Normal VRBM phase. However, the overlap of water and lahar sediment is much more exposed in the Normal+ phase.

The national level creates guidelines for mineral extraction, with reference to other related government institutions (ministries) and also lower levels of government, which have jurisdiction in defining the mining locations. However, as explained in Chapter 6 on lahar management, responsibility for the control of, and permits for, sand mining lies at regional and municipal level, depending on the size of the quarry. River quarries are suitable as community-owned mines. However, as the whole river originating from Mt. Merapi has the potential to be the quarry, the issuing of permits is a regional level matter. The Sabo dam system, in particular, requires the maintenance of river channel capacity, and sand-mining activities have an essential role in this. Similar stakeholders are engaged in both the Normal+ and the Normal phase, such as BPPTKG for the volcano and BBWS SO for the rivers, except for the regional level BPKM DIY, which gives the permit for the mining activities.

The policy is not clear with reference to who is the main stakeholder responsible for lahar management in general, but most respondents agree that this should come under the authority of BBWS SO. BPPTKG's role is mainly the monitoring of volcanic activity, whereas Balai Sabo functions as a research institute for Sabo technology and development, especially the making and testing of models. However, BBWS SO is responsible for lahar risk management because of its involvement in infrastructure construction and for lahar resources management because of its involvement in technical recommendations. The main characteristic of disaster management reflects the humanitarian side of values, where volunteerism and collective action are needed. This study shows that, during a disaster event, all involved stakeholders show great flexibility in order to ensure that aid is delivered to the communities that need it.

MLG is presented on the volcanic hazard map in terms of administrative jurisdiction, and the volcanic activities cycle demonstrates the sectorial and temporal multilevel arrangements. The maps are based on BPPTKG's monitoring data, which covers more than 100 years of data, to develop a systematic way to predict future eruptions. For lahar, as BNPB collaborates with BPBD DIY, the map was produced in 2010, also based on BPPTKG's data. BBWS SO in this regard also uses the same source for its lahar map, but combined with satellite imagery data. Regarding the EWS, the volcanic and annual flood cycle, which includes the lahar cycle, all the stakeholders who monitor the volcano and its surrounding including land and rivers are still starting to coordinate their massive range of different measuring equipment.

The BBWS SO (RPSDA WS POS) planning document addresses lahar more intensively than any BBPTKG or BPBD DIY planning documents or reports. It provides the calculation of volcanic sediment materials that can be held at the flank of Merapi using the Sabo dam system. The other two organizations focus mainly on evacuation during the onset of eruption.

The Sabo dam system as an infrastructure managed by BBWS SO demonstrates the interrelations of the lahar risk and resources management functions, as well as the water–lahar coexistence, whether at management level or in the natural condition. The location of Sabo dams near residential areas needs further study to delineate a lahar buffer zone and its relation to important local places (i.e., sacred location, spring water). The management of Sabo facilities is more delicate post-construction, as they should be maintained with dredging activities. The current sand-mining activity in all Mt. Merapi's rivers should be regulated as a matter of the highest priority, as it could offer a solution in Sabo operation, but also pose a danger to the stability of the infrastructure, if not carefully monitored. The handbook on sand-mining management is a good starting point, but the community needs more support in their legal authority to report any misbehavior.

At regional and municipal level in all VRBM phases, interrelations also take place in the infrastructure used for lahar. This could be extended to function also as water intake for irrigation or water supply. As the Sabo dam stops lahar and water, the intakes are protected by the Sabo structures and located at the side (dike). This multifunction of Sabo dams as irrigation intake was not available in sub-case study 1, but it is in use further upstream at Kuning River, which is also in the Opak sub-basin. Figure 7.6 shows Sabo Dam KU RC-3 at Kuning river, where its multifunctionality is apparent: lahar control, temporary bridge, and irrigation intake.

Figure 7.6 Sabo dam as a form of water and lahar management (BBWS SO, 2015)

At municipal level, the experiences with lahar onset in Disaster VRBM differ in impact severity between up-, mid-, and downstream. Logically, the most affected would be upstream in sub-case 1, but respondents there were more concerned about recounting their experiences with the pyroclastic flow than with the lahar flow; this is understandable given that around 100 people died in the incident. The mid-stream area impacted by lahar was composed mostly of informal riverside settlements. Sub-case 2 presented the example of Code Riverside settlement, Gowongan, as the most impacted by the 2010 lahar, although lahar had been recognized through patterns of the cycle during the rainy season after previous eruptions. The houses in this settlement were half buried up to 1 meter deep, but no direct victims were recorded. Sub-case 3 suggested less impact on residents, as the area is further from the Opak River. The impacts there related more to river sedimentation, with no direct victims of the lahar flow. The actors at each level of governance are presented in Table 7.2

Table 7.2 Actors in VRBM phases

Level of Governance	Normal Actors	Disaster Actors	Normal+ Actors
National	KemenPUPR, KemenESDM, LHK, Int'l Donor-JICA	BNPB, Int'l Donor-humanitarian	KemenESDM
Regional	BBWS SO, BPDAS-HL SOP, PU-P ESDM, PDAM Pammaskarta DIY AKSY	BPBD DIY, BBPTKG, Forum PRB regional	PU-P ESDM, BBWS SO
Municipal	Din.SDAEM, Din.PU, Din SDA River communities: FKWA, PKC, GWC, TBCSpamdes	BPBD municipal Forum PRB municipal, SKSB, Tagana	Din.ESDM River communities

7.2.3 Interaction Attempts Overlap

The interaction attempts, as explained in the earlier chapters, are summarized in this section, paying attention to whether direct relations occur between the existing attempts regarding budget, water, and disaster. When there are no direct relations, alternative relations are found through the roles of some actors. These attempts are summarized in Figure 7.7, which is built from the interaction attempts diagrams in earlier chapters and describes the interaction attempts in a VRB. The three types of interaction attempts existing in both water and lahar management are used in VRBM, with the horizontal arrangements: budget (A), water (B), and disaster(C), and the level of governances as the vertical arrangements starting from the highest to the lowest hierarchy: national (1), river basin territory (WS), regional (2), catchment (DAS), municipal (3).

In water (B) and disaster (C), informal and formal attempts exist. In each of the attempts, the integration levels are also assessed based on coordination, collaboration, and cooperation. There is plea for the use of more CEK values (*gotong-royong* and discussion) in the interaction attempts to promote integration.

> So far, this means we are criticizing, but forgetting the existence of (collective action) *gotong-royong* and discussion. But, this (research) shows that in reality we still have the sectorial ego. (Respondent BPDAS SOP, 2018)

The term '*gotong-royong*' is used to describe a collective action spirit and social capital. This quote explains that, whatever form interaction attempts take, what is missing is CEK values in the way the interactions are handled. No wonder the sectorial boundaries (between ministries or agencies) are still holding firm. Table 7.3 summarizes the interaction attempts in each VRBM phase.

Table 7.3 Interaction attempts made in VRBM phases

VRBM phases	Normal	Disaster	Normal+
Interaction Attempts	Budget (A): Rakorbang and Musrenbang (formal) Water (B): Water councils (formal) River communities, Pammaskarta (informal)	Budget (A): Rakorbang and Musrenbang (formal) Disaster (C): Disaster Task Forces (formal), Forum PRB (informal)	Budget (A): Rakorbang and Musrenbang (formal) Water (B): Water councils (formal)

Normal and Normal+ Interaction Attempts

The interaction attempts for Normal and Normal+ VRBM correlate with conservation, utilization, and preparation for hazard control in IWRM implementation and with pre- and post-eruption management in LRM implementation. Thus, the attempts relate to budget and water interactions.

In national attempts between budget (A1) and water (B1) in the horizontal arrangements, there are no direct interaction attempts. The interrelations occur through the actors within the two interaction attempts, as some are the same actors. This failure in national coordination attempts is caused by ministries' 'sectorial ego' leading to full fragmentation.

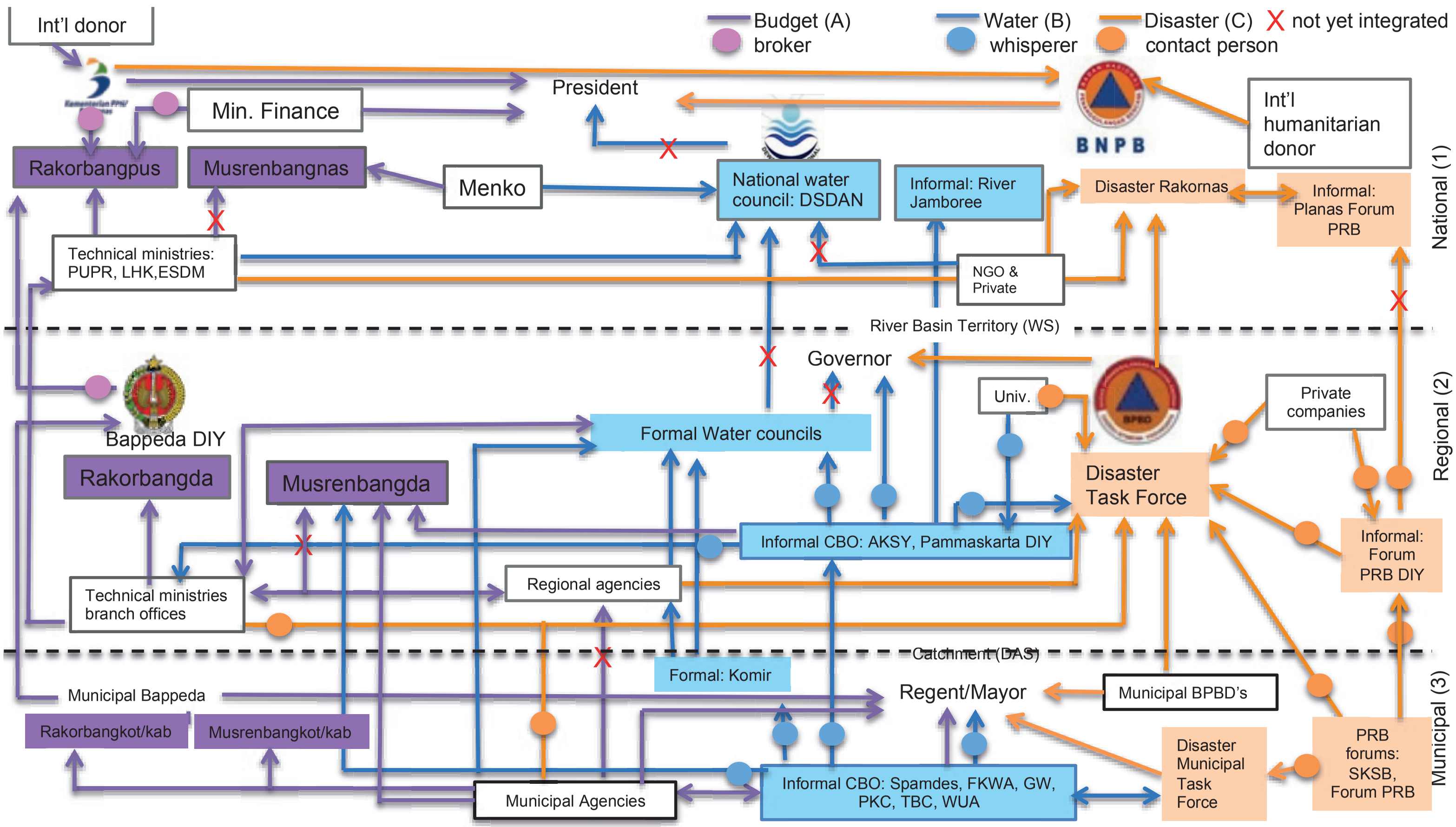

Figure 7.7 Interaction attempts in VRBM: Budget, Water, and Disaster themed

The National Water Council (DSDAN) (B1), consisting of 50% government representatives (ministries) and 50% non-government representatives (NGO, private companies), facilitates water interaction attempts. The budget positioning makes the Ministry of Public Works and Housing, as the host, the driving actor. The data acquired for this are based on reports published by DSDAN and news. Each year, plenary meetings are held, and recommendations on water management are made to the President. The meeting mechanisms are not very engaging for the stakeholders, they are not continuous, and sometimes there is no follow-up.

The informal attempt in water (B1) – National River Jamboree – has been held twice by the national initiatives of river communities in Indonesia, with the aim of raising awareness of river restoration activities. Government support for this kind of entity falls under both the RBO (public works and housing: PUPR) and the catchment management office (environment and forestry: LHK).

For Normal+, an interaction attempt for sand mining does not explicitly exist. It can be addressed as an issue within budget or water attempts, but no interaction attempts evidenced such discussions at national level. Between the national and regional levels, the interaction attempts exist within the same sectors, for example, the direct interaction between the ministries and their branch offices at regional level. However, interaction between inter-ministerial and inter-branch offices, or diagonally, is not possible. The interactions should first go through either the relevant minister or Musrenbang or Rakorbangpus (A1) for budget and DSDAN (B1) for water.

However, within the same interaction attempts (A1-A2 and B1-B2), there is a mechanism for reporting the results from the lower level, but there is always negotiation about the common aims. When asked whether any recommendations from DSDAN (1) indeed reach the President's desk, many respondents have a similar answer:

> Well, that's it. What (recommendation) reaches there (the President's desk). (Respondent BBWS SO, 2018)

This informs the integration level within the same interaction attempts but amounts only to coordination or information sharing; interaction attempts between budget and water (A2-B2) are still non-existent.

In the regional interaction attempts, between budget (A2) and water (B2), similar conditions exist. Most actors in the water attempts are also involved in the budget attempts. However, the representatives who attend the attempts may not be the same. Thus, information sharing is established, but it is unsure whether there is any follow-up, especially as the results of water attempts (B2) are merely recommendations. The respondents, from both the government and the community side, have similar doubts about whether the information shared in water attempts (B2) has been included as a priority program in the budget (B1):

> TKPSDA and DSDAP, they are not representative of the community. (Ari, Pammaskarta DIY, 2018)

Even the existing water attempts (DSDAP, TKPSDA, Forum DAS, Komir) at regional level (B2) are merged between provincial, river basin territory, and catchment. The same members of each of these formal attempts mimic the structure of the national water council, with the 50%:50% rule. However, even though the results of the meetings are conveyed to the leaders (TKSPDA to the Minister of Public Works and Housing, Governor and Regents/Mayor, and DSDAP and Forum DAS to the Governor), they do not have the mechanism to translate their recommendations into actions or annual programs. The most prominent of these three is TKPSDA, as it addresses WS POS or two provinces: Central Java and Yogyakarta Special Region, hosted by the RBO (BBWS SO).

From the TKPSDA (B2) annual reports and minutes of meetings (MoMs) (2010–2015), it is seen that coordination is not easily reached, as that organization is also faced with limitations of: (1) scheduling of meetings, (2) dispersed locations of members, (3) non-continuous attendance of the representatives from the government sector, (4) most representatives are old and have limited technological literacy and capacity, and (5) the meetings consist mostly of listening to presentations and no significant contributions are made.

> No significant change is made, last year's TKPSDA is boring, it's just the same, there is need for change, the members should be more active, not only saying 'yes' all the time. (Respondent BBWS SO, 2018).

The meeting agenda is set each year at the first meeting and proposes to address water issues. The agenda is still very general at this stage, with no means to translate the agenda into action, for example:

> Encourage law enforcement against regulation breaches on river and irrigation setbacks to the Minister, Governor, and Regents. Institutional optimization for water resources managers to Minister, Governor, and Regents. (MoM No: 02/BA/TKPSDAWS POS/IX/2013)

The members of these water councils (B2) are almost the same; for example, BBWS SO participates in all of the attempts, as does the Pemerti Kali Code, but, for the private-sector members, participation depends on the location and the focus of the water attempts. Differences include who the host is, the scope of administrative jurisdiction, and the focus. For example, as explained in Chapter 5, TKPSDA and DSDAP have more or less the same focus on water resources management for all of the pillars, except that BBWS SO is the host of the first and the scope is the whole of the WS Progo Opak and Serang, and, for the second, the host is PU-P ESDM for the whole Yogyakarta Special Region. Forum DAS focuses more on land conservation or catchment management and is hosted by BPDAS SOP. Komir is hosted by BPSDA (under PU-P ESDM) and focuses more on daily activities of irrigation, such as water allocation at specific times and in specific places.

At regional level, informal water interaction attempts (B2) exist, such as the meetings of Pammaskarta DIY (drinking water supply) and AKSY (river communities). The meetings are held organically – the organizations arrange the facilitation and the budget on their own initiative. As they are community-based organizations, their meetings are not very formal. They discuss in rounds, seated on the floor. The agendas of the meetings are pre-set, but additional agendas can be addressed. Some of the members and the heads of these CBOs (the whisperers) are in close communication with the heads of the budget line (A2), such as Pammaskarta DIY with PU-P ESDM in supplying drinking water and AKSY with BBWS SO for river restoration.

The sharing of information, aims, and budgets at regional level has achieved some successful results, for example, SPAM Regional. This project is about providing drinking water for the whole region. It was formed through cooperation between BBWS SO (water sources), Satker CK-SPAM (water treatment), PU-P ESDM (facilitator), and PDAM (distribution), or at times Pammaskarta DIY and Spamdes (distribution). Therefore, there is some evidence of the existence of integration at regional level, although at the initial level of cooperation and only on water. Integration for irrigation still exists only in the information sharing at Komir. Therefore, the integration level is not equal for all aspect of water utilization. It can be said that integration is on the level of collaboration.

For Normal+, sand mining is discussed in TKPSDA as an issue to be addressed, as found in their 2014 MoM on sand mining in all rivers originating at Mt. Merapi. The points of discussion include:

- The need of a concept to let the upstream sand flow to mid- and downstream
- Empowerment of the community in the quarry areas
- Enforcement of regional regulations governing mining activities
- Review Sabo dam building in relation to sand-mining management.

TKPSDA was critical about the condition of sand-mining activities and was already raising awareness by making these recommendations to the regional and municipal governments. However, there was not a rapid follow-up, and the next TKPSDA meetings did not monitor follow-up or discuss this matter further.

The role of whisperer between water and budget is seen as being that of communicator. This whispering can take place in the inter-level interaction between A2 and B2 and guarantee smoothness of interaction when the same person (the whisperer) is representing the institutions in both attempts. The continuation of information flow also guarantees that the priority list of the water attempts progresses into the budget attempts.

At municipal level, the interaction attempts include both budget and water attempts. However, the municipal level only has Komir (B3) and the link to budget (A3). Furthermore, during the Musrenbang meetings, the farmer group's representatives, who are Komir members, are not always definite. Moreover, the Komir in this case study does not have representation from Yogyakarta city, as there is no significant irrigation area there. The Opak sub-basin case is represented in Komir by the hosts: DSDAEM Sleman and DSDA Bantul.

The Musrenbang is supposedly a two-way discussion between government and other sectors (private and community), whereas the Rakorbang is comprised exclusively of governmental organizations. Both of them have the same format, but with different participants. So far, they exist as 'ceremonials' and are not yet integrated. The term ‘ceremonials’ is chosen as the plenary discussion is not as participative as it aims to be. The discussions are unidirectional, led by the government sector as a way to present development planning. The following quote confirms this:

> The Musrenbang is there, but I beg your pardon, only for formality. (Respondent BPDAS SOP, 2018)

These Musrenbang meetings or budget interaction attempts (A3) have no mechanisms for feedback from local partners from the water sector (B3). This interaction attempt does not embody integration. Therefore, in general, these attempts are not yet considered as successful coordination. Sometimes, water projects are proposed in the Musrenbang through the bottom-up approach, but they are mostly allocated from regional to municipal level governments. Moreover, as the members of the attempts are not the same, there can never be information sharing between Komir and the Musrenbang.

Meanwhile, the informal attempts are represented by SpamDes or Pammaskarta for water supply at municipal level (in Yogyakarta City, SpamDes Sleman and SpamDes Bantul) and the river forums, mostly in the inner city or the urban agglomerations of Kartamantul (Yogya, Sleman, Bantul), FKWA (Winongo River), PKC (Code River), TB (Tambakbayan), Gadjahwong. These are community actors with support from private companies, universities, local and even national government. Water user associations for each village community are also referred to in sub-cases 1 and 3. However, their roles are diminishing, as irrigation problems do not predominate. Therefore, it can be concluded that the integration level for this level is also non-existent.

Disaster Interaction Attempts

Disaster interaction attempts are only active during the Disaster VRBM phase and focus on the disaster. They have an active command line from BPBD and BNPB. The structure under them is not on different levels; it is mostly horizontal and creates flexibility, also with the help of flexible budgeting mechanisms. During this phase, the whisperer (B) takes part in the interaction attempts and becomes a contact person (C) for his organization.

At national level, there is a formal interaction attempt (C1) led by BNPB, with which international donors make contact during disaster onset. BNPB’s dominant role is activated when a national scale disaster takes place. For the case study, lahar hazard control and lahar risk management became the focus. The Mt. Merapi eruption in 2010 affected two main provinces in Java (Yogyakarta and Central Java). Furthermore, all Java to Bali flight schedules were disrupted with the ash clouds, and the lahar flows cut the inter-provincial main road and devastated many infrastructures in Central Java Province and Yogyakarta Special Region, all of which brought it under the jurisdiction of BNPB.

The actors use Planas Forum PRB for the informal attempt (C1). Although it is an informal attempt, the Planas meeting has a formal agenda. The members are combinations of government, community, academicians, and private companies. However, Planas is not so active, unlike the lower level Forum PRB, and does not contribute as much as the lower level Forum PRB.

At regional level, Disaster VRBM is performed through disaster interaction attempts (C2) in both formal and informal ways. The attempts are made through BPBD DIY in the Satgas Bencana or Disaster Task Force. Here, the volcano actor (BPPTKG) supports the decision on volcano status and the river actor (BBWS SO) supports decisions on lahar status. The current established framework for lahar management coordination and collaboration needs to be more systematic, especially pre- and post-eruption, to be as integrated as during onset eruption. This requires overlapping action by actors, where actors can be introduced and trust can be built. This trust can start between the primary information holders at BBWS SO for lahar and PPK PLG Merapi (branch office) with the Merapi Section at BPPTKG, at least to come up with collaborative works, for example a lahar map and integrated EWS in collaboration with BPBD DIY. However, during the Normal and Normal+ phases, there is no method for direct coordination between the three (BPBD DIY–BBWS SO–BPPTKG). The interaction attempts during these conditions go through the existing water actors in BBWS SO and BPBD-DIY, but not BPPTKG.

The informal methods are channeled through Forum PRB (disaster mitigation forum), with members located all over the region in the municipalities.

> The forum members are institutions, where the command is now Miss Yani from Yakkum (Disabilities Rehabilitation Center). Many of them are working on the (evacuation) plans. (Respondent BPBD DIY, 2016)

Although coordinated at regional level, the forum has ‘organic’ (self-governed) branches in the municipalities, districts, even villages or hamlets, as explained later for the municipal level. The forum gathered momentum in 2011, as BPBD was formed at the same time.

Both the formal and informal interaction attempts contribute to the regional integration level, toward cooperation. Information is unhesitatingly shared in the formal and informal attempts; the common aim to save and help as many people as possible is also shared, and the shared budget comes from different actors within the attempts, through tactical budgets, also supported by the on-call disaster fund, which is allocated by the government.

At municipal level, the BPBD in each location is actively involved in commanding on the site directly. This level is more familiar with the locations and also uses locals’ CEK to find safe locations, utilizes indicators provided by the five senses wisdom, and provides insights into any taboos during disasters. The municipal disaster task force has the advantage of being sensitized to the kinds of potential hazards that can occur in particular locations. Therefore, when it needs to react, it can do so more rapidly than the regional level can.

> Fortunately, this village has Forum PRB (Disaster Forum) and *Desa Tanggap Bencana* (Village’s Disaster Response). When eruption we become buffer zone (evacuation area). We manage the implementation unit at Argomulyo. However, in normal conditions, the forum is doing training. When disaster strikes, the forum changes to an implementation unit. (Semprit, Argomulyo, 2016)

The term 'Village's Disaster Response' is used for those villages that are trained for the disaster onset condition. The above explanation describes the shifting roles of the forum; this means that the disaster task force members are also members of the forum. This shows that the municipal level also has a high integration level (cooperation) between formal and informal methods, especially at village level.

7.3 LRM Interrelations with IWRM as Integration Level of VRBM

The integration level is determined on the basis of the performance of the overlapping interaction attempts. It is investigated regarding whether there are direct or indirect interrelations between the interaction attempts and the actors. The integration level is measured using the same indicators as in the earlier two chapters, ranging from (1) the lowest: information sharing: coordination, (2) the medium: information and aims sharing: collaboration, to (3) the highest: information, aims, and budget sharing: cooperation. However, to visualize the summary findings, a cumulative scoring system has been developed to present the results. The scoring ranges from 0 for no coordination to 3 for complete cooperation, as referred to in Chapter 3 (Table 3.7).

Table 7.4 presents the scores within each theme in relation to the managerial contexts used for the VRBM phases. As a reminder, the Normal and Normal+ VRBM use the budget and water attempts, and the Disaster VRBM uses the disaster attempts supported by the budget attempts. The explanation for the scoring for each integration level is given for each phase.

Table 7.4 Integration level per theme within each governance level

Integration Levels	Budget (A)	Water (B)		Disaster (C)	
	Formal	Formal	Informal	Formal	Informal
National (1)	0.3	0.3	1.3	1	0.3
Regional (2)	0.6	0.6	3	2.6	3
Municipal (3)	1.3	0.3	2.6	1.6	3

Normal and Normal+ Integration Level

As shown in Table 7.4, at national level, the integration of both formal budget and water (A1 and B1) scored 0.3, because the existing mechanisms are there, but only limitedly utilized and unidirectional. The low score (0.3) for the national formal water attempts results from the ceremonial nature of the DSDAN or national water council (B1); it only exists, without further communicating any information. The informal water attempts scored higher (1.3), as the River Jamboree is utilized as a platform to share information and communicate annually the aims of river communities all around the country. However, as this newly established annual event just began in 2016, further proof is needed to decide whether it can be deemed as having the highest integration level. The use of informal methods helped the water attempts (B1) to achieve a better score. Another point is the non-existence of direct interaction attempts between the lahar and water actors. The integration level for this is not yet traceable, an information-sharing platform existed (A1 and B1) but was not used to communicate in an integrated manner. Therefore, the integration level scored the lowest at national level.

At regional level, the formal water attempt scored higher (0.6) than at national level, with the existence of many water councils, although information sharing is still limited and relates to meetings and the synchronization of the annual program. However, the informal water attempt scored high (3), as it raised the integration level to cooperation, with budget sharing between community stakeholders, ministries, regional government, and private sectors as sponsors of their activities. The integration of the informal water attempts is based on the community's need and sense of belonging; for example, with the SPAM regional cooperation between the regional agency – PU-P ESDM DIY, national agencies – BBWS SO (RBO) and Satker CK-SPAM (water supply unit), municipal company – PDAM (water company), and CBO – Pammaskarta DIY, to provide drinking water for the residents of the municipalities. Each actor provides a budget for this cooperation. The term 'budget' here includes resources, as person-hours are also calculated. The AKSY activities on river restoration are undertaken in collaboration with the RBO, which provides the funding. On the other hand, AKSY provides volunteers to minimize the budget.

Disaster Integration Level

The water and general attempts are not under control during the Disaster VRBM phase. Disaster attempts are both formal and informal. At national level (C1), the formal attempt is made through the Disaster Rakornas and scores as coordination (1), as the data are shared between all actors involved during disasters. Again, referring to Table 7.4, informal attempts exist but have hardly any function, because of the lack of follow-up by Planas PRB, making its score very low (0.3). No higher integration level is achieved, as the aims are shared in the Regional Disaster Task Force.

At regional level, the integration attempts score highest (3) concerning formal and informal ways of working cooperatively (C2). With the on-call disaster budget, most of the actors are prepared to deploy their resources to address disaster emergency needs. The integration reflects the volunteerism and collective action spirit of all actors involved, as the facilities and capacities are ready at hand. Sometimes however, there is still an element of hesitancy in the formal attempt, when it comes to deciding whose budget should be used; this is why it scored not a perfect 3, but rather 2.6, where budget alignment occurred but budgets were not merged. As proof, during lahar onset, the RBO along with PU-P ESDM DIY sent out their heavy mechanical equipment, but without a budget. However, in the informal attempts, Forum PRB DIY shared full information and aims in relation to saving as many people and as much infrastructure as possible, and combined their funding and labor with the government to ensure people's safety. This is why it scored the highest integration level (3). These informal attempts are connected and interwoven between municipal, regional, even national actors on the ground. An example is when the Pammaskarta from Gunung Kidul sent water tankers to people on the Merapi slopes during the 2010 eruption, without any orders from any of the government agencies, and helped to provide clean water for evacuees from upstream Opak. Another example is the river communities, whose members switched function as members of Forum PRB or the Tagana to help BPBD DIY in providing updated 24 hours information on the river's elevation and lahar occurrences.

However, the municipal level attempts (C3) do not score as high (1.6), because the rivers cross municipalities and the RBO is located at regional level. Therefore, the Municipal Disaster Task Force (C3) with its limitations can address only the needs within its administrative jurisdiction, where information is shared and alignment of aims occurs, but the decision about shared purpose is taken at regional level (C2). Forum PRB's informal disaster attempts achieved the highest integration level (3), as PRB is more ready to help within its sporadic network of contact persons at community level, and, as it is not limited by administrative jurisdiction, it is more flexible to the nature of its inter-municipal cooperation. Informal cooperation is more integrated, but it is not ordered in hierarchies and is very flexible in communicating information, aims, and budget to actors across and within the same level. The 'sister village' and Tagana networks are examples of inter-municipal cooperation.

7.4 Why Does Lahar Management Relate to IWRM?

After the above explanations about the overlapping of water governance in a VRB and how the integration levels differ, the next step is to explain why the overlapping happened. Therefore, this section focuses on the following actors: organizations and persons delivering the overlaps and thereby contributing to the VRBM integration level. Thus, the terms 'overlapping of activities' and 'overlapping actors' are used to name these conditions. The conceptual operationalization of these overlaps is dealt with in the appendix to Chapter 7, Table b.

7.4.1 Overlapping of Activities by Organizations in VRBM

The organizations working in the overlapping of the water and the lahar context of this research are not understood limitedly as providing the bridge between science and policy, as found in most definitions. Instead, in a broader context, they facilitate different ranges of possible interactions, as the bridge between LRM and IWRM. In the scope of this research, these characteristics are translated into organizations' ability to (1) connect communities and organizations or organizations and multiple roles and acknowledge the importance of CEK and (2) provide a platform for negotiation and for brokering different interests. In this research, they reside in-between the vertical (hierarchical order), horizontal (on the same hierarchical level), or even diagonal (inter-hierarchical and on the same level) layers in VRBM (see Figure 7.7). These 'inter' or in-between areas are a dynamic 'playing field,' in which the overlapping organizations construct and reconstruct according to their needs and wills. For example, when they need disaster management and water management, they form the playing field between the RBO and the disaster agency. However, when they have different needs, for example to connect the budget to water management, then the field no longer includes the disaster agency, but rather the RBO and the planning board.

While doing so, the organizations labeled in this research as overlapping are generally not consciously aware of their role. However, they understand the importance of building better communication in the 'inter' or overlapping areas. They far from just communicate, though, as they also develop networks and receive updates about developments in each organization.

Normal and Normal+ VRBM

In the vertical arrangement, the national government has established branch offices throughout Indonesia to help regional and local governments with direct aid. These branch offices function as overlapping organizations in their selected and fragmented sectors. They are the 'spear' of national government's implementation, operation, and maintenance of VRBM at regional level. They are situated at regional level; yet, their identity belongs to the national government. The blurred boundaries are visible under the same ministry's office, but not inter-ministries. Inter-ministerial boundaries are still solid, and therefore relationships between crossing ministries have to go through their central offices, except if the ministries have a branch office.

For example, the relationship line between BBWS SO and Bappenas has to go through KemenPUPR Ditjen SDA; but, as both BBWS SO and BPDAS-HL SOP are regional level branches of ministries, they can connect directly, without the consent of their main offices in Jakarta. BTNGM, which manages Mt. Merapi national park, also functions in this way. KemenESDM also has its branch office, BPPTKG, to monitor the status of Mt. Merapi. Even though local autonomy is on the rise, apparently the national government still has an active involvement in developments at regional and municipal level, particularly for many water projects, which require an immense budget, and inter-basin and inter-region annual operation and maintenance are still nationally subsidized. They are the gateways between the national and local levels. The function of branch offices at regional level is to facilitate the fulfilling of municipal, regional, and even community needs. In the context of overlapping, these offices ideally produce studies through applied science and make decisions based on these studies. In reality, the studies also have to accommodate some political interests: as explained in relation to the budget interaction attempts, those who are 'strong' get funding for their projects.

Boundary spanning activities between water and lahar management are apparently taking place under BBWS SO, as that organization seems eager to ask BPPTKG about lahar potential, which is not the primary function of BPPTKG. The authority for rivers falls under BBWS SO, and there are no arrangements whereby the two organizations should make the calculation together, as 'idealized' by BPPTKG respondents. Consequently, the BBWS SO's position is as the connector of several interests in the management of water, lahar, and volcano. This position establishes its role as the leading actor in lahar risk and resources management.

> Although it is only on the lahar's destructive power, not on how much potential, it is the ESDM on volcano management. BBWS's becomes a connector between several interests. (Respondent BBWS SO, 2016)

With this statement, the connection between LRM and IWRM implementation is identified: BBWS SO is the main actor implementing IWRM and is also the main actor implementing LRM. This connection shows that the RBO located in the volcanic basin may have taken up the role of lahar manager. Partner organizations of BBWS SO in VRBM include BPPTKG (volcano center), PU-P ESDM (regional level public works agency), BPDAS SOP (catchment management authority), BTNGM (Merapi national parks authority), and BPBD DIY (disaster management agency). However, from this list, the only true water–lahar manager is BBWS SO, as it plans, implements, monitors, and evaluates both water provision and control of lahar risk and resources.

Besides the RBO, there are other overlapping organizations, such as CBOs and the university. The CBOs are now more engaged and actively collaborate directly with the government. The first example is the river communities: Pemerti Code (Code river community) and FKWA (Winongo river communication forum). These two are active in engaging in interactions in Yogyakarta urbanized area, and the whole region is connected through AKSY. Another CBO noted here is Pammaskarta DIY, which collaborates with Spamdes under one organization. The existence of CEK in these CBOs is the strongest compared to other types of overlapping organizations as they have collective knowledge that varies from one community to the next. Their characteristics have strong resemblances; this complies with the CEK patterns formulated in Chapter 4. Thus, CEK can be traced and learned as part of a CBO's assets. CBOs are the ones that can re-introduce CEK in practice to other organizations in the governmental and private sectors. Their strategy usually deploys informal ways of knowing someone in the interrelated sectors, using alumni networks, family ties, or friends' networks (based on the interviews in 2018 with respondents from CBOs). The following quotes also explain the trend toward interaction attempts between government and community being made through CBOs rather than through NGOs.

> Well, the community is no longer accompanied by an NGO. It has to transform itself today, responding to the new developments whereby the community grows with the growth of information technology. (Agus Maryono, the river restoration movement, 2016)
>
> If this is distinctive in Yogyakarta, right. Here, they consists more of the urban river's local community live interactionally all narrowed down to river restoration.(Tri Bayu, BBWS SO, 2016)

Some overlapping organizations are flexible enough to operate both horizontally (inter-sectors) and vertically (inter-hierarchies). These organizations usually attach themselves to sectors related to their aims, but these are also the CBOs with CEK that provide and use CEK on the ground during a disaster and for water and lahar hazards management, and even for water management during onset hazards. The CBOs active in these conditions are AKSY and Pammaskarta.

Another example of a horizontal overlapping organization is the university, although not all universities – only those who have alumni working in organizations involved in interaction attempts. The alumni network is strongest when trust about quality is at stake. The example in this research highlights the University of Gadjah Mada alumni network, as one of the best universities in Indonesia, many of whose alumni are ministers. Therefore, the university has inter-hierarchy, inter-sector, and inter-discipline access.

The universities in this regard are located all over in Yogyakarta, with Gadjah Mada University as the biggest. They form the bridge between community needs and the government in many ways, but most actively engage with government agencies in river restoration developments.

> Well, this is not an automatic trip, the government and universities are there. That is also included as interdisciplinary cooperation, inter-stakeholders, including the government, community, UGM (Gadjah Mada University), and 10 other universities. Yogyakarta has 310,000 students. (Agus Maryono, river restoration movement, 2016)

As the horizontal and vertical overlapping organizations, the CBOs are located in river communities and the water supply community (Pammaskarta DIY). They are positioned as access points between communities and government to coordinate and collaborate, and often also to cooperate. However, these CBOs are still very much dependent on the persons in the organizations. This situation is a point of vulnerability; like for Pammaskarta DIY, after the death of their founder in 2015, the current status of the organization is that it is no longer as flexible in its ability to act as whisperer to BBWS SO or PU-P ESDM as its partners.

Disaster VRBM

The overlapping organizations, in this sense, facilitate several interests and aspects of VRBM. They conduct studies and make decisions in collaboration with academics and decision makers. The overlapping organizations manage water and lahar during onset hazards. The overlapping organizations for Disaster VRBM are located in both the vertical and horizontal arrangement of disaster forum members (Forum PRB). These members are CBOs operating in Forum PRB DIY at regional level (C2) and Municipal Forum PRB (C3). The main overlap occurs when a disaster is considered to be a national threat; all disaster management agencies (BNPB, BPBD DIY, and municipal BPBDs) work at the same time and in the same location. Although the organizations work on overlapping management levels, this condition is not considered as crossing jurisdictions; as long as an organization is helping to cope with the disaster, it is allowed to participate. However, the overlapping stops as soon as the disaster phase is determined as having passed.

7.4.2 Overlapping Actors in VRBM

In this VRBM, there are three types of overlapping actors: the broker, the whisperer, and the contact person, depending on their role in each of the interaction attempts. These boundary spanners have been identified on the basis of respondents' explanations and their characteristics. In the interaction attempts diagram (Figure 7.7), they are marked with dots, located by the actors.

Normal and Normal+ VRBM

The first type, the broker, exists in the general interaction attempts, creating the possibility to broker a project between lahar and water management.

> Usually, there is a broker, the broker is only one, at the Budgeting (Department under the Ministry of Finance), and then the Budgeting will invite Bappenas. Or, if I know someone from PU (Ministry of Public Works and Housing), then PU will invite the Budgeting and Bappenas. Only one is invited, later the lakon (role) each year is different. (Respondent BPSDA, 2018)

As described by a respondent, a broker can come from any of the actors in the budget (A), as long as he can facilitate the approval of the budget for the project. The above quote signals the broker as a form of boundary spanner who connects water management actors. Although this still falls within the government's scope, sometimes the broker can come from a political party or the legislature. However, the fragment 'the actor changed each year' suggests that it is an unwanted role or that there is a rotation system that prevents the same person from staying in the position. Brokers have a benefit motive behind their endeavor to connect the interaction attempt.

The second type is the whisperer in water integration attempts, as explained in Chapter 5. The name suggests that they operate subtly, indirectly, and in a personalized way. They are responsible for information dissemination until follow-up actions are taken. They are also characterized as not being in the highest position but able to give enough information to the decision maker to enable the implementation of an idea from the community. It is believed that these whisperers can shorten the bureaucratic process, rather than waiting for a response to letters.

> Precisely, being whispered is better than just the proposal only being stacked. (Respondent Kebonagung, 2016)

This explanation indicates that the whisperer is a catalyst, connecting sides or stakeholders. The whisperer operates between levels, and use of the whisperer may smooth the process of inter-attempts communication.

Another version of the whisperer is known in this case study as the facilitator. The facilitator has an intermediary role, helping aims to become a reality. If whisperers are not attached to any side, facilitators take the side of the communities. The communities need people who can support their causes, but remain impartial, meaning the person should come from outside the community. This condition is explained as follows:

> Because the forum itself is not in the form, for them, there should be a strong forum facilitator that can shape the forum. (Endang, AKSY, 2018)

The facilitator shares similar characteristics of smoothing interaction attempts by merely listening and passing information through and needs to have some trust footing in the interaction attempts to catalyze the communication process.

Disaster VRBM

The last type of overlapping actor is the contact person in disaster attempts. This actor's role is that of communicator, which is also used to describe the person in charge of the entry point for the first contact. These people can be either a person of some importance in the community or the leader of an organization, but, actually, these would not always be the best person. The contact person also serves as a filter, determining whether the information exchange is required, either in the community or in the government organizations. The relevance of having such a person is to provide a quick communication channel and open up the interaction attempts, especially in informal ways. Examples of contact persons in this case study are the villages' administrative respondents or the RBO officer at the Sabo dam construction site. Therefore, even though their role is that of a mere communicator, their role is significant, especially during onset disaster, as the contact person functions as an information center and is part of social EWSs.

> We have some (monitoring) posts, also contact persons at many of the rivers, and (monitoring) instruments in the volcano, with information 24 hours daily at the office. The system is needed to decide Merapi's status. (Heri, BPBD DIY, 2016)

Because of the characteristics and roles of individuals who are prominent in fostering the integration levels in the VRBM context, the overlapping actors in this case study are defined based on their activities more than on their role in each interaction attempt. All the roles attributed to these actors are grounded in the findings, thereby proving their existence. The lahar and water attempts may not yet have direct interaction attempts, except during Disaster VRBM, but with the presence of these overlapping actors when they are strategically located and targeted, the water and lahar interaction attempts may be able to achieve a better integration level.

Of these overlapping types, the contact persons prove able to integrate the disaster attempts, but Disaster VRBM is also the shortest-lived VRBM phase. Meanwhile, whisperers/facilitators are consistently on the ground during the Normal and Normal+ phases. During Disaster VRBM however, they shift role to become contact persons. The broker role is the most unreliable, as the person changes each year. This condition explains why the integration during Disaster VRBM is the highest (both whisperer and contact person are present), then comes Normal (whisperer and broker), and last Normal+ (none).

7.5 Boundary Spanning Activities in a Volcanic River Basin

Addressing these overlapping activities involves reflection on the theories of boundary spanning activities. The boundary interrelations in this chapter refer to IWRM and LRM; these are termed 'sectorial boundary spanning activities.' In Chapter 8, the overlapping activities addressed are those between CEK and VRB, and they are explained more in-depth through an additional analysis by understanding them within the boundary layer. The existence of this boundary layer has been sensed already by the presence of the whisperer and the broker in Chapter 5, and the contact person in Chapter 6. In those earlier chapters, their existence is scattered and not given special attention. However, their realities are essential in delivering better interaction attempts. Therefore, this chapter highlights their existence within the interaction attempts and the integration level (section 7.3) but, more specifically, also points out where the boundary activities are taking place in which VRBM phase (section 7.4). Thus, part of the fourth sub-question is answered by investigating these interrelations, which are taking place within MLG settings.

The answers are based on the activities of existing actors found in the interrelation layers within boundary activities at organizational level (boundary organization) and individual level (boundary spanner). For a more in-depth analysis of how these interrelations are shaped, these boundary organization and boundary spanner concepts are used to sensitize the findings in all earlier empirical chapters (4, 5, and 6) and summarized at the end of this chapter and Chapter 8. Precisely, for this chapter, the boundary organizations and boundary spanners are operationalized within the VRBM context, but in Chapter 8 they are operationalized between CEK and VRB.

7.5.1 Organization Level: Boundary Organizations

When boundary objects exist in two different worlds, they have the opportunity to interconnect two sides of these worlds (Star and Griesemer, 1989). In the context of an organization, these boundary objects exist in the interconnection of communities and organizations, or even between organizations. A boundary may be defined as something tangible, such as location, or even as something intangible, such as concepts or task descriptions. The boundary object's role is rigid and established in a formal way to be the interface of communication and collaboration (Guston, 2001).

For dual accountability, the organization needs to stabilize at least two sets of principles and remain stable when faced with external as well as internal forces. Typical forms of boundary organizations are: (1) those linking science and policy and (2) those that answer the needs of diverse groups (O'Mahony and Bechky, 2008). In this research, there is a tendency toward the second category, as the organizations involved are not scientifically based.

The boundary organization differs from the typical organization, as it tends to respond to external authority not by isolating itself (Aldrich, 1999), but by drawing stability through responsible acts and accountability to this authority. A typical organization engages in activities to acquire resources, grab opportunities, and respond to threats, but a boundary organization incorporates representatives of external authorities to be part of its decision-making structure and attempts to balance the views between different interests. The boundary arrangements of an organization have different typologies; some of the established ones between science and politics (Hoppe and Wesselink, 2014) can be divided into advocacy models – between enlightenment (science) and bureaucracy (politics) – and learning models – between technocracy (science) and consultants/social entrepreneurs (politics).

However, in the context of this research, the boundary organization should exist between cultural groups and management organizations. When the setting of the boundaries for both the community groups and the management organization is more precise, empirical categorizations can be made. Thus, the arrangement mentioned above can act as inspiration, but the existing forms still need to be found.

In the context of cultural groups, boundaries are based on identity. For the time being, the working definition of community groups' boundaries for the purposes of this research is that these groups have a Javanese identity (Koentjaraningrat, 1985, Geertz, 1976) and, living for generations in the location, communities can transfer knowledge between generations (Berkes, Folke, et al., 1995, Inglis, 1993). These boundaries in the case of Javanese culture are assumed to emanate from the polycentric system, which is based on quasi-feudal political structures and a prestige trade sphere (Barth, 1998). Within the same cultural boundaries, the same cultural beliefs and social patterns of agency relations are shared (Greif, 1994), but wealth may not be equally distributed.

The community groups may be mostly Javanese, but, in the city center, this may change. It is therefore determined that the CEK under study in this research is based on indigenous society.

Regarding management organizations, the boundaries are evident as membership is based on a person's employment status (Barth, 1998). In reality, these organizational boundaries are also changing alternative forms, i.e., partnership, consortium, and forums (Santos and Eisenhardt, 2005). The boundaries of the existing organizations under study are of the more rigid type. The organizations working in the fields of water resources and lahar management at the implementation level have been selected as participants in the light of this definition. As the research is interested in looking at the interrelations of CEK and IWRM plus LRM, it is essential to find these boundary organizations. Some characteristics found in the relevant literature can guide their identification (Parker, Crona, et al., 2012):

(1) They provide opportunity and incentives for the use of boundary objects (Star and Griesemer, 1989)
(2) They involve participation from different boundaries in decision-making processes (Aldrich, 1999)
(3) They exist between different interests and are accountable for all (O'Mahony and Bechky, 2008).

7.5.2 Individual Level: Boundary Spanners

As explained in the IWRM and LRM dimensions regarding humans, actors on an individual level determine how things are. On the organizational level, they are the leaders or managers (Savenije and Zaag, 2008, Jaspers, 2003, Birkmann and von Teichman, 2010, Sperling and Szekely, 2005). These are people involved in management with decision-making responsibility. They may be positioned in high-level management (head of an office), medium level (head of a division), or even low level (field supervisor). On the other side, CEK also has main actors: prominent leaders or even a wise person as a steward who is managing the environment. Their job description includes, but is not limited to, deciding rituals to be performed.

However, in reality, there are persons with double roles, as both organization members and community members. Such people are seen as 'the connective agent' with an interesting role and significance in network performance and trust building for governance networks (Van Meerkerk and Edelenbos, 2014). They can facilitate interactions, mediating between actors (Pennington, 2008): communities and managers. They appear mostly in the context of addressing 'wicked' problems or non-conventional issues where basic aspects are interlinked (Brown, Harris, et al., 2010, Lach, Rayner, et al., 2005), such as this case study of managing water resource in a VRB. Characteristics of these boundary spanners also include networking ability (Pennington, 2008). Boundary spanners focus on managing relational and inter-personal interdependencies to build social capital, as entrepreneurs, innovators, cultural brokers, trust builders, collaborative persons, and leaders. With these characteristics, they build a culture of trust, improve cognitive ability, and are flexible in operating in non-hierarchical power relationships (Williams, 2002).

These boundary spanners may emerge or be nominated, but, to be effective, they should be legitimately recognized as having the role of negotiator between actors (Levina and Vaast, 2005). This type of actor may be difficult, but not impossible, to find. Therefore, the researcher is reminded to keep an open mind about the actors and their roles involved in this research. Both communities and organizations will suffer when hazards happen and will flourish when good management of water resources occurs. So, this division is not a fixed structure, one may be a manager, but also a local. It depends on the point of view about a condition. Therefore, these two sides are interlinked in the third category. It would be better to view it not as a rigid structure, but more as an introductory category in the process of narrowing the number of people that can potentially participate in the research.

7.6 Conclusions

This chapter presents the interrelations of lahar and water management in VRBM. VRBM is presented as comprised of three phases: Normal, Disaster, and Normal+. In these phases, the actors are the same, but they perform different roles during the different phases. The key to the correct functioning of these phases is flexibility and the changing roles of actors within the interaction attempts. The existence of boundary activities is the accumulated result of water–lahar interrelations in VRB governance. These activities, which are located in organizations and persons, are also the reasons behind the achievement of better integration levels. The significant role of the boundary layer between the water–lahar interplay as the location of interconnectedness is also demonstrated.

The RBO plays the role of boundary organization between water and lahar management. It is does so because of its mandates and also because of its capacities. It has become the pivotal point of information, communication, and management. As it covers the management of water and lahar, the RBO lacks an understanding of volcano issues, especially during the Disaster phase; it needs support from the volcano center and the disaster management agency. In the Normal phase, it collaborates more with water supply agencies, water conservation agencies, CBOs, and private actors. Its role is very significant in water allocation, both for water supply and irrigation. In the Normal+ phase, the RBO fulfills the technical recommendatory role, but permits are issued by the regional government. The VRBM phases are all dealt with by the RBO, which continually performs functions.

The chapter also introduced the type of boundary spanners found in each of the interaction attempts. Their types are linked to the theme of the attempts. The more boundary spanners are involved, the more integrated the interrelations are in a VRBM phase. These boundary spanners are involved in the attempts as follows (deeper to shallower): whisperer/facilitator (water, disaster), broker (budget), and contact person (disaster). Both the whisperer and the contact person are community-originating actors, whereas the broker comes from the government side. This condition explains the first two as existing more consistently, whereas the third one changes each year (based on job assignment). Disaster VRBM has the highest integration level because the person who is a whisperer in Normal and Normal+ becomes a contact person in Disaster VRBM.

CHAPTER 8
IMPACTS OF CULTURAL ECOLOGICAL KNOWLEDGE IN THE MANAGEMENT OF A VOLCANIC RIVER BASIN

8 Impacts of Cultural Ecological Knowledge in the Management of a Volcanic River Basin

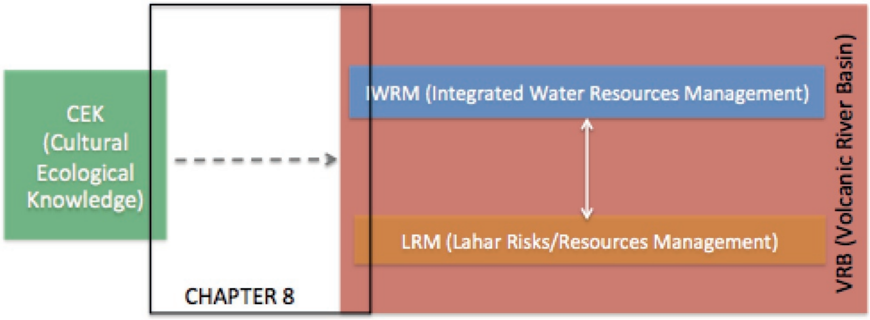

Figure 8.1 Addressed CEK Impacts to Management of a VRB within the Research Framework

8.0 Introduction

This second meta-level analytical chapter focuses on answering the 5th sub-RQ in this research: "How and why does the cultural ecological knowledge impact the management of water and lahar in a volcanic river basin?" The chapter addresses the connection of the CEK and the VRB in figure 8.1 above. It is structured following the earlier structure of chapter 7, adding the impact patterns of CEK in policy settings, managerial contexts, and interaction attempts and integration level. Also using the VRBM phases (Normal, Disaster, and Normal+) as the second backbones of the structure within each of the level. This chapter provides a more in-depth analysis of the roles of CEK actors in the management of this VRB.

The first part of this chapter answers the relationship between findings in chapter 4 on CEK and the VRBM phases presented in chapter 7. The impact patterns used for this was presented in chapter 2 (Kirkhart, 2000, March, 1957) and they are defined as positive (+) when CEK exists and impacting, negative (-), when CEK exists, but not used, and neutral or non-impacting, and (0), when CEK does not exist at all. Each of the CEK (both soft and hard) existences is clustered into its types based on chapter 4 and assigned a pattern within the VRBM phases. The more a pattern received existences; the trend became the dominant patterns for the phase. It uses a similar structure as earlier chapters (5, 6, and 7) by presenting the CEK impacts on policy setting, managerial contexts, interaction attempts, and culminated in the integration level for each of the VRBM phases.

The second part focuses on a more in-depth analysis of 'why the CEK impacts the VRBM.' In each of the VRBM phase, the type of CEK with impact depends on the actors who carry it. These actors are located at the boundary level. In this section, again the boundary level is located where the boundary spanning activities takes place, signified by the existence of boundary organizations (BO) and the boundary spanners (BS) in the VRBM as explained in chapter 7 and where the CEK is used. The soft CEK is more eminent in this part, as this part relates more with the interaction attempts where philosophies, values, and internalization are easier to 'seep' into them. This additional information can explain more precisely who and where the CEK delivered into the VRBM. Looking back to the definition of boundary organization provided in chapter 2, these are characterized by the intermediary role and leading sector in bridging grey areas of different kinds of organizations interactions. Meanwhile, the boundary spanners are recognized based on their characteristics. This chapter argues that the connective capacity of these actors (organizations and spanners) is needed to smoothen the integrated relations of CEK with the water-lahar management found in the utilized interaction attempts.

8.1 How the CEK impacts the VRB?

To remind the terminology used in the previous chapter, the following are the VRBM phases: **Normal VRBM** is when the volcano is at pre-eruption, where conservation and utilization of water can be dealt at the same time, **Disaster VRBM** is during a hazard onset, including volcano eruption and lahar flood, where all conservation and utilization activities are stopped, and the hazard control activities are taking place, the water is taken from another place and distributed to those in need, and **Normal+ VRBM** is during post-eruption, where water utilization and conservation are again active with additional sand mining activities. Another important concept for this chapter is the lahar risks management is active throughout, but lahar resources management is only active in the last phase. In each phase, the existing CEK types are introduced, and their pattern of impacts are explained. This section will use the above-mentioned CEK's impact patterns (+, -, and 0).

As the findings in chapter 7 are organized by the multilevel structure in the policy settings and the managerial context, also within the interactions attempts, which closed into the integration level. In each of the levels, the multilevel is peeled per VRBM phase, while for the management contexts and the interaction attempts aside from the VRBM phase are also arranged into the level of governance: national, regional, and municipal. In the interaction attempts section, the integration level is scored based on whether the CEK existed in the interaction mechanism, using the summative scale used in chapter 7 (from 0 to 3, with an increment of 0.33 and 0.66). The summary for each section is presented at the end of the section.

8.1.1 CEK (non) impacts in the VRBM Policy Settings

The policy setting is found in the national level, but the CEK does not exist as an apparent policy setting, rather it is scattered in bits within the spatial planning, the cultural heritage conservation, the catchment conservation, the disaster management, and the local knowledge conservation. The foundations for the existing of CEK conservation are based on the environment protection and management policy (Law no.32/2009) on intangible heritage and on cultural heritage conservation policy (Law no.11/2010) for tangible heritage. However, the links to other related policy products are not substantial, as explained by the following details of the policy setting in each VRBM phase.

There are many CEK existences found in the policy settings for VRBM of a VRB. In this sense, the national level functions as the policy setter, not on the actual implementer. It exists in the forms of the community's values and philosophies in water conservation on catchment management, but not so much in the form of on resources management practices and cultural heritage sites for water utilization. These policies are aimed at using the CEK as a way to partake in the co-hosting of community development, geared towards conservation, by paying attention to local knowledge. Most of the implication of this policy aims to use it as a socialization strategy. However, the community and NGO actors that were highlighted in the Jakstra do not necessarily deliver the results. Most results were obtained at the regional level, which means that monitoring this at the national level not exists. For a nation who is proud of its heritage, Indonesia has not developed a strong link towards all aspects of life to be linked with their heritage. This is especially true in the case of the water resources management sector, the interrelations at the national level are then concluded as parallel, with some exception in the community development aspect.

The following table 8.1 shows the overview discussed in this section, highlighting the existences of CEK in policies in each form of the VRBM phases, answering 3rd RQ. The table is explained into narration in the latter part of the section. The types of influences are used through these symbols to answer the 4th RQ, on how the CEK influences the VRBM, which are used throughout the summary tables in this chapter:

- (+) CEK exists and used
- CEK does not exist
- (-) CEK exists, but not used

Table 8.1 CEK Impacts on the VRBM Policy Settings

Levels of Governance	VRBM Policy Settings		
	Normal VRBM	Disaster VRBM	Normal+ VRBM
National	(+) Conservation on catchment, environmental protection, and management law: Existences of CEK in the conservation of values, conservation of heritage areas (sacred locations-artifacts) The revoked law on water acknowledges (embedded in ministerial regulations): the existence of indigenous community structure-dynamics, resources management practices, artifacts: conservation areas and cultural heritage locations, values, and rituals. Utilization: acknowledgment on local knowledge in resources management practices: water, including the attempts in conserving resources using heritage conservation law of practices at irrigation	(+) DRR policy: RenasPB National, values: *gotong-royong,* volunteerism, acknowledge of local wisdom in hazards management practices (0) No reference made to CEK on volcano management policy	(+) References to CEK on lahar management through sand mining policy: river regulations, normalizations Small reference on policy for mining of non-metal

Normal Phase VRBM

The CEK is the Normal phase relates to the conservation and utilization of water resources policies. The national government uses the policies as a way to conserve CEK in a more structured approach for the artifacts and landmarks (tangible), but not so structured for the knowledge (intangible). There is the presence of CEK in the following policies on nature conservation, spatial planning, and water resources. Out of this list, the spatial planning policy holds the highest order of implementation as it sets the zoning for land use. The CEK is only detected as layered policies and for the national level, which is very little referring to the types of CEK, mainly about the general local wisdom or cultural values. They are not contradicting one another, but they also are not referring to the CEK in conservation policy transparently. As explained above, for the CEK, the most crucial policy is the cultural heritage conservation policy for tangible heritage and the environment protection and management policy for intangible heritage.

The first existence is shown by the effort of the spatial planning policy (RTRW) to include the artifacts (a type of CEK), such as cultural landscape, landmark, and cultural heritage sites. This existence relates more to the conservation of cultural heritage, locations where CEK can be found conserved and preserved. However, a recent Minister's of Environment and Forestry Regulation (Permen No.P34/MENLHK/SETJEN/KUM.1/5/2017) does acknowledge and aim to protect local wisdom in natural resources and environmental management. It also lays the definitions needed for CEK to be conserved. Nevertheless, this regulation came late in response to the earlier produced policies on water. Therefore, the existences of the CEK in water-related management policies are not related to this minister's regulation. A similarity for the conservation area allocation in the upper stream, where the mountain is a protected forest. For conservation area downstream, the water bodies, usually have set back, for example, a beach, lake or dam, and rivers. This existence is strengthened with the Government Regulation no.38/2011 on a river. However, the implementation rate of this policy will prove to be not as successful as explained in the next section on regional and municipal managerial contexts.

These policies relate indirectly to the second existence of CEK in the water resources policy setting. They use the body of the revoked Law no.7/2004, but now the content of CEK existences are only being distributed into a list of ministerial regulations. The utilization of water resources even after the annulled of Law no.7/2004 acknowledges the socio-cultural condition as part of the decision-making process. However, as it now becomes Minister's Regulation, its reach is not as strong. For example, the existence of artifacts, indigenous community, water-related resource management practices, conservation areas, and sacred locations. The law was carefully structured and supportive of the existences of CEK.

The following policy is the President's Regulation on national strategic policy on water resources management or Jaknas (Perpres no.33/2011) set up a deadline of two years to regard the local wisdom. The two years have passed, but not much progress is made. An exception is made for the *Subak* irrigation in Bali as a national priority, which will be explained more in the management context. Meanwhile, in the current policies as these were revoked, the water resources management policies are dealt through a series of Ministerial Regulations. These regulations, however, are not so carefully prepared, redundancies are abundant, and only a small number of them are acknowledging the CEK. For example, out of 19 regulations, only three are referring to existences of the general CEK values, rituals, activities, and sacred locations. These are regulations about dams, river and dam setback and development-management of an irrigation system. With this, the CEK chance in influencing the water resources management at the national level is based on the agglomeration of the CEK utilization in the managerial context in the regional and local levels. This second existence is due to the reference made in the policy settings are very global, but it opens up opportunities for each cultural and traditional context.

The third existence is found in the conservation policy on the environment. The Law no.32/2009 on protection and management of environment lays a base for the use and conservation of CEK. It is recognized as local wisdom, values, resources management practices, and other forms of indigenous community cultures to be respected and used. The law refers to them as follows:

> "Local wisdom is the noble values that apply in the life of the community to protect and manage the environment in a sustainable way."

It recognizes the local knowledge in resource management practices, cultural values, sacred lands, and traditional right lands in catchment conservation. This national policy expressed these types of CEK as local knowledge. Also, with the effect of the Minister's Regulation, the ministry is geared towards specifics on inventorying and patenting them. Nevertheless, as it only been in effect for one year, it is too soon to find out the results of such tasks. The CEK's are acknowledged rather generally in spatial planning and water resources policies. But, both policies are showing coherent aim with conserving and using the CEK. Although, it is not always on conscious grounds and not implement as successfully as the policy intended. In this sense, the policy is weakly enacted is not equally prioritized nor embedded in the management level. It also does not directly specify the water resources or volcanic basin, instead generally lining the support for all kind of natural resources conservation.

The fourth existence is a special regulation, which relates the national to the regional level on the CEK: the Law no.13/2012 about Privileges Status of Yogyakarta Special Region, as explained in the 4th chapter on CEK. This regulation specifies the special status of the region, to form a Sultanate government under the Republic of Indonesia. It elaborates the privileges in "(1) the procedures for filling the positions, positions, duties and authorities of the Governor and Vice Governor; (2) institutional of DIY Local Government; (3) culture; (4) land; and (5) spatial." By this, the Government of Indonesia protects the rights of the region to be unique. In the CEK relation to the VRBM, it translated into utilization of local knowledge, the special land rights land status owned by the Sultanate (Sultan Ground: *wedi kengser, Kraton* land), also the spatial orders (imaginer-philosophical axis, Kraton plan.). More explicit references are not addressed in this law, but rather in the Perda (Local Regulation). This law also becomes the foundation of the Perda DAS DIY (Catchment Management in Yogyakarta Special Region), which is explained in a later section.

Disaster VRBM

Within this phase, the existence of CEK in hazards control-related policy is explained. At the national level, the policy referring to CEK within the scope of VRBM is scattered in the disaster management policy using the Law no.24/2007. As part of the aim in disaster management, it appreciates local culture, *gotong-royong* (collective action), solidarity, generosity, and other values, which can be categorized as CEK's values. However, no elaborate explanation is done in this respect. This policy relates to general hazards, including water and volcano-related hazards. It gives the command role to the disaster management agency. Another form of CEK existence is on the acknowledgment of *mufakat* (consensus cultural value) as the first step in dispute resolution within the disaster management. In all aspects of disaster responses, these values mentioned are to be used, but the implementation practice is explained later in the managerial context.

Additionally, the phase used the Minister's ESDM regulation no. 15/2011 on Guidelines of Disaster Mitigation for Volcano, Land Movement, Earthquake, and Tsunami, but this regulation does not refer to CEK in any form. It seems there is a missing link between the two policies, although the second stems from the Law no.24/2007. The regulation based its guidelines on pure scientific monitoring to the geological conditions of the volcano. For example, the volcano hazard zones are determined as KRB 1, 2, and 3. The KRB 3 has the highest risks (primary threat: lava, ash, pyroclastic), KRB 2 (the combination of primary and secondary threats), and KRB 1 as lowest (secondary threat: rain lahar). It also explains the types of hazards related to a volcano eruption, without reference to local knowledge. This regulation also defines eruption lahar and rain lahar, as results of a volcano eruption, but does not relate to any CEK concerning them.

On the other side, Law no. 26/2004 on spatial planning helps in delineating the hazards zone, which in relation the Disaster VRBM are framed into primary and secondary hazards maps based on the KRB zones explained above. This law, although referring to the cultural heritage, does not explicitly clarify whether this heritage can relate to the volcano eruption. Based on this law, the upstream area of the Opak Sub-Basin is determined as a conservation area. However, the interpretation is a sacred location or artifact of CEK and not concisely made.

During a disaster, the central policy is on disaster response. There is no relation to water management being mentioned, aside from the changing in water acidity during active eruption referred in the Minister's ESDM regulation. However, based on Law no. 24/2007, the water during a disaster response uses the values mentioned above, but the relation is not made explicit. Aside from that, the law no.7/2004 does not refer to volcano eruption but refers to lahar management policy as a water-related hazard. It also acknowledges local knowledge; mentioned one time in community development. This gap between the management policies leaves open interpretations and is not well designed to accommodate the possible interrelations of water management to other resources in a volcanic river basin within volcano eruption. Moreover, the fact that CEK is only mentioned in the disaster management policy proves that the foundation for the CEK utilization in the policy setting is very general. Not enough support for managers to use it, but in managerial contexts, surprisingly, the CEK is shown in all levels, which will be explained later.

Normal+ Phase VRBM

On the Normal+ VRBM phase, in addition to the above Normal phase policy setting; a specific reference is made on behalf of the lahar sedimentation as resources management through the sand mining activities with the CEK. The comprehensive regulation about the sand mining *(Galian C)* activity is by an old Minister's PU Decree no. 458/KPTS/1986, which carefully guides the way the mining activity has to be done. It explains about sand mining as a way to normalize the river channel. The word river normalization is equal to dredge the River's flooding capacity, which practically is done in the WS or under the regional level. Thus, the normalization needs technical recommendations from the Ministry's PU or the PU agency in the location about the safe distance between river infrastructure and the mining locations. The mining volume is calculated based on mapping analysis and on the spot calculation, which is included in the technical recommendation. It explains miners' obligations to provide access roads for the Armada to the location. It is the responsibility of the miners to rehabilitate any destruction to the River's infrastructures and the river channel. Newer regulations are not as complete as this one.

However, there is no trace of any form of CEK is being referred to in the old decree. The study analyzed the newer regulation as follows: Government's Regulation on River (PP no. 38/2011). The regulation regards the river setbacks and geomorphology and the justification for sand mining activities to take place as river normalization. Although this regulation is annulled, as domino effects of the Law no.7/2004, the essence is still used in the Permen PU no. /2015 on River. The regulation acknowledges the CEK existence concerning the community's local wisdom, norms, and attitude towards the River as part of data inventories on a river, referred as:

> "The socio-cultural conditions of local communities are the attitudes, customs, and norms that live in the local community, especially those associated with the river."

The regulation also reminds of the dynamics of rivers' geomorphology to designate the setbacks, through the following characteristics, but without reference to the CEK:

> "(1) Fluctuation of river flow low fluctuation, (2) changes in sediment content in rivers, and (3) the trend of changes in river geometry. Specific characters such as meandering, braided, carrying sand, and lava flows. This type of River, the trough is very dynamic. Determination of the setback for such a river needs to be done."

Also, newer regulations on sand mining by the Ministry of Energy and Mineral Resources set the policy, in collaboration with Ministry of Public Works and Housing as a way to 'normalize' the rivers' channels. The term normalization here is used to describe the sediment extraction activities done to river channels to an earlier condition. However, the Law no.4/2009 and the newer Law no. 37/2017 give attention to licensing of mineral and coal mining. These are used for sand mining base policy, but they do not refer to CEK in particular, aside from the statement on socio-cultural considerations for each mining location. Nevertheless, the rivers are under the jurisdiction of the second. The sand mining is categorized as non-metal materials mining, and the permit has to be given minimum by the regional government. One has to acquire the technical recommendations from the river basin organization in the location to get this permit.

The next related regulation is the Government Regulation no.23/2010 on the implementation of mining business activities. This regulation acknowledges the existence of CEK in the procedure for giving permits to non-metal mineral and rocks, including sand mining as follows:

> "Recommendations in this provision are in the form of considerations containing information on land use in the mining area and cultural characteristics of the community based on local wisdom in order to auction the mining area."

The minister gives a mining permit if located in crossing regions/provinces. However, the governor gives a permit, when located in a province or from the regent/mayor within a municipal. In this case study, the sand mining located in the Opak sub-basin is under the jurisdiction of the governor.

8.1.2 CEK (non) impacts in the managerial contexts

This section is also arranged as the earlier chapter, which is the existence of CEK in three types VRBM phases: Normal, Disaster, and Normal+. In each phase, it is divided into the level of governance: national, regional, and municipal. Where in each level, the implementation of VRBM phases will be explained. The main findings for the management are based on the types of VRBM phases are presented in the table 8.2 below with CEK existences are coded with similar symbols in the earlier section. The contents are explained in the narration after the table.

Table 8.2 CEK Impacts on VRBM Managerial Contexts

Levels of Governance	Existences of CEK		
	Normal VRBM	Disaster VRBM	Normal+ VRBM
National	(+) **Conservation**: artifacts of the cultural landscape, cultural heritage, a sub-directorate for CEK conservation KemenLHK (+) **Utilization:** resources management practice in water allocation is not using CEK, except for *Subak* in Bali (UNESCO heritage) KemenPUPR community empowerment	(+) **Hazard control: v**alues, local wisdom, acknowledged in the BNPB The BNPB relies heavily on updates from volunteers and local wisdom of the communities	(+) **Utilization:** Artifacts for sand mining: non-metal material, under the KemenESDM, Dir.Gen. Mineral and Coal do not have any reference to CEK, but the KemenLHK has CEK's acknowledgement on natural resources management

Regional	(+) **Conservation** for the sacred locations as conservation areas-artifacts, i.e., Mt. Merapi summit as TNGM, the *wedi kengser* as a floodplain, Opak Estuary at Parang Kusumo Beach as dune conservation RPJMD DIY as *Hamemayu* philosophies, values RTRW: conservation of philosophical axis, utilization of artifacts RPDAST: CEK values in the community role Pola and RPSDA: cultural condition, community role in values: Pammaskarta coop and AKSY river community **Utilization of water management artifact:** Mataram Channel DIY Privilege Status Law: Catchment as cultural landscape/sacred -artifacts Perda DAS DIY: resources management practices, rituals, philosophies River basin as a philosophical plane (-) The encroachment of *wedi kengser*	(+) **Hazard control** through Forum PRB (Disaster Risks Reduction): SKSB, Paguyuban RW, Tagana are usually the same people; they all still use CEK with combined scientific data. RPB DIY: uses the values of *gotong-royong,* volunteerism, *hamemayu* philosophies, acknowledge the local wisdom The philosophical plane used to understand flood-free zone and philosophical axis as the tool to monitor lahar flow from the Mt. Merapi to downstream areas and the Parangkusumo Beach. Sultan's Premonition as EWS Traditional *kenthongan* sounds as social EWS **Utilization** Resources management practice: ex-situ water dropping from another area by Pammaskarta and PU-P ESDM The practice of water utilization from under the river (baseflow) in-situ	(-) **Utilization** of resources management practices is not being used in the governor regulation on mining in rivers. Examples of these are: permits for the sand mining do not acknowledge the CEK on cultural lands and the limited supply of sand due to Mt. Merapi's inactivity (based on Sultan's *wangsit*) Rivers have cultural meanings in Yogyakarta as it is the passage of the deities. The existence of illegal sand mining by the governmental organization and privates with the support of high ranks military officers (0) No CEK reference used in BBWS SO's technical recommendation for river sand mining

Municipal	(+) **Utilization:** Values of *gotong-royong* in Spamdes in Sleman and Bantul Resources management practices use local spring or drilled wells, even PDAM taps Conservation: FKWA, PKC, TB, GW, river communities (trans-municipal, preferably according to the river channels), five senses wisdom: water quality assessment with *biotilik* (FKWA) and communities living along the river: knowledge on types of fishes, values of *gotong-royong* or collective action in conservation (+) **Conservation and utilization** of water policies by the regent use the governor's policies, when necessary derivation of the policy into Perbup, an example of resources management practice in *pranata mangsa* seasonal calendar used a crop pattern.	(+) **Hazard control** by social networking, even *kentongan,* to contact persons in charge of each village. Five senses wisdom: the sound difference between flood to lahar, the visual of wild animals migrating downstream as a sign for evacuating, the sound of *kentongan* rhythm as signal-faster, the more volume lahar is coming Artifact: historical safer locations as a sacred geography, **Utilization:** Resources management practices: inter-basin water droppings based on values of *tepa selira* (tolerance, empathy) distributed through CBOs: SKSB, Tagana, paguyuban RW jogoyudan.) The CBOs practice *gotong-royong* and other cultural values: *Nrimo* (accepting) or fatalism towards Mt. Merapi eruption Not to sit too close to the river during the flood – hazard zone delineation CEK values and philosophies, local wisdom, in RPB Sleman, RPB Yogyakarta City, RPB Bantul: *gotong-royong, tepa selira, lan waspada ngadepi bebaya*	(-) **Utilization** of resources management practice: Sand mining practices based on CEK: *Hamemayu* philosophy in use, take what needed, let the rest for conservation. Five senses wisdom: over-mining indicators springs died or moved, the riverbed is deeper than 2010 condition (not heed) (-) **Utilization: t**he rivers are 'auctioned' for their sand Sediment dredging from the wells (+) **Utilization** of artifacts for *wedi kengser* or lahar sediment in rivers channels as temporary farmlands

Normal VRBM

For Normal VRBM, the utilization and conservation pillars of VRBM are active. The management of water on the national level is handled through the Ministry of Public Works and Housing, in collaboration with Ministry of Forestry and Environment for catchment management and Ministry of Agriculture for water in irrigation utilization. Aside from that, there are other water utilization managers based on each specific context. These are PERPAMSI (water supply companies associations), PJT (government-owned company on river basin organization) for dam management, or the PT PLN - government-owned power company for hydropower generation. In this case study, however, there are no PJT and PT PLN branch offices. The rest of the organizations have roles in the water management of this volcanic river basin.

Within the national level for conservation pillar, a sub-directorate for managing the utilization of CEK under the Ministry of Forestry and Environment. A further reference for the conservation of cultural heritage may exist for local knowledge in the heritage conservation law, which addresses heritage land uses and spatial planning as a form of CEK. The Ministry of Public Works and Housing as the main actor on water resources management at the national level does not have a specific branch or sub-directorate to address the CEK. They use a global approach to community development in all aspects of water resources management pillars: conservation, utilization, and hazards control. This condition gave high autonomy to each RBO to deal with the CEK for regional level contexts.

This difference is seldom acknowledged at the national level, but the implementation may take actual form at the regional level. For example, the CEK forms are *tanah adat* (heritage land), *Subak* cultural landscapes in Bali, heritage water canals, sacred geography. They can be formalized within the spatial plan (RTRW). At the national level, there is no trace of CEK being legalized for water utilization, except for the Subak cultural landscape and irrigation water allocation in Bali. This one is even promoted as UNESCO world cultural heritage in 2012 (http://whc.unesco.org/en/list/1194). Similar CEK in water allocation existed elsewhere for example in Yogyakarta, but have degraded and not conserved as a UNESCO heritage, but instead is being proposed as a cultural landscape. In the municipal level, these are represented by villages' institutions such as *Ulu-ulu* (traditional water leaders), WUA's irrigation water distribution, and local knowledge of the seasons, among other things. These are not so easy to be traced at the national level unless they are as significant as the *Subak* not as a cultural landscape, but also as the irrigation system. The *Subak* is using the national government budget to maintain its existence, as explained in the following quote.

> In Bali, the national government does not own an irrigation area (DI). Essentially, the whole DI belonged to the province, but due to budget limitation, the national government asks it (to maintain). (Respondent Komir, 2018)

The national government is not against conservation of CEK, unaware of how to conserve the many existences and/or significances of it in everyday life. Those with high significance ended up being conserved, as explained in the *Subak* example.

Also, within the regional level, the Bappeda DIY has provided the planning documents for management: mid-term development planning (RPJMD DIY, Perda no.4/2009) and the spatial planning (RTRW DIY, Perda no.2/2010). The first states the *Hamemayu* philosophy, and the importance of local knowledge conservation to deal with future challenges of modern society's values.

> "DIY has various cultural potentials, both tangible (physical) and intangible (non-physical) cultures. Tangible cultural potentials include cultural heritage areas and cultural heritage objects. Meanwhile, intangible cultural potentials such as ideas, value systems or norms, artwork, social systems, or social behavior are present in society."

The second explains more about the spatial use, either, land, underground, water, and air in the region. On water management, the RTRW DIY does explain about water infrastructures and future development but is rather vague in reference to the relations with CEK. Both give general direction about the region's vision stepping into the future.

More specific documents referring to water resources are water management planning: Pola PSDA and RPSDA WS POS (BBWS SO) and the catchment management: RPDAST Opak (BPDAS-HL SOP). The first document highlights technical approaches, while the second has mixed technical-vegetation approaches. The later also has more of CEK existences acknowledgment on the community development side. The water resources management framework (Pola PSDA WS POS) and the master plan (RPSDA WS POS) legalized as Minister's Public Works and Housing Decree (Kepmen PUPR No.590/KPTS/M/2010 and No.23/KPTS/M/2016 respectively) as explained in chapter 5, is arranged on the pillars of water management: water conservation, water utilization, and water hazards. It addresses the way water resources are planned, utilized, monitored, and maintained, also how water hazards controlled. In the results of the policy, 20 years of master planning for water resources development are designed. It uses units of percentage through five-yearly targets on water development. These, however, do not refer to the conservation of cultural heritage areas, and the CEK values explained in the range of regional policies. The direct implementation of such plan decreases the chance of adding 'CEK flavor.' The plan only mentioned the Mataram Channel as part of irrigation work, but with no relation to the CEK underpinning it as an essential artifact. Another reference to local knowledge is found in the matrix of community development within the RPSDA WS POS. In reality, the Mataram Channel still supplies water to Mataram Irrigation, in order to irrigate 7,000 ha of farmlands operated and maintained by the national government through BBWS SO. Unfortunately, the inner city channels are not as clean as those located in suburban or rural areas. Still, the term *Selokan Mataram* implies that these channels are a part of the sewer system. The water utilization from the Mataram Channel works using the CEK values of *tepa selira* or empathy, to provide inter-basin transfer from the overflow of Progo basin to 'dry' Opak basin. The channel was the idea of the previous Sultan and was built during the Japanese colonization era in 1942-45 (Suyono, Hidayat, et al., 2015). The philosophy of *hamameyu hayuning bawono* in this context is interpreted as giving the world a better condition, where the Mataram Channel is seen as this form of improvement. These implied the existence of results of CEK ingenious in current water resources management practices.

The second document, the master plan for integrated catchment management (RPDAST Opak) by the BPDAS-HL SOP, on the other hand, is legalized as a Governor's Decree (Kepgub no.285/KEP/2014). The RPDAST Opak (in its chapter 4) explains about the inexistence of linkage between the CEK to the current catchment management. Specifically, it reasons the implementation of Law on Yogyakarta Special Status have not been addressed, the problem with the Sultan Ground inventory, also the inexistence of historical philosophy values, culture, local wisdom, and the support to the people on the arrangement of the "special space." The plan aims for conservation and carefully planned land use as a way to conserve water quantity and enhance water quality. This plan is more at heart with the CEK, as it acknowledges the conservation attempts of local wisdom, cultural heritage and conservation zone, cultural values, traditional resource management practice, and the role of CEK in community development. Like the Governor, the Sultan legalized these regulations; this also functions as a legitimization process for those acknowledged CEK. In summary, most of the regional-produced policies are coherent with the conservation and utilization aspects of VRBM with the use of CEK in current society.

With this as a background, the regional government reacted in producing a regulation on catchment management as the Perda DAS DIY (Regional Regulation on Catchment of Yogyakarta Special Region) no.11/2016. This Perda acknowledges the *Hamemayu* philosophy, local values, and resources management practices. It also discusses the revelations of the river basins as sacred locations and the conservation of cultural landscapes.

> "Cultural peculiarities related to environmental management takes into account the position of Mount Merapi-South Java Sea as the imaginary axis and the Kraton-Kraton-Panggung Krapyak as the axis of philosophy. Their existence as sacred locations (Sanctuary Areas) is a stretch of Cultural Landscape (*Pusaka Saujana*). It is flanked by (five) Sub-DAS of Code, Gajah Wong, Opak, Winongo Bedhog, and 1 (one) watershed, Progo waters on the west side, Mount Merapi to the north and South Sea (Samudera Indonesia) on the south side."

Based on this explanation, the philosophical axis, and its surrounding region: the whole Opak Sub-basin and the Progo basin originated at the Mt. Merapi suggest a philosophical plan. All rivers have spiritual and environmental meaning to the indigenous. This understanding is making sense when relating the CEK with the river basin concept: the philosophical plane is explaining the river interrelation of up, mid, and downstream. This ancient river basins concept is rightful to be proposed as a cultural landscape under the heritage conservation law. The following map using mymaps.google.com visualizes this finding (figure 8.2).

Figure 8.2 Progo and Opak Basins as a Philosophical Plane and the Philosophical Axis

Two new respondents in the 2nd fieldwork of 2018 reminded of the existence of GNKPA; the national partnership movement for water rescue back in 2005, which highlight cooperation inter-ministries and local governments into actions. The DSDAN is a formal council in which GNKPA can make use for coordination; yet, the movement has its coordination mechanism. Note that, the DSDAN will be explained more in the interaction attempts section. In this regard, the CEK relates to water conservation are appreciated to implement GNKPA. However, there is no direct reference made. The CEK compiled is not linked to the existing conservation and resources management practices found in the area (such as *setrenan*-planting at home*, Nyabuk Gunung*-terracing). The plan does not include any CEK in the document explicitly, aside from one sentence on the management of local wisdom area, which is not even located in the location under study. Unfortunately, the existence of GNKPA at the regional level, especially in Opak Sub-Basin is unavailable. This existence is due to the lack of interest at this level. The trend of the program is also a way to visit far places with additional tourism.

> The GNKPA's trend is (including) sightseeing in Sleman is too close not attractive. (Respondent BBWS SO, 2018)

Aside from this reason, it is also due to the Opak River as being not in the list of GNKPA conservation list.

The regional regulations, which are specified to the CEK relations in spatial use and development, are on the Privileges of DIY (Perda no.1 and 2/2017) and the Heritage Conservation (Perda no.6/2012). These two local regulations are specific in the CEK types and legitimization, but not much reference is made towards water management. It is aside from the philosophical-imaginary axis of the region, which showed the awareness of river basin morphological conditions. Both are strongly suggesting the importance of CEK in any forms for cultural conservation. However, on the philosophical axis, it is conserved and free of non-Kraton building. In this condition, the philosophical axis and its artifacts are still used as guidance in spatial planning. The dune or *gumuk pasir* located at the terminal of Opak and Progo by the Parangkusumo Beach is a protected area (both from the CEK point of view and the conservation law) and also used as tourism object. On this account, the CEK proposed the whole river basin as a conservation area for water resources or as an artifact for cultural landscape. The CEK sacred location implementation in the spatial planning for Mt. Merapi as upstream water conservation area (TNGM) is coherent. This area is still in order, as most areas are now belonging to the national park and free of settlements. The inhabitants of the KRB or hazards zones were resettled to safer locations nearby the flank of Mt. Merapi.

Within the regional level, the rivers from the CEK point of view is perceived as the channel of deities, spirits, and demons to pass through from Mt. Merapi to the South Java Sea, which is also considered as sacred geography. However, the locations on the riversides between the TNGM and Parangkusumo Beach are not free of settlement. In the midstream area, floodplain or *wedi kengser* area (Sultan Ground) has a setback of 5m to 15m from all water bodies. In Yogyakarta urban areas, the riverside is highly populated with up to 2500 persons/km2, as reflected in sub-case 2 in Gowongan. In this regard, the CEK is neglected by the current practice of land use. This riverside encroachment in Yogyakarta is due to the high land price; ranked 2nd in Indonesia after Bali. This way, the CEK exists but is not being heeded.

The municipal policy does not have much say on the management, as most capacities and budget come from the regional level (APBD). The budgeting mechanism is also the reason why the budget interaction attempts are connected in the day-to-day basis of water management and cannot be separated. The municipal water resource agencies work more on daily monitoring of the discharge of the river on control points, usually at weirs, dams. For example, the respondents at this level can only explain the condition of the management on their local authority and do not understand the importance of integrated water resources management. For example, when asked about the upstream-downstream condition, they explained that it is not their authority, which is mainly in irrigation.

However, the CEK is considered in the management of this level, as a tribute to the cultural heritage. For example, at Tegal Weir, sub-case 3, during the construction period, they found a *lumpang* or megalithic stone allegedly dated from hundreds of years ago and possibly used for a water container for horses, in the location where the weir is going to be constructed. Before the construction ended, there were two *tumbals* or human victims, who were related to the project. Even the respondents in the water resources agency believe that these two were related, to appease the river or the 'spirits' who guard the river, the *tumbals'* lives were taken. The CEK is used to set a taboo for future river constructions unless more *tumbals* are allowed.

Looking back to the relation of the regional budgeting (APBD) to water management at the regional level, this is pointing to the strategic development plan (RPJMD DIY). This document highlights the importance of cultural heritage in the Yogyakarta Special Region. The RPJMD DIY supports the CEK and in general the cultural heritage conservation. Especially the 'Renaissance Jogja' movement declared by the Governor in 2012, the region aims to become more aware of its assets in culture. Thus, it explicitly explained the setting of the *Hamemayu Hayuning Bawono* philosophies, cultural values, resources management practices, rituals, which are part of everyday life. It in line with the BPDAS-HL SOP, who works hand-in-hand with the regional and municipal stakeholders to formulate the Perda DAS DIY, which was mentioned earlier in the policy setting. This condition was a way to legitimize the CEK awareness and support. The implementation of such regulation cannot yet be assessed as it was just legalized in 2017.

However, in reality, the BBWS SO works in close cooperation with the PU-P ESDM as described in chapter 5 on VRBM, both know about the use of *Hamemayu* philosophy and honor the values of the regions, *gotong-royong* or collective action. Both support the active participatory role taken by the river community, the volunteering values of communities during disasters, WUAs' activity in managing water at the municipal level, *nrimo* philosophies of the farmer. However, it does not reflect the policy that the river basin organization makes, but in the actual activities in partnering with community-based organizations (CBOs) both in the regional and the municipal level. This condition will be presented at the municipal level.

Within the municipal level, the management is derived from the regional management level, although more detailed. The resource management practices relating to water are not very popular in use in the regional or national level. But, they are still partly used at the community level such as the *pranata mangsa* (seasonal calendar), which connects water management, meteorology, and farming activities. Out of the indicators used for the sub-seasons, only three are still in use. The existence of CEK as municipal water management policy is rather rare. A good example glance from the neighboring Serang river basin at the Kulon Progo Regency, where the seasonal calendar is translated into cropping pattern and legalized as PerBup or Regent's Regulation. Each year, based on both scientific data (BMKG) and local *pranata mangsa*, the cropping patterns are used (based on an interview with BPDAS SOP). The regencies of Sleman and Bantul, however, do not use this as a comparative tool. The last two are based on the results of modern scientific calculations with BMKG data. This finding shows that the awareness is there, but not the political will to support the practice, it depends on the municipal leader.

Unfortunately, this regency is not part of the case study under investigation, but it shows that when there is the political will, the CEK can also play its role in the policy. The communities' role in CEK and water resources management are found as follows:
(1) Support the communities' need for water supply and quality; manage the water coop and pricing.
(2) River restoration objectives: watch-over river condition, river tourism activities, river school activities, and environmental education.

These main two water-related CBO's, which were named time and time again by the respondents are the Pammaskarta DIY (regional level) and their Spamdes (municipal level) and the AKSY (regional level) and their river communities (inter-municipal level).

The first CBO is the Pammaskarta DIY, but later it is formed into a coop, as it also arranges the water pricing and management. The regional government also supported this. The Pammaskarta DIY was founded and led by Darmanto (deceased 2016), as a CBO for water supply the whole Yogyakarta Special Region. It uses the CEK of local communities in location for water sources, either well, underground stream or spring. They specialized in community-based water supply off the grid, but at times also cooperating with the PDAM, where no water sources were present. Under the Pammaskarta DIY, the Spamdes located in each hamlet and village, which collaborated in the regency level. The communities feel more comfortable with the Pammaskarta approach than that of the Minister's of Public Works and Housing approach, as theirs are based on participation approach and reliable to sustain, as explained in the following quote.

> No, the first, the Pamsimas system when you look into it, in their guidebook and the model, there is a letter of statement about this and that, with mentoring model. All volunteers, when there is problem they use call via WhatsApp, we fix it directly also the, but when through Pamsimas, it's a headache. (Ari, Pammaskarta, 2018)

The way the system works is summarized as follows: (1) community set a team and proposed a location for water source, (2) the regional or national government support with budgeting to set up the calculation, the installation of the pump and reservoir, and (3) the Pammaskarta runs the water allocation and pricing, also operation and maintenance in collaboration with the community. The CEK practiced by the Pammaskarta and communities are the blessing rituals, values of *gotong-royong*, and tolerance in managing the facility. The rituals were done during the starting point of the water extraction as a way to ask for permission to God and nature, which, including communal prayers for the village, offerings: food and flowers. This condition is symbolic of setting the balance of nature and conservation values towards the environment. The community knows their limit in taking water and not being greedy, with the ritual, the community set some 'a pact' to honor nature. The values of *gotong-royong* are used in forming coalitions between villagers to connect as a community-based organization, with that value emanated the sense of volunteering, reciprocal of help, and spirit of togetherness. Tolerance (*tepa selira*) is a CEK form to feel the empathy of those in need and help in time of need, just as the example during a disaster VRBM.

The second CBO is that of the AKSY: a CBO for an Association of River Communities' in Yogyakarta Special Region as the result of existences in the lower level (river communities). Before the AKSY was formed, the river communities in Yogyakarta city center at the river Code and Winongo were the ones active in engaging collaboration with the BBWS SO. Later on, other communities arose; the Tambakbayan and Gadjah Wong are also having their organization.

The AKSY was formed in 2013 as Asosiasi Masyarakat Sungai Yogyakarta (PIP2B, 2013), which also took a stepping upscale to the national level, in the River Jamboree in 2016 and 2017 (Hermawan, D., 2017). This Jamboree will be explained as an interaction attempt. The kind of CEK practiced by the river communities: using types of fishes as a way to know water quality in the river (*biotilik*), which is used with different names in each sub-case studies: *uceng* in sub-case 1 or *lele* in sub-case 2. This CEK is even disseminated through short practice during the National Jamboree for River Communities in Yogyakarta in 2016 and 2017. The collective action (*gotong-royong*) is usually used in cleaning the river activities and other types of meetings. The 'mystical' sound of drums in the morning is a sign of the greatness of the Sultanate's legitimization for certain people to lead.

> Yes, I heard it (the drum) often, which the Kraton (mystical sound), yes, I heard it, but not everyone can hear it, only those who are lucky. (Endang, AKSY, 2018)

A respondent also stressed the importance of having the community's partner for bureaucrats and government agencies. With the existence of Pammaskarta, the responsibilities for water supply always sustain. They are always ready when time most needed, and the government embraced this as an opportunity.

> I think for this kind of things, for bureaucrats have to have the 'soul' that they have the community as their partner, right. These are whom they need to hold hand-in-hand with. (Rani, TP5 DIY, 2018).

Disaster VRBM

As for the Disaster VRBM phase, the hazard control pillar is taking the lead. At the national level, the shifting pattern of management from budget and water management to disaster management is quite clear. The same pattern exists between water and disaster management and overlaps with one another. The disaster attempts have more attention as they directly relate to the urgency of saving human lives. The existence of flexibility of budgeting system in the disaster phase is maximizing this condition. The BNPB does acknowledge CEK importance for each specific location concerning the potential hazards. However, this goes stronger at the regional and municipal level, as each level add a deeper understanding of their surrounding (natural and environmental conditions).

The water-related hazards are considered as the most frequent in Indonesia (BNPB, 2015), ranging from the flood (38%), drought (13%), and landslide (18%). As water hazards control is part of VRBM implementation, at the regional level these are directly controlled and managed by the RBO (BBWS SO) and BPBD DIY. However, the flood data for the location in Opak Sub-Basin does not show major damages, unless when it relates to lahar, which is addressed in the Disaster VRBM. In the management of water-related hazards, the RBO uses EWS and hazards mapping based on historical data. The BPBD DIY accepted reports of hazards occurrences, while the BBWS SO in collaboration with municipal agencies gave the updated data for water hazards.

The example of CEK existence is through the disaster management plan (RenasPB), which directs the water-related hazards management, acknowledges the importance of CEK in disaster mitigation, and mainstream it into targets of knowledge to be obtained for disaster management. In RenasPB, the volcanic eruption relation to lahar is not very clearly discussed, yet the 2010 eruption was listed as a national-level disaster. Lahar is categorized under volcano eruption hazards, while the flash flood also has a similar effect as lahar flood. So, the document does not differ these characterizations. However, the document is referring to the CEK as part of disaster risk analysis on the frequency of the hazard and to minimize risks, using implementing community development as part of disaster preparedness strategy and planning. It does not primarily address the water-related disaster, even though most of the frequent hazards are related to water, in this sense, the CEK is overlapping somewhat, which belong to the findings in the LRM chapter.

While at the regional level, the disaster management master plan for the Yogyakarta Special Region (RPB DIY) shows the importance of the community's role in any hazards. Meanwhile, on other types of water hazards, such as drought, never really happened, perhaps landslide, which also related to the lahar formation as it travels downstream through the ravines or river channels. Most hazard control is addressed with the technical approaches, such as the Sabo Dam and small dams (retention basins). The non-technical approaches came as a second priority.

The policy highlights the DRR as the concept and divides the condition of hazards into pre-, onset, and post-. However, it does not link to VRBM master plans, such as the water resources management plan (RPSDA WS POS) or the catchment master plan (RPDAST Opak). It linked more to the spatial planning (RTRW DIY), using designated the hazard map of Mt. Merapi eruption. The CEK in this regard relates to the statement of the philosophical axis in the spatial planning of Yogyakarta, which will be explained more thoroughly in the managerial contexts on the regional level.

The philosophy of *hamemayu hayuning bawono* at the regional level might even inspire to become living in harmony with disaster risks philosophy (Maarif, 2012) by the national government to use it as the philosophy in DRR strategy (RenasPB). This action recognizes the local wisdom, and culture of *gotong-royong* (collective action), *tepa selira* (tolerance) and volunteerism are beneficial to the resiliency in rate the nation. The fact that the Javanese philosophy was born centuries (Olthof, 2008) before the BNPB becomes the consideration of such correlations. The philosophy of living in harmony with risks in the national government as stated by the BNPB in RPB Nasional are interpreted into different motto or jargon in the regional and municipal level. The philosophy of "living harmony with disaster," which is similar to the *hamemayu hayuning bawono* philosophy is used as a resilience strategy all over Indonesia. The philosophy exists as the results of historical experience living with disasters. The awakening of this philosophy is since 2004 with a tsunami in Aceh.

Nevertheless, at the regional level, the CEK's traces for in this situation exist in the collective action or *gotong-royong* as a spirit for volunteerism and reciprocal help is still evident, especially in the case of disaster. The following quote is taken from the 2nd fieldwork as a validity check towards the findings of chapter 4, 5, and 6.

> The characteristics of Indonesian, when being pressured, then the vigor (of *gotong-royong* or collective action) is heightened. (Respondent BBWS SO, 2018)

The respondents' quote implies that most Indonesian have a latent *gotong-royong* spirit ready to be awakened when the timing is right. For example, during a disaster onset, this will be proven helpful towards building back better. However, when things get to normal, the urgency settles down and no more of the spirit shows, after a while, this will be back to ignorance and untrusting until a new threat is ascending.

During the 2010 eruption, the water resources management cannot function, in the whole river basins, which originated from Mt. Merapi, all irrigation systems, and water supply structures are either collapsed or submerged due to pyroclastic flow and lahar. Therefore, water tanks dropped the clean water for those in the upstream. Thus, during onset eruption, water utilization and conservation do not exist, the focus change to hazards control.

An example of Disaster VRBM phase during the 2010 eruption, the Pammaskarta DIY as communities' representative in water resources throughout Yogyakarta independently form teams of volunteers, which were ready to work tirelessly to help the victims. More activities were detected at the informal attempts, with the support of infrastructures from the formal attempts. These informal attempts were mostly organic from a bottom-up approach, using the community's social network and CEK, such as the social capital of *gotong-royong*, tolerance, and volunteerism spirits.

One thing was highlighted there; the Pammaskarta Gunungkidul comes from the southern-most regency of Yogyakarta in the Karst area, wherein reality in everyday life, they are also striving for water. The Karst geological area inhabitants let their rivers to run deep under the ground (at times more than 100m). However, during the disaster onset of Mt. Merapi, the CEK values they believed in, guided them to help their upstream colleagues.

The use of heritage spatial planning, the philosophical axis is cleared up the view between the Mt. Merapi, the city of Yogyakarta and the South Java Sea. As explained earlier in the policy setting about the cultural landscape of the region, both Progo Basin and Merapi-originated Opak Sub-Basin are meant to be conserved, especially those areas and artifacts located in the imaginary axis. This condition is also explained in the LRM chapter as the philosophical axis is revealed as a form of the disaster mitigation strategy. The axis is filled with much symbolization, as it is also philosophical ideas, *manunggal ing kawula Gusti* (the unity of human and God, human and King), the link to *hamameyu hayuning bawono* (beautifying the world's beauty/living in harmony with nature), and along the axis: artifacts were built as reminders of the philosophies. As a designated heritage area, the axis is to be free of buildings. It became a road, while the building on the side of the road should not be taller than a coconut tree (more than seven floors) and allows the viewing as part of monitoring the condition of Mt. Merapi. These are honored as the roads for deities commuting from North-South, which symbolized as the flood and lahar flow. The communities living in Yogyakarta still believes these.

The *wangsit* or premonition is used as an EWS and supporting the legitimization of modern EWS. In this way, the hazard warning will be heeded well if the Sultan legitimates it as a *titah* or command. The example of the 700 years cycle eruption (Troll, Deegan, et al., 2015) shows that 2010 was not the most significant eruption of Mt. Merapi. Further, based on this trend, it will happen in the year 2100's or beginning of the 22nd century. It somehow correlates with the statement of the Sultan about the change of Mt. Merapi's nature of eruption:

> Asleep, but when it woke up, it erupts as horrible as the last one. The older experiences with four years cycle are still horrible. However, the last one was the end mark of a (supranatural) agreement. (Governor's Expert Staff, Member-TP5 DIY, 2018)

A known volcanologist: Mr. Surono an ex-head of BPPTKG, who is honored and nicknamed as a *Mbah* or an elder with immense knowledge introduced in chapter 6, confirms this statement, although not explicitly stating when the next eruption will be. It confirms the possibility of a different eruption cycle:

> Well maybe not easily felt, every 2-3 months, Jogja has an earthquake. People may not feel. Moreover, the earthquake is not big, but it is recorded, in the seismograph. The Merapi is filling its kitchen. (Respondent BBWS SO, 2018)

These processes of CEK (*wangsit)* and modern science corroborating into a grounded knowledge, legitimatized from both the Keraton and the technical government organizations are everyday happenings in the Yogyakarta Special Region. The acceptance rate for this kind of knowledge is a lot higher than if it only comes from one side, as the indigenous community regards both their Sultan and government officials as the leader in society.

At the municipal level, the lahar management also tends to refer CEK as a part of a community awareness EWS system in the RPB DIY (disaster management master plan). It does not explicitly mention what they are, for example the five senses wisdom on how to differentiate the sound of the flood to lahar, how to stay safe, when to evacuate when the wild animals are migrating downstream, how to communicate with drums (*kentongan*) when hazards coming, While the historical experiences of the community level are part of social EWS, for example, this study found that the range of the CEK contributed are more than just the EWS, but also during the onset and post-disaster.

The CEK for the river communities is as follows. They believe in the sound of flute during the lahar flow and simple EWS with the local wisdom of rain combined with BMKG data, when the flood will come according to each location as they have access to this knowledge through one of the volunteers.

> The knowledge circulating in the community because BMKG always shares the information, so the river communities always get a report like this, besides the '*titen* knowledge' (local wisdom of the nature observation). For example, in ours, there is coordination with upstream friends know when so heavy rain within the duration until 3-4 hours later already there is a report to inform this in Monjali. It does not have to always Pemerti Code, or FKWA for Winongo as a volunteer of BPBD. (Respondent AKSY, 2018)

The Forums PRB (disaster risks reduction forum), Forum SKSB (communication and social forum), and other types of communities' forum know more about the eruption experiences, hence they are more succinct and sensitive to the 'signals' of lahar (the sound of flood in the river) or eruption (the animals evacuated from the mountain). However, for the case of an eruption, some were instead having paranoia remembrance from 2010. Most respondents in this research stated that they do not feel afraid the eruption (even those in the upstream) as they have the capacities and knowledge through training and simulations. This knowledge is about evacuation, how to get clean water from a river's base flow, and these experiences can be formed into future CEK as it is passed down to the next generation of the community.

JICA's role in lahar management does not include the water management in general, but put lahar sedimentation impacts to irrigation or river channel as additional studies in their work. They have more concerns about sand management, which positioned in the water-lahar-volcano nexus. The JICA's extensive studies since the 1970s in Mt. Merapi has proven their interests and concerns about lahar management. The many volumes of studies from 1976, 1980, 2001, 2010, and 2011 were also part of this research material. Their studies' contents are mostly (almost 90%) consisting of lahar master plan studies: volcanic sediment, riverbed fluctuations, river channels changes, and technical approach.

Meanwhile, in each JICA master plan, there always exists a volume dealing with the social studies of the communities as part of the regional development section as integrated sediment disaster mitigation management project, which covers: volcanic disaster mitigation riverbed stabilization, sustainable sand mining management and additional works, such as rehab of irrigation facilities, and multifunction of Sabo facilities. Interestingly, they have reported the existence of Yogyakarta as the center of Javanese culture, public participation, and support the importance of the communities' role in sand mining management and Sabo facilities monitoring.

Not much was found about the CEK being used in the case studies they reported, which are mostly located in the upstream area of Progo and Opak basins, being within a radius of 10km from Mt. Merapi's summit. These studies were not geared to understand the indigenous knowledge, but rather on how to include the indigenous as part of public participation. In the end, studies results do not reflect, and even undermine the communities understanding of CEK on the volcano disaster and its relation to water management.

At the municipal level, there has been no clear delineation for safe lahar zones, except those made in 2010 by the BPBD DIY, yet there is proof in sub-case 1, Argomulyo, that the CEK helps in pointing the safe zone for the area by using a marker of the 'bride stones.' The difference in sounds between lahar and flood used there also shows the specific types of five senses wisdom. Another EWS is by the visual of wildlife going downstream from the volcano as a way to tell an eruption is underway. Even so, this sub-case also has the CEK from the historical experience of the Sultan IX visit in the 1960s:

> To sit politely during a flood, to pay respect to the flow in the river, not to stand, not to scream and keep silent. (Respondent Argomulyo, 2016)

Until today, the people in Argomulyo do this, and the riverside is delineated as a hazard-prone zone for lahar. Also, by staying by the riverside, one respects the natural dynamics and does not cross the river during lahar, which is useful to keep safe.

Meanwhile, reports from river communities under BBWS SO, either in regional (AKSY) or municipal (FKWA, PKC, GWC, TBC) also became parts of additional information. Other communities under the disaster risks reduction forum by BPBD DI (Forum PRB) also report voluntarily. Based on an interview with the BPBD DIY, it is found that both the members of the river communities and Forum PRB sometimes are the same.

> We have the Forum PRB the members are (communities') institutions, currently commanded by Yakum. Each Ministry made their programs, (at BNPB is) *Desa Tangguh* (Resilient Village), at the Ministry of Social is *Kampung Siaga* (Alert Kampong) or at the Ministry of Health is Desa *Siaga* (Alert Village). (Respondent BPBD DIY, 2018)

The BPBD DIY also underlined the importance of CEK utilization in the *Desa Tangguh.* Most of the time, the local knowledge of the village dwellers helps in assessing the types of hazards and has sensitivity in recognizing the incoming hazards through historical experiences.

> For *Desa Tangguh,* it is hoped that the Cultural Agency also take concern as (their program) is *Desa Budaya* (Cultural Village) because there is a culture of local wisdom, which are usable. (Respondent BPBD DIY, 2018)

In all the cases used in this research, all of them recognized the *Desa Tangguh* program, by the mentioning of a different term as Tagana (*taruna siaga bencana* or cadets on disaster alert) as part of the community structure to manage the program. Most of the respondents in the FGD are either aware or members of the Tagana.

Each municipal BPBD adopts the regional BPBD guidelines into their disaster management plan (RPB). An example in BPBD Bantul uses the philosophy: *eling lan* *waspada ngadhepi bebaya* (aware and alert in facing hazards) for its municipal disaster plan. The CEK acknowledgment in the policy also directs to the local wisdom conservation, honoring the local cultures and values to optimize the community's development. The sub-case 2 experiences were to stay away from the riverside as the lahar flows and calculating the timing from the start of rain upstream until it reached their location within 45 minutes. Besides, the *kentongan* drums were also used as lahar flood EWS. Meanwhile, the sub-case 3 had no experience of lahar flood, but after the eruption, starts having the fright of flood, due to sedimentation of riverbed forming *wedi kengser*. Therefore, the CEK historical experiences combined in each sub-case with artifacts or flood management practice gave indications of a safe area from lahar and the timing to get away from the river.

Normal+ VRBM Phase

The water conservation and utilization work as in the Normal VRBM phase, but with the additional activity of sand mining. At the national level, the CEK existence under this phase is not so much dealt. The organizations on this level are more concerned with providing guidelines and institutional frameworks to control the activities based on the regulations in policy settings.

At the regional level, this is related to the deposit of lahar becoming abundant after an eruption occurred. The RPDAST document on catchment management referred to the sand mining activities, about the imminent danger of sand mining. In river channels of Mt. Merapi, especially in this case study refer to Gendol, Opak, Kuning, and all others in the Opak river system are rich with lahar sediment materials. The LRM strategy with the Sabo Dams requires maintenance using river dredging after lahar flows, especially in the volumes of 2010 eruption. This maintenance is done through normalization of the river channels. However, as already explained in chapter 6, as the sand quality is proven to be of best for construction materials, the normalization is alternated as the sand mining industry.

The regional government handles the permit for sand mining, based on the technical recommendations from BBWS SO as implied in the regulations mentioned in policy setting. Generally, for the normalization, which in this case has a double meaning as sand mining, is given access when the Sabo Dams are filled with volcanic materials up to the brink. The allowed distance to do the mining is 50m upstream, and 100m downstream of the Sabo Dam, when these are in series the distance will also be serried, and at times only leaves 200m distance between the dams.

The CEK at the regional level for sand mining is based on the conservation ground. Overall the respondents in this study believe that the sand has been over-mined. This condition is supported by the Sultan's statement based on his *wangsit* or premonition in 2018:

> (Mt. Merapi) will no longer erupt as the last time. No more four years cycle, then I asked if there's no more four years cycle, then what of the sands? Well, do the calculation (he said) the mining activities should be under strict control. (Respondent TP5 DIY, 2018)

Another explanation for the taboo of sand mining is found in the acts of the miners in the location. During the rainy season, at times the slope of the channels are getting eroded, and new sand from the steep river's slope enters the channel. However, this can mean extra income for the miners, but also has to be careful with the next incoming landslide, which usually follows after the first one. There was even a bad experience in December 2017.

> There were (17) miners trapped under sand after a landslide from river slope incident happened, the miners were lured by the new materials input in the river. They even called the location: Backhoe *pendem* (buried). (Respondent BBWS SO, 2018)

This taboo is coherent with the conservation act and *Hamemayu* philosophy for the environment.

> Their (the spirits') duties are to protect. However, they do it is for conservation, so when there is someone reckless, will be 'trampled,' because they don't honor the Earth." (Respondent TP5 DIY, 2018)

Based on chapter 6 findings on the JICA's Monitoring Handbook for Community-Level Sand Mining Management and Disaster Management, the community has an active role in truck traffic and Sabo facility monitoring. In reality, the community does not have this active role; only a group of elected representatives from the community takes this role. As observed in the fieldwork, the representative of the miners' associations mostly controlled the location of monitoring posts. However, there are some locations where the miners are not controlled. The locations of the sand mining have been continuously moving upstream as the deposit downstream diminished from 2010 to 2017. Although the regional government has issued specific permit regulations and limitations, the mechanism in controlling the sand miners is still weak. The sand mining activities at TNGM are an example of illegal activities protected under the management of the national park.

> Let's say Merapi; it belongs to the TNGM (national park). We (BBWS SO) were not allowed to get in. That day, I went in, because it has rivers. When we got to there, we saw that they have 'escorts' (sand miners under their protection). There are 1,200 people. That is illegal, as they do not have permits. (Respondent of BBWS SO, 2018)

The sand of Merapi is also named 'black gold' as it is straightforward to get, and the result will instantly make the miners rich. Extreme instances are found in the adjacent river basin of Progo, based on the 2nd fieldwork to this location. There were also locations where only the miners and their bouncers have access to, not even the village administration. A respondent explained:

> Those miners were protected by "a bunch of stars" (people who have high-level ranks in the military); even the Central Java governor could not stop them. (Respondent BBWS SO, 2018)

At the municipal level, complaints from the local communities can be found throughout the interview rounds with the villagers, especially in rural upstream. In general, the monitoring of sand mining is done with the help of communities, as also referred to in the JICA Sand Mining Monitoring Handbook. However, the communities are not given the role to give sanctions, merely reporting illegal mining activities. They do not possess the authority to 'throw-away' these illegal miners out of their village. They can make reports and hand it over to authorities (RBO or PU-P ESDM or the Governor's office). However, no clarity to which organization one should report for trespassing or illegal sand mining activities.

Figure 8.3 Gendol Sand Mining Activities from January 2018 upstream of Mt. Merapi

Some claim to mine on their field, as the river morphology change, some fields were part of the river channels. In reality, in the villages of case studies, communities level miners exist; those without permits, who are practicing this on the household scale. Either in the sub-case 1, using shovels and cart, in sub-case 2, dredging the riverbed and use the sand to add the second floor of their houses by the riverside, or in sub-case 3, using bamboo rafts and bamboo shifter to filter sand from water. These practices by the locals are not as harmful as the sand mining industries, but less controllable.

The CEK teaches the communities not to be greedy towards the sand. They can only mine up to the previous condition of the river channel (depth and width). The locals have known from their elders about:

> There will be a time when the Gendol River will be auctioned. (Respondent Argomulyo, 2016).

Many existences of the sand mining activities observed in fieldwork 1 and 2 are industrialized for the sub-case 1. Throughout the Gendol River, this industry is booming, and moving further upstream as the deposit in mid and downstream areas are no longer as abundant in 2018, compared to the condition in 2010.

However, the lahar sedimentation supply relates to the healthy supply of sand in the estuary of Opak and Progo to form the dunes.

> It happens from the sand in the estuary, formed by the sea wind. All rivers end-up in the south resulted in dunes, due to the southeast wind. (Respondent TP5 DIY, 2018)

How the *Gumuk* (dunes) by the Parangkusumo Beach downstream occur, as a result of sand from Mt. Merapi is still not so much known. However, the CEK of protecting the river sediment deposit from lahar flow is known. For the dune conservation to happen, the river needs supply from the volcano. The CEK asked for the Parangkusumo Beach to be a conservation area as it is located in the south end of the philosophical axis. This beach serves as an artifact. The philosophical axis explains the up-downstream correlations. Its spatial arrangement is implicitly acknowledged in the Perda DAS and managed by the BPDAS-HL SOP. Thus, most locals let the sand in the rivers; they used the sand that is on their field or plot of land. However, they use it like a 'saving account,' as many were relocated from their homes in the upstream, those locations became abandoned, but the land ownership stays with them. They only sell the sand, when they need big-spending, i.e., celebrations (weddings, circumcision) or when their kids enter universities, among other examples.

Community-based sand mining and Sabo dam monitoring is recommended by the JICA, needs stronger understandings towards the CEK. As the community understands their rivers characteristics and the lahar flow as part of their daily life, they are operating on the mechanism of neglect towards this guidance. They do not feel that they are part of this, do not have the authority, nor are given such status. The CEK does explain about the missing or moving springs due to over-mining. Now, the sand becomes irresistible, even auctioned.

Observations in 2016 and 2018 reflect that the sand miners are still at large, parallel with daily villagers' activities. Many villagers do not know the identity of these miners. When asked about this, the villagers replied:

> Those people are not from here. (Mrs. Jaka, Argomulyo, 2016)

The trucks may be parked in the river or Sabo areas, also drive through their village, but no contacts were made between the miners and the indigenous communities.

Some villagers know from their experiences that the lahar sedimentation in the river channels (also called as the *wedi kengser*) can be used as temporary farmlands. It is possible to use it during the dry season, as even without water, the plants will be fertile. The land is composed of rich nutrients from the volcanic materials mixed with mud, especially after a year from the eruption. The water in the river channels dried, but it is a common characteristic of volcanic basins in the world.

As referred in chapter 5 on VRBM and chapter 6 on LRM, the CEK of the communities are related to the resources management practice in the rivers on the movement of springs, the river's base flow utilization, and the lahar sedimentation dredging. On the movement of springs, when the locations of spring changed, the sand mining activities became more and more dominating in the river channels. Some springs died due to the location being mined, as the groundwater flow was cut-off. Some springs were displaced to nearby locations, as new groundwater flow formed due to the disruption of the mining activities. Many respondents also reported these in the up and midstream (7 out of 20). The VRBM implementation by the government has not recognized these details. Reports were made for diminishing of flow in more significant spring in the other the adjacent basin, where water supply intakes were built. The second is on the practice of using river base flows like the drinking water source, post-eruption, while other wells are either too hot or contaminated with iron or sulfur. This practice is also not recognized in the master plans for the river basin. Although, it is an excellent good source of water, as alternatives to the water tanks solution directly after an eruption. The third is on the sedimentation dredging for wells by the riverside after lahar flow. The dredging is used mostly in case 1 and 2 as many residents build their wells near a stream or river. The well water after dredging can become clear again. They needed to wait a week before reusing the water to let the sediment to settle at the bottom of the well. This dredging is also not included in the master plans for the river basin.

Artifacts concerning VRBM and LRM are on indicators of over-mining and lahar sediment or the *wedi kengser* as temporary farmlands. The visual riverbed and channels appearances are positioned as artifacts for as indicators of over mining. When the appearances are not the same after sand mining is taking place, most community respondents (6 out 11 in the upstream), testified that the current condition is already more profound than it was before the 2010 eruption happened. However, no photo proofs can help to strengthen these claims, as there were no photos taken before the 2010 eruption took place. They claimed that the miners had taken about 5m deeper than what it used to be. The indicator from the RBO side is the Sabo Dam's holes base when the holes can be seen then it means the sand mining must stop. On the second artifacts of *wedi kengser* or the lahar sediment in the riverbed created island, which is used as temporary farmlands. This activity is done in all the cases, even the one in midstream located in the city center. The residents know what kind of vegetables or seasonal plants to cultivate. Based on 2016 fieldwork observation, the upstream case used it for a rice field, as the water flow is regular. The midstream *wedi kengser* used it for corn or vegetable as water becomes scarce. While *wedi kengser* in the downstream has dominant sedimentation up to 100m from the riverside, is being used for planting bigger plants such as Papaya, Banana, Sugar Cane, or just some grass for cattle food. These practices are also not examined in any of the master plans.

8.1.3 CEK (non) impacts on Interaction Attempts

The interaction attempts for water play a significant role at the regional level, with many different attempts, either formal or informal. The CEK's relation to the interaction attempts mostly relates to the attitude of the attempts towards possibilities of its utilization and the current human values being used. The arrangement of this subchapter will be based on the level of governance and the type of attempts as defined in earlier chapters: budget, water, and disaster. The VRBM phases are used again as the main arrangement with the type of influences the CEK may contribute. However, as the interaction attempts used for the Normal and Normal+ are the same, the two phases are clustered into one phase. The most prominent CEK in the interaction attempts are the values, norms, and philosophies. Positive (+) marks are given when CEK are used, such as values like the *gotong-royong* are found and supports the interaction attempts. Negative (-) marks are given when CEK exists but neglected in the interaction attempts, such as when sand mining practice is not heeding the conservation values of the river. Also, zero (0) is given when CEK is not referred to at all.

Nevertheless, most of the interaction attempts failed to show CEK impacts, unless those created by the communities. The interaction attempts diagram found in chapter 7 is used as the starting point, but in this section, it is added with the CEK impact patterns. The patterns are presented in figure 8.3 below, as a way to visualize the output of the analysis. Accompanying figure 8.4 below, the following table 8.3 summarizes that interaction attempts with informal ways have a better chance of impacted by the CEK within the VRBM phase and the level of governance.

Table 8.3 CEK in VRBM Phases for Interaction Attempts

Levels of Governance	CEK Impacts Patterns	
	Normal and Normal+ VRBM	Disaster VRBM
National	Formal: (0) (1) Budget: musrenbangnas, rakorbangpus (2) Water: DSDAN	Formal: (+) Disaster Rakornas by BNPB Reference of CEK in disaster response
	Informal: (+) River Jamboree: transfer of CEK – *biotilik* (water quality indicators by type of fishes), values, philosophies	Informal: (+) Acknowledgement of living in harmony with risks and CEK's importance for each specific locations on EWS and values
Regional	Formal: (0) (1) Budget: musrenbangprov, rakorbangda (2) Water: TKSPDA, DSDAP, Komir (+) Forum DAS acknowledgement of CEK values and resources management practice	Formal: (+) Satgas Bencana: CEK in social capital, philosophies, values
	Informal: (+) Values of *gotong-royong* (collective action), *handarbeni* (ownership) in Pammaskarta Forum and AKSY discussions & partnership	Informal: (+) Forum PRB uses the CEK in the form of resources management practices (local wisdom for hazard indicators), *hamemayu* (living in harmony with nature) philosophy, social EWS through *kentongan* and walkie-talkie, *gotong-royong* values Pammaskarta: the partnership with the Forum PRB in provides clean water with *gotong-royong* and *tepa selira* AKSY: partnership river watch, in giving information on water level or lahar occurrence
Municipal	Formal: (0) Musrenbangkot/kab, rakorbangkot/kab	Formal: (+) Satgas Bencana: CEK in social capital, philosophies, values
	Informal: (+) CEK values in *tepa selira, gotong-royong* in Spamdes and river communities: Pemerti Code, FKWA, Tambakbayan, Gadjahwong. (-) Monitors of river depth in sand mining activities & Sabo Dams.	Informal: (+) Tagana, SKSB, Paguyuban RW use the local wisdom as EWS and the social EWS using *kentongan* drums and walkie-talkie

The CEK referred to in table 8.3 are both soft and hard CEK, but the soft CEK is more often referred. This condition is due to the flexibility belonging to the soft CEK, making it more embedded in daily management practices, mainly when the practices focus on human interactions.

CEK Impacts on Normal and Normal+ VRBM

Both conditions use the budget and water management interaction attempts (A and B). However, the interaction attempts do not differentiate the conditions of pre (Normal) and post-disaster (Normal+), but rather divide between Normal and Disaster. In these budget attempts, these are the formal ways organized by the government, especially by the national government (A1); it is highly hierarchical, and functions mostly like ceremonials. These are formal attempts called: Rakorbangnas and Musrenbangnas. The Rakorbangnas (inter-ministerial coordination meetings at the national) put the many ministries into a series of meetings, where coordination is happening through 'turns of speech.' It is also seldom conducive to stay focus while waiting for one's turn. During the meetings, there are also smaller group discussions based on the cluster of more integrated development issues. Due to the short amount of time, even the imprecise measures to give priorities, each year, the Bappenas made use of the 'red pen' strategy.

> From the proposal side or the benefit side, but we forget to use the merit point scoring system, no weighting system, so yes, just based on memory. Nah, and this, the 'red pen,' just strike-through, not easy, when there is a weighting system, I will be happy with that. So, it is clear, yes, but when not, (this is) just who 'strong will prevail' (condition). (Respondent Komir, 2018)

This system indeed asks for transparency in the decision-making process, yet the reality, as explained above, is not very clear with the 'red pen strategy.' This strategy made use of crossing those unwanted programs out of the list of proposed programs in a year. The 'strong' in this sense can be supported from different directions, which can be summarized as those with 'power.' For a person to be able to negotiate and place himself/herself in a benefiting position, s/he has to learn about the context of political conditions as well as the organizational relations. This condition holds the CEK usage, as the legitimization process needs the support of a figure, the Sultan.

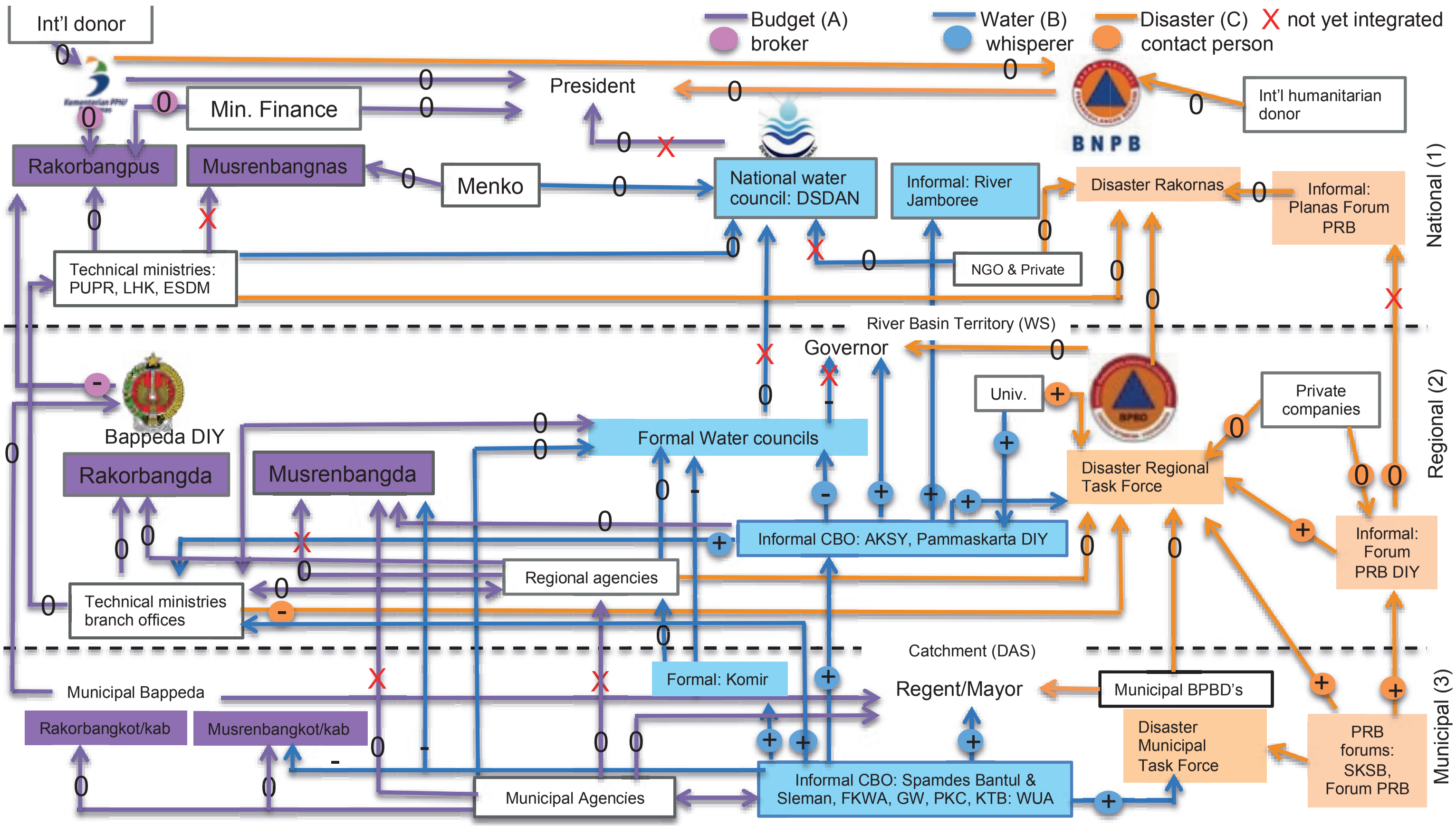

Figure 8.4 CEK Impacts Pattern on VRBM Interaction Attempt

The budgeting for water development (A1) also runs through this line of interaction attempt, where the Ministries synchronize their programs (national level or A1). Through this budgeting line, the involvements of international donors, such as the World Bank and JICA in the river basin management are channeled. The budget goes through the Ministry of Finance, while the programs were listed under the Bappenas. This budgeting line was how the water management sector reform (WATSAL) was happening through the World Bank. The JICA's concerns are more on lahar management. The Sabo Dam structures are included as preparation before the onset disaster of lahar flow goes under the Ministry of Public Works and Housing, and not through the BNPB. The international funding mechanism is explained as follows:

> The APBN (national budget), but can also be a plus loan. This path has many sins because of the interest rate (from the loan). A loan is much sin; the ones returning the debt are our children and grandchildren. A lot more secure is looking for Grant, with bluebook still manual, written in handwriting. Now it is easy. That is using if not JICA, KOIKA for a grant, but IGGI is a bit hard with politics. Hard political content. (Respondent Komir, 2018).

This condition illustrates the medium where the international donor, such as the World Bank and JICA (A1) took their role in this case study. The quote also explains the existence of CEK being expressed with eternal life (*bawono langgeng*), to think about the debt passed on to the next generation. However, this person stating the quote was located at the regional level, so the perception might not be the same all over within the national level.

The other mechanism for interaction attempt in the budget is the Musrenbangnas (A1). This mechanism is a way to involve the private sector, NGO, and representatives of the regional level in the meeting. Nevertheless, in reality, this is mostly one-way information flow from the government to the other stakeholders, and not much chance is given for the other way. Most of the time it is used to sound future development plans, where the President opens the meeting and halfway might leave for other tasks. Again, the meeting is held in turn and is not an integrated way to conduct a feedback mechanism.

The budget attempts (A) goes hand in hand with the water attempts (B), although not always harmoniously and not yet integrated. This is because the connection has to go through the Menko or Coordination Ministry. There is no direct link existing as mechanisms from the national water council (DSDAN) into giving input to the national development and planning agency (Bappenas) (between B1 to A1). It is still impossible to foresee how the DSDAN's recommendations (B1) can become a part of the development plan in the current or future fiscal year (A1). Moreover, there is no trace of CEK at national level attempts; the meetings were held very rigid and technical. The CEK values, such as *gotong-royong* are not traceable in the budget attempts (A1). Mostly the 'red pen' strategy prevails, even though there is a trace of 'brokers,' but they do not always a sign for the existence of CEK, but more of motives. These brokers will be explained more detailed in the boundary spanner section.

At the regional level, the formal attempts are the derivative of the national attempts: Rakorbangprov and Musrenbangprov (A2). The current approach for the

Rakorbangprov is more integrated as it merges the regional and municipal agenda on budget, but not so integrated as to connect with the ministerial branches at the regional level. The meeting does not include the latter in their meeting agenda, which is crucial in attempting coordination at the regional level. The Musrenbangprov are more inclusive, and this involves representatives of communities (CBO) and the other related stakeholders as at the national level. Nevertheless, the results of such attempts are also still ceremonial and not yet integrated. Again, the meeting is held mostly to disseminate information on the current development plan from the government to the people, and in return, the people will give feedback. Nevertheless, the feedback is not followed-up. There is no mechanism in tracking these, especially when the person coming as the representative to these meetings (A2) were not always the same.

Within the regional level for formal attempts in water (B2) or the water councils, there are several forms: provincial water councils (DSDAP DIY), coordination team of water resources management in river basin territory (TKPSDA WS POS), catchment forum (Forum DAS SOP), and the irrigation commission (Komir DIY). Based on several respondents' opinion: these attempts have a similar pattern, they always include community representatives, the private sector, and NGO, with the governmental stakeholders in water management. They meet several times a year (minimum 3) and have heads of the governmental stakeholder as their leader. However, they do not always attend by the invitee, but a representative, who cannot make any decision. The most hardworking part of these councils members is the secretariat or the host organizations. In the TKPSDA (WS level water council) – B2, the CEK is not traced as the utilization of local wisdom in water management, but rather as water management 'business as usual', such as the mentioning of Selokan Mataram (not as artifacts, but as an infrastructure), on the conservation activities of rivers after sand mining activities, or the culture of rainwater harvesting (MoM 1, TKPSDA, 2015-2016).

Meanwhile, within the DSDAP DIY (regional level water council), more CEK acknowledgment was made, such as the reference of cultural values and the philosophy of the region within the water information system (MoM DSDA DIY, 2 August 2017). However, again, these references are too general and not mainstreamed: "also all socio-economic and cultural activities by the community related to water resources" (MoM DSDA DIY, 12 November 2014). Furthermore, the DSDAP has more reference towards the budgeting mechanism within the regional level, using synchronizing the activities and priority lists during the fiscal year or the monitoring and evaluation from the previous year. The Komir never acknowledges the existence of CEK, but the farmers are using their calculation of water using local wisdom in everyday life. The cropping patterns were proposed in their annual meetings. These are still based partly on the *pranata mangsa* (Javanese seasonal calendar), although direct references are not given in their MoM's from 2013 to 2017.

Out of these many channels of formal interaction attempts in water, all of it is deemed to be just 'talking,' as explained by this quote:

> TKPSDA does not make a sound, only talking doing, the DSDA(P). I also got invited this last year, we tried to 'scream louder.' But, the problem is, there are like 50-70% of the invitees were government officers (PNS). The DSDA(P) also is limited

> to provide recommendations, it cannot make much (difference). (Endang, FKWA, 2018)

This 'only talking' is an expression in the Indonesian context, which means there is no action or no significant follow-up, but merely a meeting. The water council function in doing coordination, but only as dissemination information points and creating recommendations. The respondent also refers to the inability to 'scream louder,' which represents the type of communication there. It is not conducive for two-way discussions, especially as there were more than half of the invitees are government-related. This condition is what makes the informal attempts essential, as the communities can talk and discuss more freely.

Aside from that, the Forum DAS has more support for the CEK, as the host (BPDAS SOP) initiated the Perda DAS DIY. In the end, the CEK is more prevailing in the conservation aspect of water management. Even the Pammaskarta DIY was not part of any of the water councils; they held their meetings. However, more CEK values are traced in the meetings by the Forum DAS throughout the year 2014-2016. The host organization, the BPDAS SOP initiated the Perda DAS DIY or the Regional Regulation on Catchment Management. The minutes of their meeting explained existences of what local wisdom is included in the Regulation Drafts. Primarily, when they started to link the realization of the philosophical plane within the meeting, as follows:

> "The invisible whispering (premonition or *wangsit*): choose a beautiful land, which proposes prosperity of the people, located in the middle, between Parangkusumo (Beach) and Mount Merapi, flanked by the rivers, land of *geger bulus* (turtle back), whenever, it will not be hit by flood ==> CONCEPT BASED ON Catchment MANAGEMENT". (MoM Forum DAS, 12 December 2014)

However, as the municipal level does not own the water council, the interaction attempts are happening only in the budget interaction attempts (A3). The findings do not indicate any trace of CEK being referred to in the management of water in the volcanic river basin. The river basin crosses municipals, and interaction attempts require the regional level interaction to address the problems.

Informal attempts were born as alternative attempts from the communities' side to reach out the government side. CBO leads the meetings, but inviting the government and private stakeholders. An example of national-level attempts is the River Jamborees of 2017 and 2018 (B1), which were initiated by the AKSY (Yogyakarta River Community Association) from the regional level (B2). During the Jamboree, several activities were introduced to other communities in Indonesia. These activities are the *biotilik* (CEK visual indicators or five senses wisdom on water quality by seeing the types of biota, such as fishes), river school, and river tourism. The informal attempts resulted in the partnership between the governments with local communities in regional level: BBWS SO with river communities (AKSY), also the CK-SPAM and PU-P ESDM with water supply communities (Pammaskarta DIY).

The Normal+ VRBM uses the interaction attempts in the budget and water (A2 and B2). Primarily, it uses the water council or TKPSDA to discuss the sand mining problems. The TKPSDA MoM in 2014 present the evidence in giving recommendations to the Minister of PU to follow on several points related to the sand mining:

> "The sand mining management should involve the participation and empowerment of the community to improve the welfare of the community. Review the Sabo Dam building in Sand Mining Management. To manage the potential of sand in a business entity so that mining can be controlled and bring prosperity and need to control the mining of sand that is environmentally sound."

However, as the TKPSDA as an interaction attempt is not yet as integrated as it is supposed to, the follow up of this recommendation is not apparent. There is also no trace of CEK being used in this interaction.

Within the municipal level, the water interaction attempts are happening informally (B3); with the implementation of community-based sand mining monitoring not working. This condition can be seen from the lack of monitoring activities and apathy of the villagers towards this. The community, even the municipal level government feels that they do not have the authority to say stop to the miners. They think it is not their job, and they do not have the legal umbrella to support them. Primarily, as the community is complaining about the sand mining activities have resulted in their struggles in getting water during the dry season. For this reason, the five senses wisdom as the form of CEK on visual of river channel on over-mining indicator is also not being used.

What is clear; now, the problem is water. Before the eruption, there were no mining controls; either from the residents or districts government, what is important was for the money to continue (flowing). Though right now when the dry season, here, (we) run out of the water. Even it's me (a hamlet chief). I built a weir, 7 million (self-budget). To cope there who do not get water. Each dry season, (we have) drought. (Respondent Argomulyo, 2016)

The RBO may not address this issue as it falls under the municipal level authority, yet, their Sabo Dam infrastructures are the once created this problem. When there is no Sabo, there will be no sediment stopping. The logic is when the sand is over-mined; it destructed the equilibrium of groundwater and spring discharges, creating a shortage of fresh water. The groundwater flow change is also due to the disruption of the soil layer.

CEK Impacts on Disaster VRBM

The existences of CEK in the interaction attempts are stronger in the informal attempts. However, the value of *gotong-royong* is used in the DRR strategy, even at the national level (C1). During onset disaster, the interaction attempts to shift its form into disaster interactions. Here, the BNPB at the national level (C1), BPBD DIY at the regional (C2), and municipal BPBD's (C3) are taking the lead role for each level. The command-line based on the scope of the disaster, for example, during a local flood, the municipal level is leading it. However, for lahar flood, as it transcends between municipals' authority, the regional BPBD (C2) will take the lead. While for the Mt. Merapi eruption, the scale covers inter-regional, thus the BNPB will be in charge (C1).

The BNPB has the disaster Rakornas as formal disaster interaction attempts at the national level (C1). It includes all related ministries, NGO's, international donors, and armed forces. They are all involved in the emergency response, where the human and financial resources are used with extra flexibilities. Even the budget interaction attempts will subdue during the disaster response and focus on disaster risks reduction activities. Thus, during a disaster, the budget can also be allocated for disaster relief.

This flexibility of disaster budget is common to all over Indonesia, during the onset, after safe shelter location, clean water is the next priority to be prepared. The budget allocated for disaster response is somewhat unlimited, but the priority is set based on humanities values, where the CEK is found to be of local context in comparison to this. Nevertheless, the CEK exists in the formal interaction attempts during a disaster inter-organization as *gotong-royong* (collective action spirit), *tepa selira* (empathy towards the victims), and volunteerism, between BNPB to all related parties, which for the case of water resources related to Ministry of Public Works and Housing. These values existed as a joint social capital of Indonesian society in general during the onset of disaster and post-disaster. In the case of Mt. Merapi eruption, this has contributed to the fast recovery rate.

Other than that, an ex-BNPB leader in his book explained about his views of Indonesian's capacity for disaster resilience being linked in with local wisdom. He also supports the importance of philosophy in disaster risks reduction as (1) minimizing the hazards, (2) avoiding the hazards, (3) 'living in harmony with risks,' and (4) relearning the local wisdom.

> "Learning from their experience, society always aims to get the wisest way to counter, avoid, and adapt to the hazards that threaten it. From this lesson, then each local community finds particular local wisdom in dealing with the threat of disaster in each region." (Maarif, 2012)

This statement emphasized the importance of CEK in the informal attempts as each context of local communities; differing in each region of Indonesia. It also suggests a general term is given here to encompass all kinds of CEK, which is likely to be found in the regional and municipal level. The national government does take this into considerations but is still unable to list down what the CEK's are. The BNPB turn to the universities and LIPI (Indonesian Institute of Sciences) to fill them with such research (Maarif, 2012; BNPB, 2015).

Within the regional level (C2), the disaster interaction attempts are called Satgas Bencana (or Disaster Taskforce). The actors coming from both water and volcano sectors, but these actors take a different active role at a different phase of the volcano condition. With the hazards onset, the VRBM focus is on hazard control and the conservation plus utilization has less importance, using evacuation and adding temporary infrastructures to the embankments. It addresses the emergency response for water supply, such as water-dropping (transfer) with water tanks and inter-basin transfer using pipes.

The informal water attempts (river communities-B3) are changing its form into a volunteer network for social EWS for onset hazards (C3). The municipal level has a better partnership with these communities. This condition also goes for all the other type of CBO in sub-cases 1, 2, and 3. The CEK therefore still holds essential roles in the onset and social EWS of the society living in the Opak Sub-Basin. Within the municipal level, during pre-hazard just before the onset is happening is also located in the Disaster VRBM phase. The condition is 'distrust' situation, which is based on the inexistence of integrated EWS quote, which is happening in the pre and post-eruption condition.

> The EWS systems are not integrated because each institution does not give access to others. It is due to the prejudice, that if they give access to people, people can trick the system (hack). (Tri Bayu Adji, BBWS SO, 2016)

Merapi has a range of EWS, from the less sophisticated EWS to advanced. It uses walkie-talkie, *kentongan* (wooden/bamboo long drum), and computerized one at Balai Sabo. Even the latter cannot directly give direct, updated data. These EWS are all installed, but no certainty is guaranteed whether it works or not.

8.1.4 CEK (non) impacts on Integration Levels

Additionally, to explain the scoring given in earlier narration, the table 8-4 on integration level is presented taken from chapter 7 findings on integration level (table 7.4). It shows the level of integration is at the highest in the Informal Ways for water attempts (regional) and disaster (regional and municipal).

Table 8.4 Integration Level taken from chapter 7

Theme Level of Governance	Budget (A)	Water (B)-Formal	Water (B)-Informal	Disaster (C)-Formal	Disaster (C)-Informal
National (1)	0,3	0,3	1,3	1	0,3
Regional (2)	0,6	0,6	3	2,6	3
Municipal (3)	1,3	0,3	2,6	1,6	3

Comparing tables 8-3 and 8-4, the patterns CEK, especially the soft CEK as it fosters positive impacts in interaction attempts and correlates with high integration level. This condition means that the CEK has 'smoothening effect' in the interaction attempts. Some correlations are (1) the more informal actors (in table 8.3), the more CEK is delivered. (2) The higher the use of CEK (more + impacts in table 8.3) and the higher the integration level (presented in higher number in table 8.4). (3) The more informal actors located in the interaction (in table 8.3), the higher the integration level (presented in table 8.4). This smoothening effect highlights the importance of CEK agents and where their activities are taking place at the boundary level, which is explained in the next section on boundary activities. Again in this section, the interaction attempts used for the Normal and Normal+ are the same, making the two phases clustered into one phase.

CEK Impacts on Integration Level of Normal and Normal+ VRBM

The CEK impacts the interaction attempts in the Normal and Normal+ through the budget and water interactions. Within both national and regional levels, these attempts used in the formal water attempts – B1 and B2 (DSDAN, TKPSDA, DSDAP, Komir, Forum

DAS) and the budget attempts – A1 and A2 (Rakorbang, Musrenbang), there is only mechanism of interaction scored at the lowest integration level (0.3) in the national level (A1 and B1) and near the lowest (0.6) for the regional (A2 and B2). This condition correlates with little reference to CEK in their discussions. There is little chance that the community may voice their opinions through this channel, as the meetings are one-way discussions. Meanwhile, the CEK can only be brought into the interaction attempts when community actors have the chance to voice their opinions.

Within the municipal level, the formal budget attempts (A3) scored higher (1.3) as the Musrenbangkab/kot still functions as two-way discussions. In this interaction attempt, the CEK is utilized, the information is shared (synchronized within the municipal), the aims aligned (compromised), but not fully shared. The CEK utilization in budget attempt example, the budget allocation is to develop a small dam. Districts shared information, but not having the same aim. For example, one district focuses on rainwater harvesting, the other on for flood control. Thus, the municipal decides and compromises the benefits. For the water attempts (B3), it scored lowest (0.3), as only Komir (irrigation commission) is present as water council in this level. It is covering for irrigation-related agendas to be discussed. The CEK is also not delivered into the water interaction attempt as the community representative has limited access to the Komir.

The informal water attempts at the regional level (B2) take forms in the CBOs. The integration for level for this level is scored as the highest (3), as they shared information, aim, and also budgeting. The river (AKSY) and water supply communities (Pammaskarta DIY) are using the CEK values; philosophies and resources management practices for their cooperation. The aims and the means are the same, yet the budgeting alignments are not always at the ready. The cooperation between BBWS SO and AKSY aims for river conservation and restoration, but when the budgeting is not ready, they both 'chipped-in.' It is in line with *gotong royong* or collective action spirit.

Another example is the AKSY at times also uses cultural thanksgiving rituals (*merti*) to promote their activities. The support of BBWS SO to celebrate important events, such as World Water Day and River Jamboree. While for Pammaskarta DIY, their informal interaction attempts are partnered with the PU-P ESDM and at times with the Satker CK-SPAM from the Ministry of Public Works and Housing. As explained earlier, also the feel of ownership (*handerbeni*) is appreciated, as the communities are more involved within the Pammaskarta DIY water supply initiative. Their interaction attempts are functioning as the place for sharing information about water source potential; sharing locations, divide authorities, and budgeting aims.

However, the municipal integration level through the informal water attempts (B3) is not as good as the regional integration (scored 2.6). The budgeting system is fragmented per river community within the same municipalities, although the information and aims are shared within the communities. All types of CEK are used and have more local context based on the location (up, mid, downstream). However, the CBO is based on the river; the cooperation is happening at a higher level. For example, the Code River CBO has self-generated their income, while municipal agencies support the Winongo River. Shared cultural backgrounds and CEK support the river CBO collaboration. For example, rivers from Merapi are considered as sacred artifacts; the conservation and restoration activities are in the same priorities.

CEK Impacts on Integration Level of Disaster VRBM

Within the formal disaster interaction attempts at the national level - Disaster Rakornas (C1), the integration inter-ministries are at information sharing (scored 1). The existing mechanism is used to share information, but communication and alignment of aims depend on the regional focus. This condition also correlates with the commitment of the BNPB to support the conservation of CEK concerning DRR, although no further reference is made at the national level. For the formal regional disaster interaction attempt the Disaster Task Force (C2) scored 2.6 or collaboration towards cooperation, and it relates to more evidence of CEK. The Disaster Task Force respects the CEK, and it commits to honors cultural values, as it works directly with communities. However, in terms of budget sharing, although the regional actors have an 'on-call' disaster budget, the ministries' branches in the regional level do not always have this at the ready.

Therefore, the budget can be aligned but is not shared. The CEK values: *gotong royong* (collective action) supports the collaboration of the actors. Meanwhile, for the formal municipal interaction attempts (C3) scored lower (1.6) because their administrative jurisdiction limits the municipal Disaster Task Forces. They can only share information and align their aims. Although the instances of CEK are plenty in this level, the integration level is not as high, because of jurisdiction limitation. This condition limits the sharing of aims as a regional level decision.

Meanwhile, for the informal ways at the national level or Planas PRB (C1), the integration level is very low (0.3). It is because CEK is too abstract and different CEK based on different cultures across the country. However, the informal ways of the regional and municipal level (C3 and C3) scored the highest (3). It is because the actors share common CEK at the regional level to minimize disaster impacts. For example, the CEK on avoiding the rivers 'marked' as lahar channels by the Sultan. In the Forum PRB DIY (C2), the existences of CEK show cooperation during hazards. The examples are of the use of CEK in similar social EWS, such as a bamboo gong or *kenthongan* and Mosques' sound system. Also, the indicators of hazards using historical experiences (sound of lahar), resources management practices (not using river water during lahar), and the value of *gotong royong*, and philosophies (*hamemayu* – beautifying the world and living in harmony with volcano).

In the municipal level, the Forum PRB (C3) addresses the disaster based on its priority and not limited by administrative jurisdiction as what the government actors have. The community actors can cross inter-administrative levels freely (for example, the sister village) because they do not have formal forms of cooperation. These community actors are coming from the existing rivers' and water supply communities merging into the Forum PRB with the Tagana and other disaster communities. Thus, they are bringing into the interaction, the full CEK on disaster management.

8.2 Why CEK impacts the VRBM?

This section unfolds in answering the 'why' question by understanding the actors and their activities in the VRBM and more specifically, the interaction attempts. The condition of the interaction answers the reason, 'why CEK impacts the VRBM?' or those with (+) marks attempt composition. (1) The presence of organizations who support the existence of CEK within the management practices or the BO. (2) The presence of actors who bring with them and use the CEK in the interaction attempts or the BS. (3) The conducive atmosphere for the interaction attempts to allow CEK mingle within the management contexts. Therefore, this section relates more to the soft CEK, as the actors use it more often than hard CEK within the interaction attempts.

For these reasons, the section uses the 'boundary-spanning activities' concept from chapter 7, as the activities on carrying CEK into the management realm (cross boundaries) can be considered as a form of the concept. However, the activities differ from the one in chapter 7, as it was on the 'sectorial boundary spanning activities.' This section investigates the actors who bridge the CEK and VRBM, which are called the 'cultural boundary-spanning activities.'

The findings demonstrate that the CEK, especially soft CEK, impacts the VRBM. Agents brought these impacts and flourished under 'conducive atmosphere.' These agents are the boundary organizations (BO) and the boundary spanners (BS), both of which strengthen the integration levels. These concepts are operationalized in the appendix to chapter 8 in table c. Meanwhile, the 'conducive atmosphere' is the results of the presences of the boundary spanning actors (BO and BS), resulting in a relaxed setting and is more prevalent in informal ways.

8.2.1 Boundary organization

In this research, these forms of boundary organizations (BO) in the VRBM context existed as they are fostering a better integration of water and lahar management. Nevertheless, the arrangement of this section uses the structure of the VRBM phases, which corresponds to earlier sections. The BO does not have to be in the primary interaction attempts at play, but they are vital organizations fostering inter-sectorial and interests. The BO's domains are water and lahar while bridging the CEK and policy implementation. The BO is not found at the national level (1), but they are located at the local level, both regional (2) and municipal (3). The informal ways exist at the water (B) and the disaster attempts (C).

Normal and Normal+ VRBM

The horizontal boundary organizations are located and fostering interactions of the same level hierarchy, which are composed of NGO and CBO. The types of organizations operate on their independent budget. Also, the government supports some of them. Their positions are stronger as the in-between bridge of community and the government at the regional level than at the national level. They have direct contact with real people and understand real problems updated from time to time at the regional level. Their sensitivities on the subject facilitates interactions are at times, also limited to the leader. He or she mostly function as boundary spanners. However, this is not all the time, the same. This condition will be elaborated more on the boundary spanners part of this chapter. These boundary organizations are the NGO, university, and CBO. However, the role of NGO is diminishing and cannot be traced so obviously. The purpose of a university is rather apparent, mainly in the river restoration movement concerning river communities CBO, and also the establishment of Pammaskarta DIY (as the founder was an academician). The role universities or academicians are catalysts to form the CBO. Thus, the continuity of the CBO depends strongly on the community's active role.

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The members are CBOs operating in the Forum PRB at the regional level-C2. They brought along the communities' values in collective action (*gotong-royong*), tolerance (*tepa selira*) and considers the *Hamemayu* philosophy, also practiced many CEK in as water resources and lahar risks/resources management. The examples of these CBO in municipal level are the Tagana (C3) in Kebonagung and Gowongan, and also the SKSB in Argomulyo. These organizations can sound the CEK to other inter-sectors organizations in the same level of the hierarchy, inter-hierarchies organizations, and inter-sector in inter-hierarchies organizations. Their flexibilities owe to their trusted identities and legitimization by a network of organizations. The emergency condition supports the pre-condition in which they operate. During this condition, the CEK is always the anchor for the communities in the region. For example, the community is stronger when they cooperate using the same cultural values as *gotong-royong* (collective action) and *tepa selira* (empathy).

8.2.2 Boundary spanners in VRBM

Another way the CEK has the chance to influence VRBM is through the boundary spanners (BS). The boundary spanners in VRBM are positioned in all VRBM phases because their role is to connect different boundaries in any situations. Based on the theoretical framework, the boundary spanners characteristics are built upon network performance and trust-building. They are translated into (1) builder of trusts: individuals holding essential positions, (2) improver in cognitive ability: individual with understanding and the linker of CEK to VRBM, (3) operating in non-hierarchical power and (4) legitimately appointed/given legitimization.

It is easier to find the BS within the interaction attempts of the VRBM, as nature is quite flexible. They can quickly adapt to any condition and once acquired the BS status; it stays until the trust is broken or the person died. They are also very subtle, even almost subversive in their actions. Identifying them in this research requires sensitivity towards the interviews data and also the context of the condition. At first glance, potentially everyone can be a BS because this definition used in the research is more related to the activities done by actors, rather than the label of a person. The people who are referred to concurrently from different respondents are signals of the character of BS because they connect domains and levels. There are two types of boundary spanners (BS) found in this research are based on who and where. (1) Based on the role (who): the contact person, the broker, and the whisperer, as explained in chapter 7. (2) Based on their affiliations (where): free and attached.

These spanners are part of the whisperers. When they belong to an organization, they are called attached, or function as a catalyst but do not belong in any of the interrelated organizations, they are free (figure 8.4). The 'attached' BS is a member of the boundary organizations, as long as they fulfill the characteristics of the boundary spanner. Meanwhile, the instances of the 'free' BS are interesting as they do not root in any of the interacting organizations. However, they can influence the organizations in formulating their policy and management activities. The 'free' BS is not visualized in the diagram of interaction attempts, as its location is always changing. In answering why CEK has an impact or not in the VRBM relates to these types of BS. The impact is based on BS's role or affiliation in the VRBM phase. It plays a role in the decision-making process.

Normal and Normal+ VRBM Boundary Spanner

The boundary spanner exists in these phases are the whisperer in water attempts (B) and the broker in budget attempts (A). However, as explained in chapter 7, the broker is not rooted in its location (due to annual personnel change). This quality does not support the integration level, as its temporal dimension of one year is too short. Meanwhile, the whisperer has the quality to be present at all phases and goes deeper into the networks of water interaction attempts (B).

The whisperer found in these phases are both attached and free types and rooted in the regional and municipal level (B2 and B3). In becoming a whisperer, he or she has to possess an understanding of CEK. The information is passed on by the whisperer from the communities' side to the government side, or the other way around through indirect way, which is the polite ways of being Javanese (using CEK values). This way, the CEK has more possibilities to be delivered. The private enterprises do not yet have any trace in making a significant impact on the whole interaction attempts in any form of the VRBM. Examples of BS in this study are Pak Darmanto (Pammaskarta DIY) for water utilization and the Prince Wiro for water conservation. The first is the 'attached' type, because it used the CBO as its affiliation, while the second is the 'free' type. In this sense, those who are identified as attached are getting their trust through formal ways, for example, appointed as a leader or trusted by communities and as a part of an organization. The example of the first type is the leader of CBOs, and the second is a Prince of the Sultanate.

The first type example from the Pammaskarta DIY acts as a whisperer and facilitator in one, as he used his credibility and networking to support the water supply programs to the communities.

> After the death of Mr. Darmanto, our position is *kalah awu* (less experienced/knowledgeable), to drive our fellows. With him it was easy to talk to Mr. Agus Suprapto (Head of BBWS SO), in bridging and not taking advantage, not using it to get a job. (Ari, Pammaskarta DIY)

The respondent explained that Mr. Darmanto was an academician in the university. Even BBWS SO's Head was at the time came from the same alumni and a student of this person. His ways of communicating the needs of the community bridge the CEK to VRBM. For example, when the community does not give ways to developing underground well proposed by the RBO, the Pammaskarta address this with discussion and mediate the fear of the community. They accessed the water source by performing sacred permission rituals and presented offerings. Nevertheless, with the instance of

Pammaskarta, when their leader died, the organization's ability to connect with other organizations became limited. This situation is proof that the position is vulnerable to change.

The same goes for the river communities, as the drivers are the leaders when the next leader is not as capable as the previous one, then it became stagnant. In the meantime, the leaders of each river communities are not all academicians but also mixed with pure activists, who have no other job than the management of the CBO. The chance of success as a leader is higher when one accessed the interaction attempts.

Sources of income for the CBO usually come not only from internal members but also from donors. These donors are other organizations, universities, and private companies. Based on the characters and roles of some individuals, some of them are boundary spanners. These people earned their position through their legitimate role in water management, as well as the respect they received from both community and governmental agencies.

The second type is the free spanner, whom which does not belong to an organization, but moves freely between organizations, untied. Although they also have affiliations, these do not matter in the context of interaction attempts. An example is the Prince of the Kraton, who became the presenter during the water catchment regional regulation (PerdaDAS DIY) formulation meetings. He does not affiliate himself with any organization, yet, his influence to include the CEK (philosophy, values, practices) in the clauses of this regulation worked-out. Another is an expert in water resources management. She no longer held the position of a governmental organization officer, but her suggestions in using CEK into the management of water and lahar sediment are still considered.

Based on these facts, to become free boundary spanners, one needs to have the capacities, trust, and knowledge, and enters the interaction attempts as a 'catalyst.' When the results of the catalyzing activities showing positive results, then the 'free' BS earned their title. The whisperer in the water attempts (B2 and B3) connects sides or stakeholders, without motives behind their agenda. The reason for their role can be as simple as:

> Anyway, I like to work with that related to nature conservation, but real. (Prince Wiro, humanist, 2016)

The aim of genuine interest is the best precondition for an honest whisperer, also the fact that the person does not take sides. In the example of Prince Wiro, his attachment with the Kraton does not make him attached as the government representative, nor that he is against communities. He took part in the formulation of the regulation, as he was invited to give his cultural opinion on the matter of catchment management.

At the municipal level, most detected spanners between CEK to VRBM are of the attached type, where they belong to CBOs. Association of communities is essential for this level, as most of them are activist, elders, and spiritual-religious leader/figure or appointed by the Kraton. In this level, one can easily detect the spanners, as they are very active in community engagement activities. They are known in the spanners network, identified as a contact person or a 'go-to point' as the entrance to a community.

The research found that the whisperer as the honest spanner has better chances to deliver CEK, primarily as they also operate using the CEK values. The example is 'Pammaskarta's founder in mediating the community and government. He did it without the personal motive, instead of to address the community's need. It is one of the characters of a whisperer. The 'free' BS is a whisperer without affiliations. They move around between stakeholders, be it community or government. They have a similar attitude in taking the responsibility and the relatively zero motives in financial or political gains.

Disaster VRBM Boundary Spanners

The Disaster VRBM uses the Disaster interaction attempts (C) and thus, the contact person as the agents. However, the whisperer in Water interaction attempts (B) also shifted into the contact person during a disaster (C2 and C3). Based on this explanation, the 'whisperer' is located 'flexible' in the interaction attempts. These boundary spanners are the 'attached' type, as they are embedded in organizations. They have a contact person role, just as surface contacts of organizations or communities. However, the whisperers shifting role as contact persons, they are more likely to induce decisions because they embedded there.

At the national level, the existences are the 'attached' BS with the references made for Mr. Surono (Mbah Rono) by many respondents, both in the community and government sides. This person is a leading volcanologist in Indonesia, and his comments were taken into considerations from all around. The responses made on his comments are the combination of CEK and scientific knowledge on the lahar flow directions, the degassing indicators, and the volcano activities. His comments on other volcanoes in Indonesia are also being listened. The second is an ex-leader of the National Disaster Management Agency leader, whose statements were used in this research (Maarif, 2012). Mr. Maarif addressed in his books about the importance of CEK in disaster mitigation and made suggestions on how to gather this information by collaborating with universities and LIPI (Indonesian Institute of Sciences).

Within the regional level, several boundary spanners were kept on reappeared as contact persons in organizations in the Disaster attempts, which are related for both water and lahar. They are the Head of Merapi Section from BPPTKG, the PPK PLG Merapi's person in charge, and the Head of PU-P ESDM. These are the people to whom the communities asked for help. On the other side, the government agencies pronounced the Forum PRB DIY leader and Pammaskarta DIY, as contact persons to communities. Within the municipal level, the boundary spanners in the Disaster attempts also belong to the Normal and Normal+. These persons are attached to the community as active members of Tagana, but also river communities.

8.2.3 Conducive Atmosphere for CEK in Impacting the Management of a VRB

This atmosphere is provided by the boundary spanning activities proposed by the BO and BS provides a condition, which the CEK can maneuver within the VRBM. The atmosphere presence can be found within informal ways of interaction attempts. The condition for the CEK to be present is that some parties have to acknowledge and practice the CEK. This condition will make the actors feel more comfortable to use the CEK in the management realm. All of these can be found mainly in an informal setting, as the formal settings are still tinted with strong technical approaches. As the BO and BS clustered the Normal and Normal+ as one, this section also follows this order. Examples of such atmosphere are present in the interactions within the VRBM phases at the regional level in Normal and Normal+ by interactions of Pammaskarta DIY and AKSY, and in Disaster VRBM by the interactions of Forum PRB DIY, while at the municipal level in Normal and Normal+ by the SpamDes and the Tributaries Communities, while in Disaster VRBM by the Tagana. The National level does have an embryo of such an atmosphere within the River Jamboree. However, not much can be explained as the event has only been celebrated twice since 2015 and was not part of this research observation period. Therefore, this section focuses only on the Regional and Municipal informal attempts.

This section summarizes the components of the conducive atmosphere components as follow. (1) Both the BO and BS have to be present to induce the precondition, setting the 'stage' for CEK to be present and used. (2) This condition eliminates the fear of talking out of levels or boundaries, connect with the correct people in the government organization, and develop the trust on CEK to be used in current management practices.

Normal and Normal+ VRBM

Within the regional level, the 'conducive atmosphere' is created by the BO and BS interactions to the RBO (BBWS SO) and other related government agencies (PU-P ESDM, Satker CK SPAM, BPDAS SOP). They (BO and BS) aim to access the partnership with the government using the 5th Indonesian IWRM pillar on community and private empowerment. Examples of successful conducive atmospheres are presented in many water-related cultural celebrations, which took place in any water event. The following picture was taken from the 2018 World Water Day in April, which was celebrated with cultural themes and rituals, as a collaboration between the BBWS SO (RBO) and AKSY.

Figure 8.5 2018 World Water Day Celebration at Winongo River (BBWS SO, 2018)

The celebration was transformed into thanksgiving event to the Winongo River, where the Head of the RBO seen in figure 8.5 with light blue hat in the middle. They were performing a ritual of giving the river symbols of longevity for its natural flow and as a promise to conserve the river. The thanksgiving is performed by a wise person (shaman or elder), which was also accompanied by sacral Gamelan music and dances. These types of activities nurture the trust of the community to collaborating more with the RBO and not afraid to express their CEK. With the ritual symbolizing the acknowledgment of CEK, this atmosphere gave the room for other forms of CEK to be used.

Within the municipal level, the smaller scale of such an event also present. However, the example collected under the scope of this research was referred to as the Tambak Kali (upstream), Merti Kali (midstream), and Hajatan (downstream). The Sleman Regency annually celebrates the Merti Kali for Code River, which signifies the municipal's acknowledgment for CEK. These examples presented the cultural performance, as quoted below:

> These (rituals) are their ways to express; they are not told on how to hold a cultural procession. The point is to celebrate the Code River to clean up the river, encouraging community growth. The government also helps facilitate meetings. (Agus Maryono, River Restoration Movement, 2016)

However, it reflects the acknowledgment of the community has to the River. It is hoped, although at the moment, this is only an annual event; it raised the community's awareness to conserve the river in real day-to-day activities. The following respondent explains this hope:

> The rituals and the concepts are used, but the meanings are not conveyed to the community. This original meaning is not conveyed. This is wrong. (Bima, Humanist, 2016).

Disaster VRBM

Post-2010, the conducive atmosphere has increased, as the CEK was proven as an essential asset in the Disaster phase. Therefore, both Regional and Municipal Disaster Management Agencies (BPBD) is collaborating with the Disaster Forum (PRB) for each level. It includes not only technical approaches but also the CEK, which relate to the water and lahar. This atmosphere occurred during the eruption, where the forums and disaster response teams from every corner of the region, conduct direct communication, without the hesitation of different of level or statuses by the actors. All of the actors have a direct line to communicate with the decision-makers through a flexible way. These forums relied on the CEK is heavily in assessing a hazard condition. The following quote explains how CEK is used to tackle the different threats a village is facing:

> A village depends on the type of hazard. Then, we (BPBD) encourage the forums to unite with the village's core (government). (Respondent BPBD DIY, 2018)

As during Disaster VRBM, an emergency condition arisen, this condition made the actors more freely to induce informal interaction attempts. In this condition, the priority is to save as many lives as possible. Next is to provide the urge for the actors to cooperate more with the government actors. Also, listen to the BO and BS's on using CEK, while combining with scientific knowledge. This condition created the chance for the CEK to be fluidly interwoven into the interaction attempts.

8.3 Conclusions

This chapter explained two important concepts about impacts of CEK: how the CEK impacts and non-impacts on the management of a volcanic river basin and why the CEK impacts VRBM through the boundary level. The first part consists of when and where these impacts located, and types of CEK with more impacts. The impacts are most often found in the managerial contexts and interaction attempts, rather than in the policy settings. The general patterns of interrelations of the CEK to the VRBM are visualized in figure 8.6 as follows:

VRBM Phases

Legitimized historical experiences:
1. Values and philosophies
2. Resources management practices
3. Artifacts
4. Internalization
5. Five senses wisdom

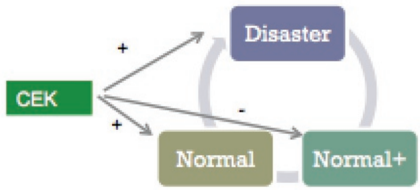

Figure 8.6 CEK existences and utilization in VRBM phases of a VRB

The how part of the sub-RQ is answered by the impact patterns of CEK forms (soft and hard) in each VRBM phases. The figure above is explained as follows. In Normal VRBM phases, most CEK impacts are positive (+). It is used to improve the current integration level, while neutral influence came second when the CEK do not relate to current practices. Meanwhile, in the Disaster VRBM phase, the CEK impacts are mostly positive (+), as it is used to remind people to stay alert and work together during onset hazard. The only small existence of negative existences was found when the CEK is neglected. The CEK's types used for this phase are values, artifacts, resources management practices, and philosophy. Quite the reverse, in Normal+ VRBM phase, although the CEK exist, it does not impact (-) the policy and the management, especially relating to sand mining activities. The CEK existences are artifacts and resources management practices. The findings show whether or not the CEK has an impact depends on the existence of CEK agents. The chances depend on existing interaction attempts and what activities they deliver in the management practices. Thus, the why part is answered by boundary-spanning activities.

On the second part, on the 'why' section, the process CEK impacting the VRBM through the boundary level is explained by the role of boundary organizations and boundary spanners. This part mostly relates to soft CEK. In this chapter, the cultural boundary organizations are informal organizations that originated at the community level. Meanwhile, the boundary spanners create the conditions, where governmental organizations accept the CEK and making sure that the CEK is utilized. However, the boundary spanners have more success in Normal and Disaster VRBM, than with Normal+. With the current condition of non-utilized CEK, the Normal VRBM fails to be achieved, as the Normal+ still dominates. Therefore, it is expected that directly after Normal+, the Disaster phase would take place. It would probably be more devastating, as the Normal VRBM is not taking place. The boundary organization and spanners should do more to promote the usage of CEK in the Normal+ VRBM successfully.

CHAPTER 9

CONCLUSION

9. Conclusion

9.0 Introduction

This final chapter reflects on the aim of this research to improve the current water resources management practices for future generations who live in the volcanic river basin (VRB) at the foot of Mt. Merapi in Indonesia. It does this by considering the cultural ecological knowledge (CEK) that has been used for generations on how to manage water while safely living side-by-side with an active volcano. The current work discovers that CEK is still used as an alternative to the scientific approach and widely used in human–nature interrelations. CEK is more accessible than scientific knowledge to people, as it does not require any complicated equipment to manage water and its related resources. At the same time, it stays true to society's ethical values and respects nature.

In this research, the use of CEK to manage water in a VRB is analyzed. The results of the research show that CEK plays a role in enhancing the integration of different dimensions of water management. The findings can be used to propose a culture-sensitive approach to the current water management practices for a river basin under volcanic conditions.

This chapter is arranged as follows. First, through presenting reflections on the empirical Chapters 4 to 7, the sub-research questions are answered. Then, toward the end, the main research question is answered. Secondly, the theoretical contributions, limitations, and further research needs are explained. Finally, some recommendations are made for policy implementation and the way forward for CEK utilization in the water sector. This work is limited to the context of one VRB case study, and the data used are based on the timeline from the 2010 eruption to early 2018. This limitation shapes the findings of the research and further research may be needed to elaborate a theory applicable on a wider scale.

9.1 Answering the Sub Research Questions

9.1.1 First Sub-Question: What are the main elements of cultural ecological knowledge in a volcanic river basin and how is it being formulated?

This first sub-question is addressed in Chapter 4, titled "Cultural ecological knowledge in a volcanic river basin." The theoretical foundation of CEK is defined as the body of knowledge passed down through the generations explaining human–nature relationships. The definition is used to sensitize the empirical findings to cluster the types of CEK and, later on, to elucidate the CEK formation process. It also uses historical literature from other researchers' empirical findings to support respondents' explanations. The focus of the CEK study is on volcanic river basin water management (VRBM), which encompasses lahar and volcano eruption in addition to general water management issues. The definition of a VRB is given in Chapter 2 as a catchment, with an active volcano as its origin, which fits the context of this case study.

CEK Formulation Process

In Chapter 2, a linear process of formulation defines CEK, starting from historical experiences, the four types of CEK (values and philosophies, resources management practice, artifacts, internalization), and finally a refined five senses wisdom. The definition and indicators of CEK are based on, and borrowing from, earlier studies on traditional ecological knowledge (TEK), indigenous technical knowledge, indigenous knowledge, and local knowledge (Berkes, Colding, et al., 2000, Howes and Chambers, 1980, Geertz, 2000). These concepts and variables are used as indicators in this research and have been helpful in sensitizing the author to rediscover the CEK elements related to water in this VBE. Building on TEK, later forms of CEK are based on historical experience and, through social mechanisms, are transmitted to successive generations (Berkes, Colding, et al., 2000). This social mechanism is perhaps similar to the legitimization process found in this study as the middle point between historical experience and the different forms of CEK.

However, the conceptual framework proposed in Chapter 2 was readjusted in Chapter 4 in light of the findings. The indicators derived from the abovementioned concepts were used to compose Chapter 4, where the focus of the CEK empirical findings is specifically on the sub-cases and the case as a whole. In Chapter 4, it was argued that historical experiences are the foundations of CEK, but the formulation process is not linear as suggested in the literature review. Rather, it may be seen as a back-and-forth process through legitimization by a group member or particular societal group. The historical experiences involved here are water-related in the natural dynamics of the study location, which in this case includes changing seasons, flooding, drought, volcano eruptions, and lahar. These experiences are recorded in the inhabitants' memory, especially when they coincide with a life event such as someone's birth, wedding, or death. Many of these experiences are amassed in inhabitants' minds as memories without filters but are not always acknowledged as CEK, yet. Written memories are recorded in the *serrat* (short letter, also used in songs) or *babad* (books) (Harsono, 2005, Satyopranowo, 2000, Olthof, 2008, Ras, Pantja Sunjata, et al., 1992).

The knowledge in this case study relates to humans in three layers of worlds (Endraswara, 2013): human–God, human–environment, and human–after life (*bawono: cilik, gede, langgeng*). The focus of this study is on CEK relating to *bawono gede*, or human–environment, but also deals with the other two as supporting layers of consciousness. The *bawono gede* does not distinguish between the natural resources water, land, and air, but instead sees all three as a holistic system of nature, surviving extreme experiences and passed down in the five possible forms of CEK, as explained at the end of this section.

However, before the knowledge is transferred or passed down to the next generation, a process of legitimization takes place. This process includes, but is not limited to, the process of filtering and granting permission for CEK to be used for later generations, usually through acknowledgment by members of society: a 'wise person' or a 'group of certain people.' A back-and-forth process happens here, because, for CEK to be legitimatized, the filtering process from time to time is also realized through these members of society. For example, out of the many remembered flooding events, some are selected by them as more important. These are generally the most extreme events or events that occur when an important person is present, such as Sultan IX's visit to Cangkringan close to sub-case 1 upstream in the 1960s during a lahar flood. Some flood events, which have not been filtered as necessary and therefore not transferred to the next generation yet still held in memory, can be deemed significant through the legitimization process when similar events later happen. The historical experiences of flood locations in the 1960s and present-day experience of the 2010 lahar flood-affected areas complement each other's knowledge of floodplain locations. In a linear process, legitimization stops at the past historical experience, but the back-and-forth process enables newly acquired knowledge to be added to, or subtracted from, the earlier body of knowledge. Thus, the legitimization process must again take place to acknowledge the significance of the later occurrence and decide whether or not it should be added to CEK.

This 'wise person' is usually an elder or an adult in the community who is considered and honored for his/her knowledge or status as a religious or cultural leader: either the *Kraton* or Kingdom and the Sultan or the community itself. In this case study, the 'group of certain people' can be the government, a community organization, a religious group, and the *Kraton.* Throughout this legitimization process, either the person or the group filter decides what is deemed to be important. Legitimatized knowledge is conserved in CEK. Only the knowledge that passes through this process is considered to be significant. This legitimization process did not emerge in the literature review, yet it is a highly important reason for CEK survival in general, whereas other memories have diminished over the generations.

Forms of CEK as Mechanisms of Transfer

As summarized in Chapter 4, the CEK's five forms in this river basin originate first in the core layer as values and philosophies. These are later symbolized in the second layer of the other four forms: resources management practice, artifacts, internalization (myth and rituals), and the five senses wisdom. These aspects are summarized as follows:

1. Philosophies of how humans relate to God, the environment, and others. The first philosophy is the *hamemayu hayuning bawono*, broadly translated as 'beautifying the world's beauty,' 'living in harmony with nature and disaster.' Second is the *manunggal ing kawula Gusti*, which is used in proclaiming the unity of subjects and their King or between human and God, as espoused in the Sultanate government of the Special Region of Yogyakarta and further symbolized by the philosophical axis. The values of *gotong-royong* (reciprocal collective action) and *tepa selira* (empathy) are proven to be still alive in daily life, especially during disasters. They live in the heart of every Yogyakarta resident and have become important social capital in society. Neither of these forms can be seen directly in any behavior, but rather in the 'soul' of an activity. To feel their existence, one has to become sensitive to the Javanese way of 'feeling.' It is rather difficult to explain to someone who is not Javanese where to find the evidence, but these forms can be felt in the four other forms of CEK as explained in the following.

2. Artifacts mostly symbolize philosophy and values, but can also be used in the myth of related objects. Mt. Merapi and Parang Kusumo Beach are geological heritage sites, but they are also filled with myth and rituals. CEK understands the river basin concept within the Kingdom's administrative boundary and sees the river basin of Progo, Opak, and Serang as a philosophical plane, with the Merapi

Opak sub-basin located in the philosophical axis between Mt. Merapi and the South Java Sea. This situation shows that CEK understands the concept of catchment and sees the Opak VRB as a cultural landscape. The philosophical axis can also be used for disaster risk reduction (DRR) and to highlight rivers as sacred geography, including their origin and estuary. Furthermore, the Mataram Channel, which has always functioned as an irrigation channel, is a heritage from Sultan IX, and thanks to this channel the Opak basin can be cultivated more frequently than other river basins. This channel performed as the artifact for inter-basin water transfer in the old days.

3. Internalization relates to philosophy, resources management practices, and artifacts: rituals of thanksgiving, giving offerings, the myth of Ratu Kidul, Mbah Merapi, which are located in the philosophical axis, are forms of symbolization. It relates to the *hamemayu* philosophy about giving harmony to the environment, whereby one performs rituals to the mythical creatures (force of nature) of the South Java Sea (Ratu Kidul) and Mt. Merapi (Mbah Merapi). The rituals symbolize humans' promise to nature to maintain harmony, but those performing the rituals are probably not the same as those extracting the natural resources (in this case water, land or catchment, and lahar sedimentation aggregates).

4. Resources management practices relate to internalization and artifacts, for example, the use of premonition or *wangsit.* This premonition uses observation as a tool and the legitimization process described above. The location for the region's capital was selected using the *geger bulus* (flood-free zone) (Olthof, 2008, Ras, Pantja Sunjata, et al., 1992). Premonition is also used in explaining the 700-year cycle of Mt. Merapi eruption in terms of its relation to change in the major political conditions in Indonesia (Troll, Deegan, et al., 2015). Other examples of resources management practice include the *Pranata Mangsa* or seasonal calendar (Retnowati, Anantasari, et al., 2014); the use of lahar sedimentation in the river as aggregate (sand and stone) building materials; the temporary farmland use of lahar sediment in the river; the use of river water as a drinking water source after eruption when all wells are contaminated and too hot to be used; and the use of thermal spring water right after an eruption to treat skin diseases.

5. The five senses wisdom relates to resources management practices, but sensitized using humans' five senses. The examples found use all the senses and differ based on the aim of the wisdom. This wisdom is more abundant upstream as it relates to hazards, especially volcano hazards; for example, the sound difference between lahar and flood, *biotilik* visuals of fish for water quality, visuals of rain upstream in relation of flood timing at specific locations. Regarding water, the five senses wisdom uses the taste of water in relation to volcanic activity, visuals of spring water location after an eruption, and changes in discharges from rivers and springs. The relation of lahar and river in particular is visualized in overmining in the river channel. The five senses wisdom is also used as a *Pranata Mangsa* indicator. For example, visuals of

> worms to assess soil fertility, the touch of soil to determine the temperature for farming, the feel of the temperature to know the season, the sound of birds indicating the start of the rainy season, the sound of cats in the mating season indicating the start of the dry season.

With the rediscovery of CEK, it is a relief to find that some elements of it still exist and are part of current society. Their existence emerges in the interviews, not only with community respondents, but also with governmental organizations, universities, philanthropists, and experts. Thus, this revelation confirms that CEK is overall still used, but the spectrum is too broad to be completely covered in Chapter 4. Only CEK elements closely linked to water in the VRB are collected, given the limited number of people and sub-case studies at regional, municipal, and village level. These findings are used to frame the report at a later stage of this research, but there might be a whole lot more out there in practice.

Legitimization and Symbolization as Part of CEK Formulation

CEK will develop continuously, as long as humans are still living in nature. The content can also change or become aligned to current developments. An example of this is the Bride Stones and Prince Jayaningrat Tomb artifacts in subcase 1 located by the Gendol riverside, which delineates the lahar-free zone. In the 2010 eruption, both artifacts still held true for the lahar-free zone, but there was something new, the pyroclastic flow. The river basin authority (RBO) had not anticipated that the pyroclastic flow would reach as far as this location. Thus, the four nearest Sabo dams were hit by the pyroclastic flow, which distributed lava and ball of fires that scorched and devastated a village. New CEK was needed for the river setback in light of the pyroclastic flow. This experience led the elders to formulate a new CEK and legitimatize the knowledge. As the river now has Sabo dams to control lahar flow, the river setback also had to be changed, as the morphology of the river changed and new setback regulations were needed.

During the writing of Chapter 4, a pattern emerged showing how CEK was formed through the legitimatization and symbolization process, which resulted in some forms being conserved. Not only was CEK categorized into different forms (artifacts, philosophies, worldview, resources management practices, and five senses wisdom), but also these forms were symbolized and interrelated, as explained in the narrative above. These significant findings were used as foundations to build Chapter 7, which investigates whether the existence of CEK is important in the governance setting.

9.1.2 Second Sub-Question: How is the IWRM approach implemented in a volcanic river basin?

This sub-question is answered in Chapter 5, "Managing Water Resources in a Volcanic River Basin." Integrated water resources management (IWRM) is perceived as a learning process for managing and governing water (Pahl-Wostl, 2006, Lubell, 2013). The theoretical framework used in this research is a modified version of IWRM's four dimensions (water resources, spatial, temporal, and water users) (Savenije and Zaag, 2008) in which the dimensions now are natural, spatial, temporal, and human. Each is explained by other scholars' works: (1) natural as interrelation of water resources and their natural processes (Graefe, 2011, Gleick, 2003, Marso, 2013, Lavigne, Thouret, et al., 2000, Jaspers, 2003), (2) spatial as linking different scales, functions, and interconnections of hydro-geomorphological conditions (Molle, 2009, Graefe, 2011, Hofwegen and Jaspers, 1999, Jaspers, 2003), (3) temporal as holistic interrelation of time-related functions of water resources (Jaspers, 2014, Ndirangu, Kabubi, et al., 2009), and (4) human as interrelatedness of all water users with their economic interests and organizational relationships (Jaspers, 2003, Medema, McIntosh, et al., 2008, Edelenbos, Bressers, et al., 2013). A VRB is a water catchment in line with the geomorphological and hydrological definition (Graefe, 2011, Molle, 2009), with direct origin at a volcano and the sea as its terminal. These terms were used in the analysis performed in Chapter 5 to answer the second sub-question.

Each of the dimensions uses indicators based on previous work to offer more general terms for the resources; they are adopted in Chapter 6 to understand lahar management. The framework is used to discern the actors and their actions in each respective dimension. Lahar as the hybrid between water and volcano is used to describe interrelations. The multilevel governance (MLG) concept inspires and accommodates the interrelations described in the water–lahar–volcano relationship. It also assists in determining the structure of IWRM implementation in the case study used for this research, which is explained in Chapter 5 in two aspects or layers: policy settings and managerial contexts. Within these layers however, there are levels and types, exemplifying the existence of MLG complexities within the case study. These complexities are unpicked using the characterization of the multiplicity of water governance's boundaries (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Termeer, Dewulf, et al., 2010, Edelenbos, Bressers, et al., 2013). These boundaries are found within the governance, between-sector, inter-sector, and inter-governance levels, between formal and informal, between government and community and private, and in relation to boundary spanning activities. The same structure is used in Chapter 6 to address lahar management.

IWRM Policy Settings

The water resources management law in Indonesia was revoked in 2013, giving a weak foundation to current management practices. The current 'make-do' conditions are based on an old centralized irrigation law from 1974, which no longer suffices for the development of the water resources management field, because the definitions used in the 1970s were different from those used today (2018). Many types of works are not included, the government is no longer centralized, and changes have occurred in the interrelations of management actors, including the private sector and communities, not just the government. To deal with this situation, the Ministry of Public Works and Housing 'plugs the gaps' by issuing ministerial regulations.

IWRM Management Context as Multilevel Governance

IWRM implementation is themed into pillars of water conservation, utilization, and hazard control. Although unconsciously, it is built on MLG as argued in publications on water governance (Moss and Newig, 2010, Edelenbos, Bressers, et al., 2013, Termeer, Dewulf, et al., 2010, Gupta and Pahl-Wostl, 2013). Their theories are used to investigate

IWRM implementation at national (trans-boundary river basin territory–river basin territory), regional (river basin territory–catchment), and municipal (catchment–sub-catchment or lower) level. This order of levels as the water resources management unit in the administrative boundary is explained by the fact that, although the river basin territory is managed by the national government, management happens at regional level (through governmental branch offices). This has led to the creation of RBOs and catchment management authorities (CMAs).

Each level has a different function: the national level functions as policy setter and provider of guidelines, the regional as implementer, and the municipal as a smaller-scale partner implementer. More interestingly, the abovementioned branches of ministries located at regional level make this level the priority 'playing field' for water resources, where the national–regional–municipal levels interact. This MLG with its multisector stakeholders was not explained well using the initial conceptual framework, which had to be reoriented to address the findings. Through all of these levels, the river basin territory falls somewhere between the national and the regional level, and authority is located at regional level.

IWRM Interaction Attempts

The study then scrutinizes the level of integration in IWRM implementation by first locating the interaction attempts and second ascertaining the existence, and determining the level, of integration. The study then explores the patterns of interrelations between the stakeholders as interaction attempts. As IWRM implementation addresses hazard control along with conservation and utilization, it is inevitable that the interactions also include disaster interaction attempts. These interactions are categorized along the following themes: budget, water, and disaster. The last two are differentiated into formal and informal, depending on the initiative: formal by the government, informal by the community, and positioned in each layer of governance.

Of these interaction attempts, the most effective ones are the informal ones, for both water and disaster, because the informal attempts tend to solve real problems, with real solutions, translated into programs or actions. The formal water attempts address real problems without real solutions, by giving general recommendations to the government leader at regional and national level. This inability to solve problems arises because a mechanism for the formal attempts to channel the results of their meetings into real actions is not yet available, due to the inflexibility of budgeting schemes. These formal attempts are lengthy meetings with low participation by invitees, the members listen to presentations and discuss problems without follow-up, and the meetings function as 'ceremonials' to follow budget absorption in the given fiscal year. Although these formal attempts are crucial in providing the opportunity for actors and stakeholders to meet regularly, innovation is needed for these attempts to become more robust and to provide valuable feedback in the form of direct action.

At municipal level, the irrigation commission, as a formal attempt, works in a more integrated way as it addresses mainly water allocation, whose problems are easily solved with an agreement on how much water, where, and when. This is not so much integrated at regional level however, and it disappears at national level. As the irrigation commission members are regional water council members, overlaps happen here as the water council has broader duties than just irrigation. These attempts become disintegrated when they reach a higher hierarchy, because the real activities in irrigation water allocation become less relevant at regional level and are non-existent at national level. The higher the hierarchy, the more it has to do with giving guidance, not with real activities.

The informal attempts can assist the much-needed integration. Lessons can be learnt from the informal attempts, for example about creating shorter meetings dedicated to active discussion, guaranteeing that decision makers will attend meetings (also offered by online chat options), and issuing a statement of intent that problems will be addressed within a timeline by specific stakeholders in the formal attempts, with follow-up of actions when a promise is made to resolve an issue. In comparison to the rigidity of the formal attempts, the solution is formulated in relaxed settings for discussions and based on cultural values (*gotong-royong* – spirit of collective action, *tepa selira* – empathy, and so on); this approach partly explains why there is more integration in informal attempts. Sometimes, the informal attempts are filled with rituals of offerings based on myth and philosophies, and meetings are held at sacred locations in the river basin, such as a spring, the rivers, and so on. CEK thus eases water governance at regional and municipal level in a way the community understands and in which it may participate.

IWRM Integration Levels

Regarding interaction attempts, further investigation is undertaken to ascertain whether or not the IWRM implementation in this case study is already integrated in line with the categories defined in Chapter 3 as level (1) coordination, level (2) collaboration, and level (3) cooperation. As a preliminary conclusion, the IWRM implementation is not yet well integrated, primarily because of the low levels of integration at each governance level. A possible solution to address this is for the informal interaction attempts to be embedded in the current institutional framework, while still keeping the attempts informal and letting the community initiate them.

At national level, 'sectorial ego' exists between actors. For example, each ministry will only follow regulations made by itself, distrust exists between ministries, and so on, resulting merely in coordination between ministries for budget and water attempts (lower than 1). Interestingly, the disaster interaction attempt has a better level of integration during hazard occurrences. This condition is also related to the culture of Indonesians in general, who come together in emergencies and when faced with common threats, one of which is hazard occurrences. Thus, the nature of this integration is still reactive, not proactive.

The existence of formal attempts in budget interactions at all governance levels helps the actors in disaster interactions to participate in an introduction phase, but this is not used in such a way as to promote collaboration, due to the existing 'sectorial ego' explained above. It can be argued that, if the integration level is already high in budget and water interaction attempts, then utilization and conservation are more integrated.

Also, the actors already know who is doing what during hazard control and this helps to save time during disaster interaction attempts; and actors even become proactive.

The ministries' branch offices are hubs of information exchange between the national and the regional level. They act as national government extension at regional level, but their budget comes from the national level. The interaction attempts between the ministries and their branch offices, whether in water, budget, or disaster, are formed as parallel closed circuits. This condition means that each ministry's line of communication is strictly exclusive to itself; it does not cross ministries, unless with the consent of the minister. The national partnership movement on water salvage (GN-KPA) has been formed as a way to address this, but real evidence of what this constitutes in terms of actions is not very often to be found. As mentioned by some respondents, GN-KPA is used to facilitate work-related 'tours,' for example ceremoniously planting trees in a degraded catchment, without further follow-up on the condition of the trees in later years, rather than finding real solutions. Examples of real solutions expected from this movement include: establishing a partnership to manage dams or rivers, or innovative collaboration between ministry A with the branch office of ministry B to rescue degraded rivers or enhance water quality.

At regional level, the interaction attempts on the formal side are somewhat integrated, with overlapping of management aspects between water-related stakeholders. However, attempts at different levels of integration – coordination and collaboration – do take place, even cooperation. Generally, at regional level, disaster interaction attempts have the highest integration level as the boxing-in of sectors disappears during hazard control, with cooperation from all sectors in mostly informal attempts. Water interaction attempts come second, ranging from coordination to collaboration, and budget comes last with coordination attempts. The highest level of integration occurs when informal attempts are combined with formal attempts. The differences for each themed attempt are discussed hereunder.

First, the budget attempts are formal attempts of the *Rakonbangprov* and the *Musrenbangprov*. Those addressing conservation have a lower integration level as not much is done on this respect, but those addressing utilization achieve at least the lowest level of integration by means of coordination between different stakeholders (regional government agencies, ministerial offices, and so forth) on locations and budgets for water development projects annually. Second, the disaster interaction attempts addressing the hazard control pillar combine formal and informal attempts, and also have the most substantial influence of informal attempt activities with CEK values of volunteerism, empathy (*tepa selira)*, and collectivism *(gotong-royong)* crossing governance levels and sectors, resulting in the highest integration level. Third, water interactions addressing both the utilization and conservation pillars have both formal and informal attempts. The water interaction attempts, namely, water councils (TKPSDA, DSDAP, Forum DAS) and the irrigation commission, do not correlate to a higher integration level, as not all of these attempts are participative or active. The formal attempts are ceremonial in nature. Informal attempts, however, may soften the 'boxing-in of sectors.' In these informal attempts, the CEK values as explained in disaster interaction attempts are also used to call for action from both sides, but with additional

CEK, for example, water-related rituals, myth, seasonal calendar, and resources management practices for rivers and sediment.

At municipal level, ‘buds’ of collaborations appear within the informal interaction attempts of river communities and water supply communities, but municipal governmental actors are again still ‘boxed’ into their sectors. This ‘boxed’ condition shows that the community actors are at level 3, whereas the governmental actors are at level 1, especially when it comes to utilization and conservation. For example, the municipal government is not familiar with the overall river scheme aside from issues within its administrative boundary. Thus, it does not know when floods or any water-related hazards are coming, as there is no direct upstream–downstream communication. In contrast, the community actors have a WhatsApp chat group and a walkie-talkie radio frequency in which they update daily river conditions up-, mid-, and downstream.

Overall, these ‘boxed’ sectorial management arrangements between actors exist at each level between those handling water conservation and water utilization. In this case study, the community actors counter this successfully by using informal attempts. Therefore, government actors, especially at regional and municipal level, have learned from informal attempts how to ease the barriers between governance sectors and levels, but they have not acted to adopt a similar working atmosphere in formal attempts. During water-related hazard occurrences, these ‘boxes’ are opened for hazard control but close again when the hazards have passed. The mechanisms deployed during hazard occurrences are addressed in Chapter 6 on lahar risk/resources management.

This study interestingly revealed the existence of actors, located in both the government and the community, who are referred to as boundary spanners in the conceptual framework between the CEK and the IWRM concepts. These actors working in the boundary layers between two or more different entities act as connectors and carry valuable information and possibilities of coordination, collaboration, and cooperation.

These important actors in the interaction attempts are labeled as ‘whisperers’ located between the community and the government in water interaction attempts. They may also be known as ‘brokers’ located in the government setting in budget interaction attempts. The choice of the term ‘whisperers’ suggests that the way in which they operate is subtle, indirect, personalized, and closely related to the decision maker, even if the person him/herself is not the decision maker. The respondent in village 3 suggests that this is a much faster way to progress things, rather than sending proposals to the RBO. For example, whisperers operating through the informal attempts of river forums may ease the community’s access to the government’s annual budget, and, within inter-sectors of government, these whisperers can help to open sectorial ‘boxes.’ These whisperers can originate from both the community and governmental organizations, as long as they function as communicator and have a close connection with actors in strategic positions. The term ‘brokers’ is used in the budgeting process in relation to water development projects. The tendency of the second type of boundary spanner is finance-related, whereas the first type is truer to the community’s needs and is thus more suited to integrating CEK in managerial contexts.

Summary of IWRM Implementation in a Volcanic River Basin

Chapter 5 shows that IWRM implementation in Indonesia is not currently on promising ground, especially in light of the revoked water resources management law and the lack of differentiation between how IWRM is implemented in a VRB and how it is implemented in a regular river basin. This condition is problematic, because consequently no direction is given on how IWRM should be implemented in a VRB, where the active volcano's status must always be taken into consideration in terms of its daily condition, not just for hazard control. Much research has explained the natural interrelations of water, lahar, and volcano, but not from the management interrelations point of view. The current implementation in this case study deals unconsciously with the integration of water and lahar, as reflected in the merging of the water and lahar manager functions in the RBO in the actual implementation. This condition required a detailed learning process in the RBO to find out what works in light of its experiences and the characteristics of the volcano's geohydrology and morphology. However, it is still not sufficient to raise awareness about connecting the hazardous condition with the normal activities in a holistic picture.

The overall condition also suggests that the existing water MLG is still structured hierarchically and fragmented, especially at national level and municipal level. The regional level is prioritized, as the river basin territory is located at this level, where the national, regional, and municipal actors meet. Within these levels, interaction attempts are detected, where whisperers are found to be strategic as CEK agents. This condition calls for further research on how to identify these whisperers. Furthermore, IWRM implementation in a VRB calls for the interrelated risks of lahar and volcano activities to be addressed; this is explained in Chapter 6.

9.1.3 Third Sub-Question: What constitutes lahar management and how is it being implemented in a volcanic river basin?

This sub-question is answered in Chapter 6, "Lahar Risk/Resources Management in a Volcanic River Basin (VRB)." The VRB concept includes the geological condition of volcanic activities, which in this case relates to lahar production. The word lahar is of Indonesian origin but has become internationally recognized as describing the debris flow originating from the summit of a volcano, which carries volcanic materials downstream. It can flow gravitationally as a result of its weight but is mostly rain triggered (Rodolfo, 1991, Pierson and Scott, 1985), using river channels as a drainage system as naturally the lowest point given the morphological conditions. However, when the channels overflow, it also submerges the riverside areas. It is a natural phenomenon as long as there are no human victims, but, when there are victims, then it becomes a disaster. Lahar differs from usual floodwater as it also contains volcanic materials, from gigantic boulders (the size of a big bus in the case of Mt. Merapi) to stones and pebbles, and even sand. Also, lahar's fluidity changes in its flow downstream, because the composition of the water changes as the flow incorporates additional materials from the riverside and the riverbed.

As lahar is partly formed by water, it can be investigating using a conceptual framework similar to that used in Chapter 5 on IWRM's four dimensions: natural, spatial, temporal, and human (Savenije and Zaag, 2008). However, the indicators for each of the dimensions are different, as now they relate to who is doing what in lahar management: (1) natural as the interrelatedness of ecological change inducing lahar: volcanic activities, geomorphological characteristics, and lahar's characteristics (Dove, 2008, Wisner, Blaikie, et al., 2004, Lavigne and Thouret, 2003, Leung, Santos, et al., 2003, Chester, 1994, Pierson, Wood, et al., 2014, Marso, J. N., 2013, Rodolfo, 1991), (2) spatial as interrelation of geographical location of the lahar hazard zone (Newhall, Bronto, et al., 2000, Thouret, Lavigne, et al., 2000, Sumaryono, 2011), (3) temporal as interrelation of periodic volcano eruption cycle (Lavigne and Thouret, 2003) and change in seasonal patterns (Case, Ardiansyah, et al., 2007), and (4) human as interrelationship of people affiliated to different institutions in managing lahar (Wisner, Blaikie, et al., 2004, Cardona, Aalst van, et al., 2012, Birkmann and von Teichman, 2010)

Following the logic of the former chapter, Chapter 6 is also structured in two levels of understandings: policy settings and managerial contexts, with a focus on the lahar-related actors and their activities. The slash sign used in the title between risk and resources shows the shifting patterns of management for lahar, which is based on the status of hazards: pre-, onset, and post-eruption. The difference between pre- and post- is also dynamic, as the eruption onset can have several occurrences, and the two statuses can be interchangeable. However, the post-eruption period commences some months after the eruption has ended. After some years of no eruption, the condition reverts to pre-eruption. The basis for deciding what status applies at a particular juncture depends on the timeline between eruptions. The differences in activities also signal the volcano's status. During eruption onset, the activities relate to emergency relief in volcano and lahar management. Post-eruption, the activities relate to rehabilitation and reconstruction in lahar and water management. Pre-eruption, they relate to normal activities in water management and volcano monitoring.

LRM Policy Settings

Indonesia generally has no clear policy for lahar risk/resources management (LRM). It uses both disaster and water resources management policies, with additional input from volcano management policy. The policy settings are vague about who does what when it comes to lahar, and they are scattered. Some lahar-related policies are located in the ministerial regulations on disaster mitigation of volcano and disaster. These, however, relate mainly to volcanic activities and do not specifically address lahar. Some references to lahar can be found in the revoked law on water management and its derivatives, acknowledging it as a water-related hazard. This needs to be addressed as part of the water hazard control in IWRM implementation. The different actors for disaster risks management (disaster management agency), lahar hazard control (RBO), and volcano monitoring (volcano center) are also identified.

LRM Managerial Context

Analysis of data in the LRM context reveals 'flexible boxed' conditions. In these conditions, the managerial level has overlaps between the management of water and lahar and between volcano and lahar. All the actors involved have their own 'box' of management (either disaster, water, lahar, or volcano), but they sometimes reach out of their boxes to the other boxes. As volcanic eruption is a main hazard dictating the functioning of a river basin, this chapter is also arranged in line with volcano eruption status, and the three statuses are explained further. In all three statuses (pre-, onset, and post-eruption), the risks management form is active. The resources management form is active during post-eruption, after the lahar flow stops and sedimentation is formed. In the later stage, the exploitation of lahar sediment as aggregate resources (sand, stones, pebbles, and so on) for construction materials commences in the Mt. Merapi case. This lahar may not be the same as lahar in other VRBs.

Although lahar is different from water, in this case study, no separate organization line has been detected for lahar management. The existing organizations cope with a 'make-do' lahar institutional framework. The MGLs found are similar to those in the earlier chapter and are used to arrange this chapter on the basis of administrative boundary – national, regional, and municipal – but combined with volcano hazards, although the real administrative boundaries are the volcano region for the volcano center and the national parks authority, river basin territory for RBO, and administrative boundaries for the government actors. The volcano region and river basin territory are located at regional level, although some actors belong to the national government. For the community, the governance levels for lahar management are not so clear, although they are based on administrative boundaries. However, the boundaries are less rigid between volcano region, regional boundary, catchment, and river basin territory. The community can cross these boundaries as long as the aim of information dissemination is achieved. With the community actors being mostly volunteers, teaming up from up-, mid-, and downstream and crossing municipal or regional or any administrative boundaries without knowing who is where, they disseminate information on lahar flow reaching this and that location.

In this case study, LRM is composed of the Sabo dam system to control the risk of damage, in combination with spatial control of the lahar hazard zone. The first was implemented by the RBO, the second by several actors in collaboration post the 2010 eruption, with the national disaster management agency as the lead. In day-to-day practice, between 2010 and 2018, there was no major eruption. The 2014 and 2018 cases are considered minor volcanic activities or phreatic not magmatic eruptions, to release the groundwater heat trapped inside the caldera. The consequence of using the Sabo dam system is that, to maintain the dams' storage capacity, the lahar sedimentation has to be excavated. The Merapi lahar sedimentation is of a high quality that can be used in construction, and this attracts many actors to 'help' the RBO in excavating the sediment in the Sabo dam. Generally, chaotic conditions ensue, as permission is required to excavate and the processing of permits can take a long time. Hence, a lot of mining starts before the permit is given.

LRM Interaction Attempts

Chapter 6 also explains the interaction attempts for lahar management, still using the same categorization of themes as in the earlier chapter: budget, water, and disaster, with the theme also positioned on the basis of pre-, onset, and post-eruption. The budget and water interaction attempts are integral to pre- and post-eruption. These are where the planning, budgeting, monitoring, and interactions take place. During eruption onset however, disaster interaction takes the lead. Most of these interactions relate to information sharing and working together. These attempts are activated in congruence with the eruption status. Thus, eruption onset (including lahar occurrence) entails disaster interaction attempts, and pre- and post-eruption entail budget and water interaction attempts. Status change occurs also in relation to the type of lahar management. Lahar as risk management covers all statuses, whereas lahar as resources management covers mostly post-eruption.

At national level, during eruption onset, when lahar has an inter-provinces or inter-region impact, then the national disaster management agency takes over. Another instance is when international donors want to make contributions; this supposedly has to go through the national government. However, during the pre- and post-eruption stages, the national government does almost nothing, aside from providing guidelines to their branch offices at regional level.

At regional level, the pre- and post-eruption interaction attempts come under the budget and water themes. The budget interaction attempts are made by means of normal activities in development projects in preparation for the disaster fund and projects for lahar control measures. The activities mentioned come under ministerial branches and regional agencies, which are synchronized now and then through the formal attempt of Rakorbangprov. Between the municipal and regional level, the other formal attempt is made in Musrenbangprov, inviting all sectors in government and private and community representatives. Implementation of these attempts still comprises a one-way communication from government to the others about development plans. The annual budgeting for the disaster fund is established through the budget attempts. Whether there is a volcanic eruption or any other disaster, the disaster fund is at the ready. The budgets are planned by the regional planning board and the disaster management agency, but in the event of the budget not being enough the national government may add to it from the national fund.

For the water interaction attempts, lahar is still considered as part of water-related hazards and also as part of IWRM implementation. The water interaction attempts are made through water councils. The pre- and post-eruption interaction attempts are not as frequent and condensed as the eruption onset ones, as the conditions that apply are mainly normal river basin conditions. The water councils discuss the effect of lahar and its sedimentation, and also sand-mining activities in river channels. Although the recommendations produced are vague concerning actions, they are used as a starting point for informal discussions outside the councils. Alternative interaction attempts at regional level also happen irregularly or sporadically whenever an attempt is needed, and they are not centralized in the forums or councils, and the aforementioned 'boxes' of management are opened up as there are indeed overlaps. However, these interactions are not always smooth, as one side may feel disadvantaged by the extra work that has to be done for others. These interaction attempts were undertaken out of habit after the 2010 eruption. For example, between the volcano center and lahar: the volcano center helped the RBO in calculating the potential of lahar, even though their main responsibility is to monitor volcano activities, not lahar. Another example is between water and lahar: the RBO is responsible for building lahar control infrastructure because it is the main actor for river management, whereas supposedly all volcano-related infrastructures are under the volcano center. Also, between water and volcano: the national parks authority manages up to within a 4km radius of the volcano summit, but the rivers in all the areas of the volcano are under the management of the RBO.

The implication of such an overlapping arrangement at regional level is the obfuscation of authority, whereby management conflicts happen, especially during pre- and post-eruption. These management conflicts occur between the national parks authority and the RBO, especially on who has higher authority over the rivers in the national parks, and between the volcano center and the RBO on who is supposed to gather information about lahar potential. In these conditions, neither the spatial plan dictating land use nor the lahar hazards map provides precise information about the setback required for the affected rivers.

Still at regional level, during an eruption, the lahar interaction attempts take place through the disaster tasks forces and disaster forums. However, lahar can form at any time between onset and post-eruption as long as there are enough volcanic materials and a sufficient volume of rainwater. Thus, when lahar flows, the status of management is similar to that for eruption onset, with disaster management agencies in the command position. This position is obtained by leading the disaster tasks force: an *ad hoc* organization in which all actors needed to assess the eruption condition are gathered. In the case of a volcanic eruption, the disaster management agency decides the status based on information provided by the volcano center. There are currently four statuses for volcanic activities in Indonesia, starting from the lowest: normal, *waspada*-alert, *siaga*-standby, and *awas*-beware*.* The status is raised in this order, starting with *waspada*-alert when increasing seismic activities are detected, *siaga*-standby as seismic and volcanic activities heighten, and *awas*-beware as a cautionary status with the possibility of a major eruption taking place within 24 hours. However, the status does not have to follow this order and can jump from normal to *awas* within mere hours (as evidenced by the 2010 Mt. Merapi eruption). This status is monitored, as the pattern can change. There is no scientific knowledge yet on how to predict the exact time of an eruption. The eruption onset covers the *awas* status, and pre- and post-eruption cover the normal to *waspada* status.

The disaster task force includes the regional agencies (social, public works, health, and so on), the ministerial branches (national parks, RBO, volcano center, CMA, and so on), community disaster forums, the armed forces (police, marines, air force, army, and so on), and disaster relief NGOs. The degree to which information is important in the disaster task force differs depending on the condition, whether during eruption onset (volcano center) or post-eruption during the lahar flow (RBO), as it is the technical organization. The other members act as disaster relief supports.

During post-eruption, the interaction attempts for lahar management are located in disaster control located in water as lahar sediment control and sediment excavations, which lead to sand-mining activities. In a sense, this status is more related to lahar sediment dredging activities, known as sand mining. The water interaction attempts discuss this condition but do not give any solid solutions. Overall, the regional government controls the sand mining through permits, but there is no mechanism for interaction attempts there. The RBO is included in the process as it provides information about the appropriate locations for quarrying the sand in the river channels. The community is involved as part of the Sabo dam and river channels monitoring system.

At municipal level, the interaction attempts are similar to those at regional level through disaster forums. In fact, as the lahar usually flows in inter-municipal rivers, during eruption onset, the command is still located at regional level. The sand-mining activities are found mostly in the post-eruption stage for all three sub-cases 1, 2, and 3. Sub-case 1 (upstream) has ongoing sand-mining industries all over the river channel; in sub-case 2 (mid-stream) the sand is used by the riverside communities.

At all governance levels, the switching of management between risk and resources management is a cycle that depends directly on the volcano's status. During eruption onset, all actors realize that the most important thing is to work together to cope with the emergency condition of a volcanic eruption, and so the 'boxes' of management at all governance levels open up. This condition works on the basis of experience in reacting to common threats. This action is more reactive than proactive, as this study found no evidence of the existence of many interaction activities to prepare for an eruption occurrence. However, disintegration occurs as soon as the emergency relief status is no longer active. This situation calls for attention to strengthen the pre- and post-eruption interaction attempts, using both formal and informal ways.

During eruption onset, the most active actors are the disaster management agencies and the volunteers at all levels, especially regional and municipal. The volunteers use a lot of CEK to recognize the lahar flow: the sound of river flow, the timing after rain, the volume of water in the river, the path it takes, and so on. Their role in giving information is much more important than automatic devices, which in many instances drift along with the lahar, are broken, or go missing. To be admitted into the volunteer forums, people have to join the small community-based organization (CBO) in their relevant village. This cooperation relies upon latent CEK values at regional and municipal level: *gotong royong* – collective action and *tepa selira* – empathy for affected people, which last during the eruption. The term 'latent' reflects its usage, which gets stronger when there is an eruption emergency. More detailed CEK is used at village level: specific locations of lahar, the sound of lahar, offerings given to Mt. Merapi, and so on. These are all generally used to keep inhabitants safe from lahar risks.

As explained above, the actor managing lahar in this case study is the RBO, as lahar flows in rivers and also over the riverside when the river channels are at full capacity. Most of the pre-eruption phase is managed by means of hazard control and maintained by the RBO, influenced by an international party (JICA) in its studies and Sabo dam systems. The volcano center always monitors volcano activities, and the national parks authority manages the protected forest and summit of the volcano. The lahar risk management side is active during all phases of eruption as the lahar flow can happen at any time in this VRB, as long as there is enough water discharge (100 liter/sec) in the river due to rainwater in the case of Mt. Merapi rivers (De Bélizal, Lavigne, et al., 2013). Later on, lahar resources management takes over after the flow stops and sedimentation occurs, becoming a volcanic aggregate resource.

All of the actors agree that the disaster management agencies (regional and municipal) are the leading actors in lahar risk management. For lahar resources management however, chaos has been known to reign in relation to whose authority it should come under. The river is under the RBO, yet aggregate resource use and permits come under the regional government, and the potential of lahar deposits comes under the remit of the volcano center. The community in this respect supposedly does not have access, unless they are mining their land without a permit.

Later, post-eruption, when the lahar is no longer flowing as rapidly, the sedimentation becomes a source of income. During this time, the leading actor changes again to the regional government for the permit issuance process, with the RBO providing the technical recommendation on the volume of mining and the volcano center on the potential of lahar volume reserve upstream and the supposedly protected area of the national park. Most interviewed respondents agreed that the sand-mining activities have got out of hand and most of the river channels have been overmined, even in upstream farmlands. Furthermore, the sand mining takes place under the national parks authority; this is embarrassing, as it is supposed to protect the summit area. The RBO discovered this fact when it was not permitted to maintain its Sabo facilities in the national park.

Again following the logic of the earlier chapter, significant LRM interaction attempts are found, also themed as budget, water, and disaster. The budget attempts are mostly formal, making budget plans for pre- and post-eruption. Although not specifically referring to lahar, the water interaction attempt entails lahar risk management, as it is covered under water-related hazard control. The existing formal–informal water interaction attempts also have roles in lahar pre- and post-eruption in providing information on the current condition. The RBO takes the main lead in river basin territory in its capacity as responsible for regional and municipal rivers. However, the role of water forums at eruption onset unclear. Their role is more evident pre- and post-eruption; although their discussions do not lead to a real solution, the problems are discussed. The disaster attempt has the advantage of budget flexibility. The budgeting scheme for eruption onset is very generous, through the disaster budget. The municipal level budget can be accessed and, if that is not adequate, recourse can be had to the regional or even the national level or international donors. Also, the fund disbursement mechanism is less complicated, as it is based on emergency status. There are three sources of disbursement: (1) disaster management agencies (all levels), (2) planning agencies (all levels), and (3) other: international donors, private companies (corporate social responsibility), and so forth. For the eruption onset, the interaction attempts are an active combination of formal and informal. This combined attempt through the volunteer forums connects actors from government, the private sector, and communities, with some overlap. This flexibility helps to achieve higher integration.

LRM Integration Level

The integration level uses the same categorization as the earlier chapter: (1) coordination, (2) collaboration, and (3) cooperation. In short, the LRM integration level varies depending of eruption phase. The integration level for disaster-themed attempts is cooperation, for post-eruption the level is collaboration, but, during pre-eruption, the general attempts do not represent even good coordination. The level lessens the more conditions return to normal or pre-eruption. This is a consequence of 'sectorial ego' and Indonesians' tendency to work more strongly collectively whenever they face common threats.

It can therefore be concluded that lahar management does not have a fixed definition or clear policy at its base, as long as the lahar is contained while flowing relatively safely downstream. Lahar management is implemented through means ranging from technical solutions, such as the Sabo dam system, canalization of lahar rivers, sand pockets in the river body, and so on, to spatial planning: delineating a lahar-hazard zone for non-residential areas. In this case study, it also includes both aspects of lahar management: risk and resources. Lahar management has relatively loose structures in comparison to the strict water management hierarchy and is achieved through the existing governmental actors (RBO, volcano center, disaster management agency) and community volunteer groups. This arrangement works because there is no other choice but to learn by doing. The findings show that both technical and social solutions can be combined, as also formal and informal attempts, with an integrated approach in all volcano eruption conditions.

Although the level of integration scored highest for eruption onset, there is a problem getting to the precise person in charge in a timely manner and also regarding the overlapping that comes from each stakeholder's self-governance. Of course, as the initial pre- and post-eruption interaction attempts are located in the budget and water themes, some stakeholders already know one another, but, given the low integration level score in those themes, they do not know what division and what persons they have to address. For example, during lahar flow, instead of contacting the Mt. Merapi RBO division officer, some people contact the public works agency at regional level. This condition leads to the 'snowballing' method to look for the right person until the correct name finally 'pops up' and contact is established. These issues will not arise if, during pre-eruption, the integration level is already at least at coordination.

Summary of LRM Implementation

Thus, the existing changing role of the leader for each condition is essential at regional level pre-, during onset, and post-eruption. As in water management, the regional level is also the main 'playing field' for lahar management. In this sense, the existing institutional frameworks on the ground are the same but act in line with the status of the disaster. The disaster management agencies at both municipal and regional level are aware of their role during the three conditions but assume responsibility during onset and post-eruption as the possibility of human casualties is higher in those conditions. The RBO has a more active role in the pre-eruption phase to prepare the Sabo infrastructures and after the post-eruption phase to rebuild them. The volcano center has an active role as a linking hub in all conditions as it monitors and disseminates information on the volcano's status at all times, although its most important role is to declare the eruption onset condition. These combinations are used to explore the current lahar management in the case study.

9.1.4 Fourth Sub-Question: How and why does lahar management relate to the integrated water resources management in a volcanic river basin?

This sub-question is answered in Chapter 7. This chapter fuses the two earlier chapters and explains the interrelations of lahar and IWRM in terms of the overlaps located in each chapter's layered structures: policy settings, managerial contexts, interaction attempts, and integration levels. Hence, it was added as a helping lens, positioned strategically to elucidate the interrelation between water–lahar–volcano in a VRB from the governance point of view, rather than from the natural cycle view.

The chapter was added as an intermezzo, as it was needed to cluster the water–lahar interrelations from the governance point of view, before answering the next sub-question. Between IWRM and LRM, LRM is the more commanding as it is based on the natural volcano condition. As the levels of governance are the same, these patterns are found by showing the interrelations of each volcano condition in LRM (pre-, onset, post-eruption) to each IWRM pillar (conservation, utilization, hazard control) that can function in each status.

How LRM relates to IWRM

The 'how' part is answered by presenting the interrelations between IWRM and LRM, termed in this study as volcanic river basin management (VRBM). VRBM is defined as catchment management located in an active volcanic basin, focusing on the interrelations of water, lahar, and volcano. The VRBM phases suggest the overlapping (Goldstone, 1996) management of water–lahar integration in the VRB, based on the volcano condition. They are categorized as follows:

1. Normal VRBM: pre-eruption with water conservation, water utilization, and preparation for water hazard control,
2. Disaster VRBM: during onset water-related hazards and eruption, the pillar of hazard control, and no active conservation and utilization, and
3. Normal+ VRBM: post-eruption with conservation, utilization (both water and lahar sedimentation), and hazard control.

Chapter 5 on IWRM and Chapter 6 on LRM have a similar structure as explained in terms of MLG. A VRB case study is used to explain the interrelations between the IWRM pillars and the LRM stages. This arrangement formed the basis for making sense of the interrelations, and Chapter 7 is structured along policy settings and managerial contexts following the earlier chapters.

The policy setting connecting IWRM and LRM is the regulations on water resources management (currently revoked and former irrigation management policy now applied), disaster management (for all kinds of disaster), volcano management, catchment management (national park, all the catchment), mining (lahar sediment materials), and river management. These unclear overlapping policy settings create a challenge and an opportunity. The challenge is how to address the overlapping, which causes contestation about authority, especially for the rivers and the upstream VRB areas. Both lahar and water use the river as a flowing space, where many actors assert their authority over either the river or the lahar sediment materials. The opportunity is the positive atmosphere, where flexibility in the organizational framework and creativity in managing boundary spanning activities are blossoming thanks to the lack of strict rules.

The managerial contexts follow the MLG structure used before for the national, regional, and municipal levels. The levels of governance show the regional level as the main 'playing field' for the interrelations, where all the main interrelations occur. This condition arises because both IWRM and LRM take the river basin territory as the main unit of management. This river basin territory is where all the main actors are located at regional level and where municipal actors meet regional and national actors. These national actors (the branch offices of ministries), regional actors, and municipal actors from the government, the community, and the private sector, meet there during the many interaction attempts, which are discussed further.

The interaction attempts found were also themed as explained in the IWRM and LRM chapters: budget, water, and disaster. However, the significance of IWRM relates more to the water attempts and the significance of LRM relates more to the disaster attempts, and VRBM relates to the interrelations between the water and disaster attempts, with the support of budget attempts. The interrelated governance in VRBM is located within these attempts. The integration level of the interaction attempts results from a combination of the formal and informal attempts on all three themes. IWRM and LRM are most strongly integrated in disaster interactions, less strongly in water interactions, and they are somewhat disconnected in budget interactions. Lahar is mostly regarded as a risk in disaster interactions, rather than part of daily conditions, even though, as argued in the lahar chapter, lahar management also takes place pre- and post-eruption.

Lahar management overlaps because its interrelation with IWRM takes place 'unconsciously', following the unclear policy settings for lahar and the not-so-many options of lahar management theory. This unconscious status is triggered by lahar control being under RBO authority. The existing organizational framework allows lahar to be part of IWRM using the logic that every form of water comes under the RBO. Although the hybrid status of lahar as the product of volcanic activities and rainwater is acknowledged, not all actors agree upon who should be the responsible authority in relation to sand-mining management. Permits are issued at regional government level, but the RBO is responsible for technical recommendations. The RBO is therefore under pressure to calculate lahar's potential as a resource for future sand-mining quarries in the river channels. The difference between the RBO in this VBR and RBOs in normal basins is its capacity to recommend lahar control measures, disaster mitigation actions, and sand-mining guidelines.

In this respect, the disaster functions as the activation point toward integration. The decreasing and increasing integration levels are a function of the combination of lahar and water management. In the VRBM Disaster phase, the disaster attempt is the main interaction attempt, and integration seems to be at its highest level. In this case however, it is mainly lahar management and not water management that is involved. The lack of policy for lahar management has created gaps that are addressed in the managerial context by boundary spanning activities between the existing organizations.

However, the loose structure in this phase is vulnerable to changes in leadership or in the persons in charge, in that replacements might not be as flexible in interaction attempts. Therefore, to achieve better integration, the policy must be more strongly grounded but at the same time allow for flexibility between management 'boxes.'

Why LRM Relates to IWRM

This chapter also reveals that the overlapping management provides the answer to the 'why' part of the sub-question: why does lahar management relate to IWRM? This overlapping management is known in the governance context as boundary spanning. The actors managing the overlap are called boundary organizations (institutional level) and boundary spanners (individual level). The RBO functions as the boundary organization between water and lahar management. Additionally, there are three different kinds of boundary spanners based on the interaction attempts theme: broker, whisperer, and contact person. The broker belongs to budget attempts and exists in Normal and Normal+, but disappears during Disaster VRBM. The whisperer belongs to the water attempts and exists in all VRBM phases. The contact person is present in the disaster attempts and exists in the Disaster VRBM phase. The whisperer transforms into the contact person during Disaster VRBM, adding to the number of original disaster contact persons.

9.1.5 Fifth Sub-Question: How and why does cultural ecological knowledge impact the management of water and lahar in a volcanic river basin?

To answer this sub-question, Chapter 7 titled "Cultural Ecological Knowledge in a Volcanic River Basin" reflects back on Chapter 4 on CEK and the intermezzo chapter. It captures the essential CEK, which is found on the ground, and amalgamates the findings into each VRBM phase. The reason for doing this is to explicitly and structurally take a step further in answering the main research question. Therefore, both the existence and the utilization of CEK types are recalled and rearranged in line with the aspects of policy settings, managerial contexts, and interaction attempts with their integration levels. Each aspect is re-introduced based on the VRBM phases in relation to volcano eruption and coded as + when CEK exists and is used, 0 when CEK does not exist, and – when CEK exists but not heeded.

How CEK Impacts VRBM

There are two main findings for the policy setting. Firstly, CEK is generally acknowledged for all VRBM phases in water-related resources management policies, but scattered here and there. These policies are divided into the following sectors: water management, nature conservation, disaster management, and volcano management. The scattered CEK is located under different regulations and mentioned as 'local knowledge' or 'sociocultural considerations.' This dispersion also affects the CEK integration of policy between different sectors. Secondly, from the CEK point of view, the policy setting for intangible and tangible cultural heritage conservation is not well embedded in practical natural resource management policies. A lack of interrelation is also found, as the heritage conservation policies focus more on tangible heritage (artifacts) than on intangible heritage (other types of CEK). The reason for this is that the heritage policies are considered as part of the education and cultural sectors, which have no connection to the interaction attempts. These heritage policies are not yet referred to in any of the related policies for any VRBM phase.

In the Normal and Normal+ VRBM policy settings, the policies used are more or less the same on water utilization and conservation in water, volcano, disaster, and spatial plans. The existence of CEK is acknowledged in water management policies to respect the place of local knowledge in resources management practice for indigenous irrigation and conservation of water-related sacred locations, but this CEK is found in different ministerial regulations. There is some level of CEK embeddedness in these policies in the basic regulations. However, interestingly, later in the management context, CEK is referred to in the planning documents, as explained later in the management context findings. Therefore, most instances are acknowledged in the conservation policies; these are coded as +. Some instances are also found in utilization policies, but they are not very strong, coded somewhere between 0 and +.

However, the situation differs for Normal+ as this includes mining policies on lahar sediment management in relation to sand-mining practices. Lahar is not mentioned in any policy as a resource, although there is something about non-mineral mining (aggregate of stone and sand). Therefore, for policy in the Normal+ phase, CEK in the utilization of lahar is coded as 0.

In the Disaster VRBM policy setting, CEK is mentioned briefly in terms of the importance of using local knowledge in each specific location for disaster response. This general reference to local knowledge can equally sum up the different forms of CEK on the ground. The policy highlights local knowledge as a way to consider historical hazard threats in a location, and the disaster management agency can learn from the locals how to 'read' the natural dynamics and react to these particular hazards. However, it does not explain how to discover this knowledge or how to use it in the long run. Therefore, for Disaster VRBM, the code assigned is a low +.

In the managerial context, CEK use is more easily located. CEK instances appear in the Normal VRBM phase, especially for conservation activities. The next instance is in the Disaster VRBM phase, in hazard control during eruption onset. However, in the Normal+ phase, especially regarding the utilization of lahar sedimentation or sand-mining activities, CEK is not heeded. The following paragraphs give a more detailed explanation of each governance level and each VRBM phase.

At national level, CEK is less evident in VRBM. First, the policy settings do not pay special attention of this type of river basin, and, second, CEK is still not embedded in the policy settings; this is reflected at management level. CEK implementation in Normal and Normal+ is stronger in natural conservation activities, such as the national movement on water rescue – GNKPA, but also later in water utilization, for example the Balinese *Subak* irrigation system. The first example of the existence of CEK in conservation activities has the support of the Ministry of Environment and Forestry, as it has a sub-directorate. However, it is unable to provide guidelines for CEK conservation for all other ministries or agencies related to water, land, and volcano.

There is no indication in other ministries that they would take such an approach seriously. Therefore, CEK's existence in Normal and Normal+ ranges between 0 and +.

There is more evidence of CEK in the Disaster VRBM phase, in the forms of values and philosophies. As explained in the LRM chapter, the eruption onset makes the disaster the activation point for CEK. This phase also follows the same logic, as it is part of the LRM eruption onset and water-related hazard control. For Disaster VRBM, CEK is applied to any kind of hazard (whether water related or not) to help in living in harmony with disasters. As mentioned by the disaster management agency leader in 2011 (Maarif, 2012), the most commonly found CEK relates to the *gotong-royong* or collective action spirit, *tepa selira* or empathy, and awareness about staying safe from potential hazards. Therefore, this phase is coded as +.

At regional level, the existence of CEK is more apparent. In all VRBM phases, traces of CEK are found in several forms, mainly philosophies/values, artifacts, and resources management practices. In comparison to the national level, the regional level has a local context, in which the administrative boundary covers the river basin and the volcano. This helps in setting the cultural context, especially with the Sultanate reigning as the regional government.

In the Normal VRBM phase, more attention is paid to CEK in relation to water conservation, especially with the national parks being located on the summit area of Mt. Merapi and Parang Kusumo, in line with the sacred locations in the philosophical axis. The philosophy of *Hamemayu hayuning bawono* is also to be found in any related regional government's agencies, although its implementation is vaguely shaped into the character of efficient public service. The regional government has been responsible for promulgating local regulations for the catchment since 2016, explicitly stating the role of culture in catchment management and the CEK forms in resources management practices for agriculture, the seasonal calendar, and so forth, but this has not yet been included in planning documents on water conservation and utilization.

The use of CEK for water utilization is represented by the water supply initiatives of Pammaskarta DIY, the river communities – AKSY, and the cultural values employed in daily activities. These communities take an active role in partnering with the government (both regional and national ministerial branches). Important artifacts, such as the Mataram channel as cultural heritage for inter-basin water transfer, are also still in use, even though many locations in the channel have violated the river setback area or use it as drainage for sewage. Setback violations also occur in the utilization of *wedi kengser*, supposedly Sultan Grounds, as riverside settlements in the city center. Therefore, this condition is coded as 0 to +.

In Disaster VRBM, in the case of Mt. Merapi, other CEK elements appear, such as the understanding of the philosophical plane as the river basin and the artifacts lined up in the philosophical axis as disaster mitigation measures to monitor volcanic activities. Hazard controls are used by Forum PRB (DRR) where the members use CEK resources management practices as natural and social early warnings, such as traditional *kenthongan* sounds as a social early warning system and the Sultan's premonition as a traditional early warning system. Regarding utilization, the resources management practice of water transfer from other areas by the water supply community (Pammaskarta DIY) and the regional agency (PU-P ESDM) is implemented, as also the utilization of water from the river's base flow. Other CEK forms include collective action (*gotong royong*) and empathy (*tepa selira*) values, also philosophies of living in harmony with disaster. As CEK is used comprehensively by the managers and the community during this phase, the code assigned is +.

In Normal+, more attention is paid to rehabilitation and reconstruction, and also to the normalization of water infrastructure utilization. In a later stage, Normal+ also touches upon conservation, but not so much on sand mining, even though this is supposedly needed to return river channels to their pre-eruption condition if they have a Sabo dam system. The RBO and the national parks authority are in conflict about the illegal sand-mining activities, promoted by the second organization. This action is not in line with any CEK on the conservation of sacred locations: the volcano and the rivers. Accordingly, this condition is coded as -.

At municipal level, CEK is found in abundance, but these instances are location specific, and each location has its own CEK. To sum up, all forms of CEK are available in all VRBM phases. The instances of CEK use in Normal relate to conservation within the river communities: the use of artifacts for sacred locations related to water, water quality assessment with visuals of types of fish, and collective action. Regarding utilization, the water supply CBOs (Spamdes) located in villages and hamlets apply CEK to spring or well use, and the collective action spirit is mobilized to prepare and implement the supply system. The Spamdes collective at municipal level also comes together at regional level and is called Pammaskarta DIY, the water supply co-op. In Normal+, CEK is not heeded; these CEK instances include the visual of river channels that are too deep and the dying of springs by the riversides, pointing to the overmining of lahar sedimentation. This condition arises partly because the miners are not indigenous to the locations. Another finding is that the upstream CEK follows the *Hamemayu* philosophy of taking only what needed, leaving the rest for conservation. Also, it is known that rivers were 'auctioned' by earlier generations for their sand. Another finding is the resources management practice of using the CEK artifact, the *wedi kengser*, as temporary farmland. Other forms are the resources management practice of dredging sediment from wells after a lahar flow and tasting water as a water quality indicator after an eruption. In Disaster VRBM, CEK is used extensively, but mostly in relation to the social networking system that uses bamboo or a wooden drum – *kentongan*. The five senses wisdom is used to distinguish between the sound of lahar and the sound of a flood; the visual of animals migrating is used to time evacuations; the sound of the *kentongan* rhythm is used to foretell the volume of water: the faster the rhythm, the greater the volume. CEK as artifact is used to mark safe locations, such as sacred geography, a tomb, stones, and so on. In regard to resources management practice, water can be transferred inter-basin to an upstream area in line with the values of *tepa selira* (empathy) and *gotong-royong* (collective action). Another philosophy found during Disaster VRBM is *nrimo* (accepting fate or fatalism) toward the eruption, and even toward the horrifying experience of upstream deaths from pyroclastic flows.

In the interaction attempts, CEK takes the form of values and philosophies, with a focus on human interactions. As previously stated, CEK forms of resources management practice, five senses wisdom, artifacts, and internalization of rituals/myth focus primarily on human–nature interactions. The integration level is strongest in Disaster VRBM because of the disaster task force; here, collective action, empathy, and volunteerism are more actively used, as the sense of natural hazards as a threat unites people in their efforts to survive. In Normal, the water councils and budget are used, where lesser CEK values can be found. In Normal+ in particular, interaction attempts regarding sand-mining activities are still non-existent, and they are therefore dealt with between the water and disaster interaction attempts. This lack of an interaction attempt makes it difficult to create a suitable decision-making process for permits and to control the sand activities.

The level of integration between CEK and VRBM is highest in the Disaster VRBM phase. As already stated regarding the water and lahar management interaction attempts, this level is achieved thanks to the role of CEK within these attempts. The ingredient for the highest integration is the number of informal attempts; the more informal attempts take place, the higher the CEK and VRBM integration. To sum up, the correlations between integration level and CEK impacts include: (1) the higher the use of CEK, the higher the integration level, (2) the more informal actors are located in the interaction, the higher the integration level, and (3) the more informal actors are involved, the more CEK is delivered.

Overall, the five forms of CEK can be found in all VRBM phases. The three CEK forms most often found, however, are philosophies/values, resources management practice, and five senses wisdom (above 70%). Therefore, the chapter confirms CEK utilization in both policy and management. The enabling factor is support from both government officers and community members to ensure continuous utilization of CEK. However, to prepare this support, first, the relevant actors either in government or in the community need to become acquainted with CEK. If they are not native to Yogyakarta, they need to learn during their stay. Even after learning it, sometimes they still do not believe in the merit of CEK. For example, a respondent, who is a non-native government officer, described it as the 'knowledge of matching things up.' This person does not believe in the existence of the philosophical axis, as Mt. Merapi can be seen straight from any direction; but this does not mean that the Kraton people use this axis to monitor the pyroclastic and lahar flows. An indigenous respondent argued that, before the 2010 eruption, many people did not understand the importance of the philosophical axis. However, aside for aesthetical spatial arrangements, now many understand that this philosophical axis also functions as a disaster mitigation measure. This understanding of putting puzzles about knowledge together in the current context is what is meant by the 'matching' process.

It is considered 'old-fashioned' to use CEK in an office setting, especially for the CEK forms of five senses wisdom and resources management practice as alternative tools to modern equipment as the standard procedure. For non-CEK believers, other forms such as artifacts, philosophies/values, and internalization of myth are even harder to digest. Therefore, there are still challenges for any government organization, and it depends on the leader of the organization whether or not it supports the use of CEK. Nonetheless, most of the organizations' respondents agreed with the importance of CEK in VRBM, although the degree to which they show their support differs, and this support is also vulnerable to change.

For the interaction attempts, again Normal and Normal+ are clustered together, as no differentiations are made in the current conditions. These attempts are addressed through the budget- and water-themed attempts. More attention is paid to CEK in the informal attempts, which use CEK values, philosophies, and resources management practices. Integration levels are more evident in the informal attempts.

Why CEK Impacts VRBM

On the next level of understanding, the research delves more deeply into why CEK is included in the governance of a VRB. The research found evidence of CEK actors: boundary organizations and boundary spanners, which function as mediators to propose CEK at governance level and establish the precondition of a conducive atmosphere for CEK.

The main boundary organizations between CEK and VRBM are located at regional level. On the governmental side, these actors are BBWS SO (RBO), BPBD (disaster management agency), PU-P ESDM (public works agency), and BPDAS SOP (catchment management center). On the community side, the actors are the CBOs: on water supply (Pammaskarta DIY), river communities (AKSY), and DRR forums (Forum PRB). They hold this position because their authority, knowledge, and budgets for river basin management mean that they have a greater capacity to address problems.

The drivers of the organizations' openness are again the whisperers or honest boundary spanners as referred to in Chapter 5, the organizations' flexibility (be it in communication, in budgeting, or in activities), the willingness of decision makers to listen to communities' demands, and the response in following up demands. From the community side, the active roles of certain persons in communicating these demands to the governmental organizations depend very much on their characteristics.

The support for CEK relates to governmental organizations' openness to informal interaction attempts, termed as a conducive atmosphere: the higher their support for CEK, the more likely they are to work with the community. The CBO respondents shared their experience; they have a more successful agenda in informal attempts and they are more aware of the governmental organizations' structure and programs. In this respect, the community knows how to identify potential whisperers within the organizations, especially when they are whisperers from the community side.

CEK helps to integrate lahar into water management. As CEK does not differentiate between water or volcano or lahar, but rather sees them as a holistic system of nature, it trespasses on, and transcends all the management 'boxes' (domains and levels); it eases boundaries, smooths interaction attempts, and thus increases the integration level. In a way, CEK is an ancient form of integration approach, as it tries to combine related resources management in a more holistic way, but also in a vaguer way than the IWRM approach. CEK utilizations in the management of this VRB are explained in the next section.

9.2 Answering the Main Research Question: How does cultural ecological knowledge contribute to the integrated water resources management of a volcanic river basin?

The previous chapters (Chapters 4 to 8) constructed the building blocks for answering the main research question. CEK is not attached to one form of resource; it sees all resources as part of nature, thereby making it flexible enough to penetrate any kind of resources management. The interrelations of water, lahar, and volcano governance have been found in this case study. When it is used, CEK generally enhances the conservation aspect of VBRM, as it is wiser in the utilization of water and related resources by limiting resources exploitation for the good of the functioning of the ecological system. In addition, it is used as historical experiences of hazards (volcano eruption, lahar, or other water-related issues).

The types of CEK are abundant in this study, and those that are used directly are the hard ones: artifacts, resources management practices, and five senses wisdom. These CEK forms are used to provide alternative tools for managing water and lahar resources, including observations of local communities. Meanwhile, artifacts perform as a reminder of the heritage knowledge on the sacred geography of the river basin (the philosophical plane and axis, the Mataram Channel, and so on) to honor nature in its interrelation between upstream and downstream.

When CEK is used, it has a smoothing effect in interaction attempts and contributes to an enhanced VRBM integration level. CEK contributes to the integration level of water, lahar, and volcano management, combining them all in VRBM, and it also supports the interaction attempts in a more culture-sensitive participation setting (conducive atmosphere). Both soft and hard CEK produce the highest integration in the Disaster VRBM phase, as the latter combines formal and informal interaction attempts. The Normal VRBM phase has a middle integration level, as it tends to use CEK only during informal interaction attempts. The lowest level is detected in the Normal VRBM phase, as CEK is hardly used. Overall, the core of CEK, which exists in all VRBM phases, is philosophies/values (soft CEK). These philosophies are transferred through the characteristics of the people within the interaction attempts.

Although both hard and soft CEK are used, communities refer more to hard CEK, as it is easily grasped in physical forms, such as artifacts, management practices, and five senses wisdom. Community respondents do not refer to soft CEK as often as they do to hard CEK. In contrast, existing VRBM organizations, primarily at regional level, use soft CEK more often, because it relates more to human interactions in organizational life. Soft CEK has a deeper meaning for social interaction, as it connects the human–nature relationship in the form of internalization, philosophies, and values. Therefore, a synthesis is now presented of CEK in IWRM, and the adjusted conceptual framework is proposed to complete the answer to the main research question.

9.2.1 Synthesis of CEK in VRBM

A general overview of CEK and VRBM is presented as a snapshot in Figure 9.1, showing how the two realms understand the VRB and how the two manage nature within their extensive and overlapping realms. This understanding explains how CEK contributes to VRBM in terms of overlapping realms. However, this picture does not inform the complexities of CEK formulation from historical experiences and legitimization processes – for example, how the sacred geography (artifact) formulation process was known to the Kraton in Yogyakarta since the beginning of the Sultanate, namely, the Mt. Merapi–Tugu–Kraton Palace–Panggung Krapyak–Parang Kusumo Beach axis, or the philosophical axis. The axis marks the Kraton's authority on the interrelations in the two natural dynamics: the volcano and the sea. However, the legitimatization process has to keep being reestablished, and this process was undertaken recently (UU no. 13/2012 on Special Status of Yogyakarta Special Region, 2012). This legitimization process became stronger after the sites were determined by a regional regulation naming them as heritage conservation sites and after they were addressed in the spatial planning document as conservation sites (Local Regulation no.6/2012 on Conservation of Cultural Heritage, 2012). Without a legitimization process, more violations could take place. The overlapping condition of VRBM is located in the philosophical axis, which is the volcano disaster-monitoring zone and represents the upstream–downstream interrelations in a river basin context.

The simplified culture-sensitive approach for the VRB is presented in Figure 9.1, which presents the different types of VRBM phases (as presented in Chapter 7) at the left side as the VRBM realm and simultaneously represents the CEK realm on the right side (Chapters 4 and 8).

The VRBM realm on the left side of Figure 9.1 describes the complexities of merging IWRM and LRM in the VRBM phases. It focuses on the flexible priorities and activities for each phase in each location. It generalizes the Normal and Normal+ phases to support the prioritization of conservation (green border) in the upstream area. This is in line with the findings on master plans' prioritization of the upstream area, although the master plans do not make reference to which VRBM phase, and, in the Normal and Normal+ phases, water utilization (blue border) is prioritized in mid- and downstream areas. These two clusters are what is normally found in everyday conditions in the VRB (pre- and post-eruption). However, the VRB inhabitants know that behind the beautiful landscape and seemingly 'sleeping' volcano, there is always a time when it comes 'alive.' The eruption VRBM handles the onset eruption impacts, which affect the whole river basin, and this phase shifts priority to hazard control (orange border).

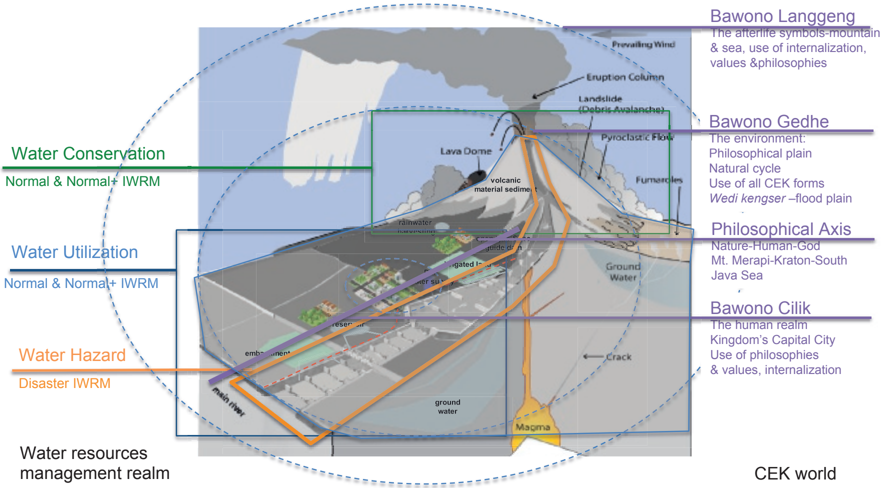

Figure 9.1 Comparison of VRBM realm and CEK realm

Simultaneously, the CEK realm on the right of Figure 9.1 represents the VRB as three levels of worlds (*Bawono*): the human, the environment, and the afterlife, all of which contain components of CEK. The human interactions are found in the lowest world (*Bawono Cilik*), where soft CEK is mostly used. The next world contains water and lahar management, as it belongs to the environment (*Bawono Gedhe*). In this second world, both soft and hard CEK are used, with more attention given to hard CEK, such as artifacts, internalization, and resources management practices. This world also functions as the connection between the human world and the afterlife world. This means that what humans do in life to the environment will have to be accounted for in the afterlife (*Bawono Langgeng)*. This last world is filled with soft CEK, especially internalization, philosophies, and values.

The consequence of having these two realms together is that a culture-sensitive approach is needed to meet both sides' demands. Under this approach, the CEK realm defines the rivers and river basin as a philosophical plane, whereas the VRBM realm defines the river as lahar channel and the river basin as cultural landscape. The CEK realm contributes to the VRBM realm as it reminds the actors of how nature and human are interrelated, resulting in an increasing integration level. However, to facilitate the CEK contribution, the cultural boundary organizations and boundary spanners have to take strategic positions in the interaction attempts, while creating a conducive atmosphere for CEK practices. In this conducive atmosphere, the actors are comfortable about using and practicing CEK at all governance levels and across sectors. If these factors were present in all the VRBM phases, the level of integration would be enhanced.

The findings have shown that the current VRBM is still at the very beginning of aligning these two. However, this study has provided ample data on CEK used actively in society (on both the community and government sides). These data are an important asset to create a more participative, effective, and efficient implementation of VRBM.

9.2.2 Adjusted Conceptual Framework

Although the study is formulated to cover the correlation of CEK roles in water/lahar management in a VRB, traces of volcano management can also be found in this work. Therefore, it is suggested that a thorough study relating the volcano to groundwater management become part of a further study. The recognition and rediscovery of CEK in this study has been rewarding, as its variations and existence can be categorized and clustered in the compatible VRBM phases.

Furthermore, CEK's contribution to VRBM can work in both directions, from the community to the government and vice-versa, as additional knowledge in managing the environment. On the other hand, CEK can be enhanced when the government takes on a CEK practitioner role. However, as this study is limited to one VRB, it may not be possible to generate theoretical arguments for all VRBs in the world. Nonetheless, the general patterns found can be used to investigate similar cases, as this study still lacks a comparative aspect and has yet to be tested in future research.

Nonetheless, the researcher wishes to contribute an expanded version of the conceptual framework to include the boundary spanning activities of boundary organizations and boundary spanners, as they have contributed to answering the last piece of the puzzle about the impact of CEK on VRBM. It is visualized in Figure 9.2.

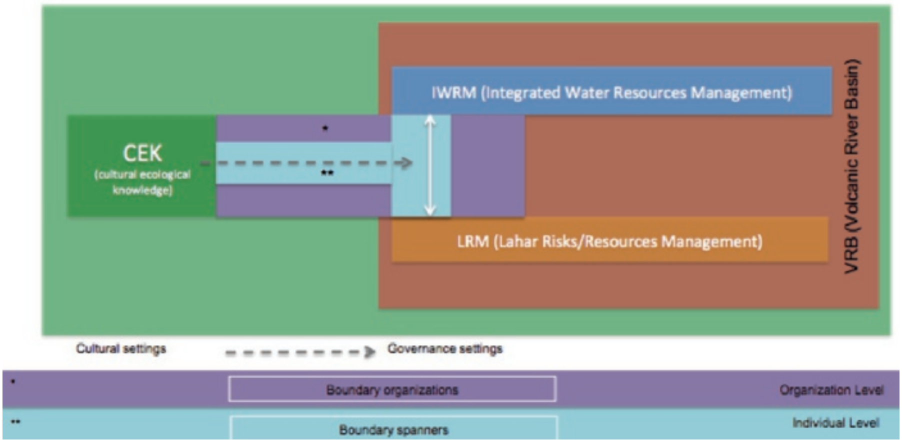

Figure 9.2 Adjusted conceptual framework

This adjusted framework positions the boundary spanning actors in the human dimension, correlating CEK to VRBM as a whole. This additional concept is useful for recognizing the actors who connect and penetrate the boundaries within water, lahar, and volcano management. Furthermore, the levels are divided in two, creating the difference between individual and organizational level. This is significant, as boundary organizations do not always have a boundary spanner, nor do the boundary spanners always belong to a boundary organization. Therefore, these conceptual differences need to be separate as in Figure 9.2. With this addition, the conceptual framework makes more sense, as it now explains the factors (the boundary spanning actors) that contribute to the success of the CEK contribution to IWRM implementation in this VRB.

The CEK in this study is proven to smooth interaction attempts, thereby enhancing the integration level when it is used in management practices. The following formula represents this situation: CEK → (IWRM + LRM) = VRBM (i).

The more CEK is used in VRBM (the combination of IWRM and LRM), the more integrated (i), the VRBM will become. This claim was proved in detailed in Chapter 8 as the culminating chapter of this study, which explains the CEK impacts on VRBM. The findings have shown that integration is higher when boundary spanning actors are present, as they function as CEK agents in performing CEK in management practices and introduce CEK into interaction attempts. In this case study, the actors are the RBO and CBOs (boundary organization), and the whisperers in Normal and Normal+ VRBM transform into contact persons in Disaster VRBM.

9.3 Theoretical Contributions

The introductory chapter of this study describes the gaps in the literature on cultural ecological knowledge (Berkes, Colding, et al., 2000, Howes and Chambers, 1980, Agrawal, 1995), integrated water resources management (Savenije and Zaag, 2008), lahar management (Rodolfo, 1991, Pierson, Wood, et al., 2014), and volcano hazards management (Paton, Smith, et al., 2008, Gaillard and Dibben, 2008, Bignami, Bosi, et al., 2012, Wisner, Blaikie, et al., 2004). The gaps exist because of developments in the divide between knowledge and policies. Therefore, research was needed to find an approach that would open the boundaries between these sectors of natural resources management and bridge the knowledge–policies divide.

The literature review (Chapter 2) identified earlier studies addressing CEK in each natural resources management sector. These studies were undertaken, for example, between CEK and natural resources in general, either water or land (Ross and Pickering, 2002, Jain, Goel, et al., 1998, Howes and Chambers, 1980), CEK and lahar (Pierson, Wood, et al., 2014, Wood and Soulard, 2009, Lavigne et al., 2000), or CEK and volcano (Dove, 2007, Donovan, Suryanto, et al., 2012, Chester, Duncan, et al., 2008, Cashman and Cronin, 2008, Troll, Deegan, et al., 2015), but not on the interrelations of CEK and water–lahar–volcano. These gaps were addressed in the current study in terms of how water–lahar–volcano interrelations are subsumed in VRBM. After the patterns of interrelations were found, these were paired with the CEK findings.

Although concepts on managing water and its related resources are explained in the literature review, these are not yet contextualized in the existing condition in Indonesia. Furthermore, in the VRBM context, the IWRM approach and lahar management within the DRR framework still needs to be tailored to fit the context of the research. Therefore, the analytical framework used as a link in this study was MLG for water (Gupta and Pahl-Wostl, 2013, Moss and Newig, 2010, Termeer, Dewulf, et al., 2010) in a VRB context. Inspired by these earlier works, the empirical chapters are arranged according to the levels of governance found in this case study, namely, policy settings, managerial contexts, interaction attempts, and integration level. The MLG concept was able to discern the complex boundary conditions (within the policy settings and managerial contexts), revealing the main actors from both organizations and community, which was later developed into the interaction attempts diagram (see Figure 7.7). The diagram simplifies the visualization of how the current actors interact in the existing condition and helps to decipher the level of integration based on the analysis of the rich data collected. The MLG concept in this research is tailored to fit the context of the research and has proved to be a flexible and reliable concept. The levels and boundaries detected in the research and taken into account in relation to water, lahar, and volcano management were blurred and overlapping.

The theoretical contributions resulting from this study are detailed in the following sections.

9.3.1 The Concept of Cultural Ecological Knowledge (CEK)

The concept was developed from earlier concepts of traditional ecological knowledge (TEK) (Berkes, Colding, et al., 2000), indigenous technical knowledge (ITK) (Howes and Chambers, 1980), and indigenous knowledge (IK) (Agrawal, 1995). CEK is defined as the body of knowledge describing the human–nature relationship, both written and oral, also transmitted intergenerationally. Both hard (directly used) and soft (background) CEK are part of the solution in bridging the interaction gaps at all levels of the existing MLG and as complementary tools in managing the resources and natural dynamics within this Indonesian VRB. The highest level of CEK utilization is located in the community at local level (first at municipal, later at regional) and can also be transmitted to the governmental and private sectors. Thus, in general, CEK has a natural resources management role in current society.

9.3.2 Integrated Water Resources Management (IWRM) for a Volcanic River Basin

A VRB is described as having the unique characteristics of a catchment with an active volcano at its origin or upstream. Although there is some scientific knowledge on how to monitor volcanic activity, CEK is still considered to be relevant. Primarily, after the 2010 eruption, Mt. Merapi developed a different pattern of eruption, and time was needed to investigate the current pattern at hand. The correlation of volcano to water resources located in the river basin involves both surface and groundwater. This research found that volcanic eruption impacts water resources in several ways. (1) The groundwater temperature rises during active volcanic activities, water quality changes for both surface and groundwater, (2) springs diminish or switch locations, and there is a change in the discharge from rivers and springs, (3) the characteristic sandy volcanic soil is suitable for groundwater recharge, (4) lahar flows in river channels, (5) springs are devastated by lahar flow, and (6) lahar flows to riverside areas (contamination of wells).

IWRM is implemented in this VRB under the pillars of water conservation, utilization, and hazard control (including lahar) with the support of community–private empowerment and the water resources information system. However, IWRM implementation itself is not yet integrated. Little enthusiasm is demonstrated in the existing interaction attempts, as revealed by the respondents' interviews and regional level water councils' written Minutes of Meetings in the period 2012–2017. IWRM is not integrated, because stakeholders do not realize that what they are addressing in the VRB needs to be managed sensitively.

9.3.3 Lahar Risk/Resources Management (LRM)

In this case study, lahar management is defined as having three stages: pre-, onset, and post-eruption management of volcanic debris flow (lahar). Lahar risk management follows the DRR approach to minimize the lahar impact in all stages of the eruption, whereas lahar resources management relates to the extraction of sedimentation composed of volcanic materials, which flows with rainwater during onset and post-eruption. There is a shift in command during these stages. The pre-eruption stage is led by the volcano center (monitoring condition) and the RBO (preparing lahar control infrastructure). The eruption onset stage is led by the disaster mitigation agency, with the help of the volcano center in deciding the status of the volcano. The RBO leads the post-eruption stage for lahar sedimentation extraction or sand-mining activities.

9.3.4 The VRBM Concept

The VRBM concept proposed in this research provides an option for VRBs to implement the IWRM approach in a volcanic setting and also to broaden the integrated water–related resources approach to cover lahar and volcano in an MLG setting and in a comprehensive way. VRBM is formulated to be sensitive to, and aware (proactive) of, volcanic activity as part of daily conditions and not just to cope (reactive) during the eruption onset. This research sees volcano hazards as one of the consequences of living in a VRB that are dealt with by including the status of volcanic activity and disaster management in the VRBM Disaster phase. The IWRM approach and the DRR framework can be merged in lahar management by examining the management sectors and clustering them according to the condition of the volcano.

However, the challenge is now to prove whether the VRBM phases with their interrelations in water–lahar–volcano management can be transferred to other VRBs. It would also be beneficial to compare cases with different cultural backgrounds and types of volcano. Further research is still open in this direction, as not much research has been conducted on this subject.

9.3.5 CEK's Contribution to VRBM

In this case study, the crux of CEK's contribution to VRBM is located in the bridges used: the boundary spanners and the boundary organizations located in the context of the study that are also the links within these interrelated managements. This study provides evidence that CEK can indeed enhance interaction attempts and serve as an alternative tool in managing water and its related resources when CEK is implemented on a daily basis. Integration levels are especially high if CEK is practiced in informal ways.

9.4 Practical Contributions: Recommendations

Some of the results of this research have already been introduced to water resources management practitioners in the VRB under study, during the fieldwork and at a presentation. This case study is chosen to represent an active volcano in a developing country, which are found in abundance worldwide. The practical contributions are not limited to this case but can provide lessons for other VRBs. The methodology used is to assess CEK utilization directly within the community and organizations, and also within the multilevel hierarchies in the water governance context.

9.4.1 Direct and Flexible VRBM Policy

The study shows that there is no direct policy available for lahar management. Therefore, the study can be used as a baseline study in sketching the current 'mix and match' management condition. It also suggests that lahar should be seen in terms not merely of risks, but also of resources, once the eruption settles and the flow stops. Government needs to be aware of the gaps in management existing between the ministries (PUPR, ESDM, LHK, BNPB) and within regional government (BPBD, BBWS SO, BPDAS-HL SOP, PVMBG, PUP-ESDM) regarding who should address lahar risk and resources management under a flexible legal umbrella. Flexibility is needed because VRBM requires the switching of roles in each phase.

In the current state of affairs, lahar risk management comes under BPBD (Disaster VBRM), but the lahar hazard control infrastructures and lahar as a resource fall within the remit of BBWS SO (Normal and Normal+ VRBM), as it manages all rivers in partnership with regional government for sand mining (Normal+). However, currently there is no institutional framework either planned or legislated for. The shifts between the VRBM phases should be recognized as the interrelations of VRBM phases, as recognized in this research. The study proposes a flexible arrangement for lahar management to take place, where the current actors are given better support from the policy point of view, thereby enabling them to decide and act directly. This condition requires direct reference to water master plans with VRBM phases, as introduced in this thesis. This will help to clarify which activities can be undertaken in each phase, as set out in the synthesis in Figure 9.1, so that the VRB is better prepared for future eruptions.

9.4.2 Realigning CEK in VRBM

The findings revealed that a precise awareness of CEK is needed for it to be included in revisions of water resources management and spatial planning master plans. This condition presents the challenge of focusing decision makers' attention toward including CEK in existing master plans. For this to happen, the existing boundary organizations and boundary spanners in the interaction attempt need to be detected. The support of the RBO, as the main boundary organization working in this MLG situation, and also of the CBOs is required here. With the trend of CEK interests gaining momentum currently, as shown in this cases study, both soft and hard CEK should be mainstreamed into the revised master plans with the assistance of these boundary actors.

This condition highlights the need for contextualized knowledge that stems from indigenous culture rather than from adapted international frameworks. For example, philosophies and values are used in interaction attempts to soften the boundaries between organizations in informal ways, artifacts are used in the spatial arrangement of the river basin for conserved areas or sacred geography, rituals/myths are used as a communication strategy toward living in harmony with nature's dynamics, and resources management practices and five senses wisdom are used as alternative tools. All of this creates the opportunity for CEK to soften the boundaries located in the interaction attempts.

As the water law is still revoked, there is still time to propose the inclusion of CEK in the upcoming revision of the law. Essentials of the CEK findings in this study can be added to the community development strategy and understanding on the sectors of water conservation, water utilization, and hazard control (lahar). The CEK conceptual framework can also be used as a tool to enlist CEK on the ground for general river basin management in Indonesia, especially to respect indigenous land and communities' rights in situations where conflicts are ignited between the government and the communities. These conflicts mostly occur when infrastructure is to be built on sacred lands or artifacts.

The study found a lot of evidence of how unstructured sand-mining activities are dealt with and how CEK is abandoned in these 'greedy' practices. There is still space to introduce CEK into the institutional framework for sand-mining activities. CEK can be used as a tool to assess easily whether a location is overmined or can still be mined. Potentially, local communities with their five senses wisdom, resources management practices, and sacred artifacts can delineate the safe sand-mining locations.

This study proposes the idea that CEK contributes to IWRM in the Normal and Disaster VRBM phases. Within its limitations, it has provided some examples of CEK utilized. However, the list may extend to other locations, and CEK needs to be conserved. Its survival is based on the legitimization process by the regional government (Kraton) and substantial support from the national government for tangible and intangible cultural heritage conservation. Therefore, the practice of CEK in the realm of natural resources management has to be made more active, by identifying the boundary organizations and boundary spanners on the ground. This study has uncovered the identity of some of these boundary spanners, but more investigation is needed to identify their characteristics, to map their whereabouts, and to identify more opportunities for integrating CEK into water resources management in general.

By the time the second fieldwork was completed, an increasing trend of interest in CEK practices was found in the case study. This trend is inspired by the important roles played by leaders of organizations, whether formal (governmental) or informal (community initiated). When these leaders are in favor of becoming a boundary spanner, they can be the bridge to accommodate both ways between government and community, a condition that is not evident in the interaction attempts. In other instances, the role of a free boundary spanner with specificity can contribute as a catalyst to form the connection.

9.4.3 Reflection on Current Relevant Literature

This research studied how CEK has evolved in current society in a volcanic Indonesian river basin. CEK is not stationary; it evolves according to communities' experiences, combining old and new knowledge with scientific knowledge (Hiwasaki, Luna, et al., 2014, Raymond, Fazey, et al., 2010). The 2010 eruption altered the known CEK and produced new CEK. The current communities utilized the new CEK developed on the basis of current actual experiences. For example, the course of lahar flow changed from the old days from being predominantly in the Progo Basin to being in the Opak Basin after the 2010 eruption. Respondents told the story of how, in the 1960s, the previous

Sultan went to the mid-point of the river and waited directly before the lahar passed in the Gendol River in the upstream area. The current Sultan with his spear went to six urban rivers in the midstream area or the city center of Yogyakarta, in combination with a scientific early warning system, to signal lahar flow before it happened. The new CEK explained that the lahar would flow midstream and not just upstream. The imported scientific knowledge referred to Japanese Sabo dam systems, the IWRM approach, the Western hydrological approach, and volcanic monitoring systems and combined with local CEK to produce new CEK. The results of this research also indicate integration of CEK into current management practices; in particular, those that are directly implemented result in a better management integration level, which in this study occurred in all VRBM phases.

The production of knowledge, in this thesis addressed in Chapter 4 and continued in Chapter 8, agrees on the continuum of understanding from facts through data, information, and knowledge, to wisdom (Weichselgartner and Pigeon, 2015). Although the boundaries between the levels are vague, wisdom, as paramount, can only be transferred to others through communication and dissemination. However, this wisdom has to be transferred with its contexts, not merely information, thereby enabling the person to whom it is transferred to use it to develop the knowledge and further the wisdom. A legitimation process is still needed, either through the cultural people/the Kraton or local government, but with regulations. The researcher also agrees with Gaillard that more research by local researchers is needed to improve the understanding of DRR using the correct local contexts (Gaillard, 2019). Although the scope of this research is limited, it provides an understanding of the cultural and political contexts in a river basin. The research highlights the importance of local knowledge and how all types of local knowledge develop into newly generated knowledge, which functions to prepare communities to face future eruptions. The study demonstrates that the production of knowledge occurred in multiple loops of learning, as addressed by Pahl-Wostl's study on the adaptive capacity of governance and management systems (Pahl-Wostl, 2009). The actors governing the VRB learned in this way to cope with the increasing risks of eruption with the progression of climate change (Kutterolf, Schindlbeck, et al., 2019).

The thesis proves that actors at local and national level have included CEK and its practices to complement scientific knowledge as mandated in the Sendai Framework (Aitsi-Selmi, Egawa, et al., 2015). Although the IWRM approach does not mandate the inclusion of CEK, it shares a similar sentiment regarding the knowledge and participation of all stakeholders under varied cultural contexts (Matz, 2008, Delfau, 2018). The needs that arise in the Disaster VRBM phase spark a sudden interest in CEK, which is most evident in disaster response activities. Although the government's understanding is limited to earlier CEK, it has learned to document, although not yet in a systematic way, and follow the development of newer CEK based on current environmental conditions and humans' interventions in nature. Further understanding is needed to build greater awareness of the learning process in order to influence decision-making processes at all governance levels.

9.4.4 Lessons Learned for Further Study

The culture-sensitive inquiry chosen for this research uses the lens of CEK in VRBM. As the research unfolded, the inquiry required the researcher to rediscover the forms of CEK that are still used in VRBM practices. The CEK formulation framework and its indicators, as explained in Chapter 4, provided an example of how the concept and methods are operationalized. This framework and the methods are useful for later researchers as a tool if they want to proceed with similar inquiries in their studies.

Also, in line with this study, this culture-sensitive approach can be applied to other kinds of river basins with different types of hazards. It would be interesting to compare what kinds of CEK are used for what kinds of hazard-prone river basins and come up with a more generalized theory or concept that encompasses these differences. Therefore, the researcher hands this study on to future researchers, in the hope that this culture-sensitive approach will be further developed to fit future conditions.

Appendix 1 Initial Operationalization (2016)

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Integrated water resources management in volcanic river basin: the process of managing water and its four interrelated dimensions in water catchments with direct origin at a volcano.	Interrelated of natural dimensions (Graefe, 2011, Savenije and Zaag, 2008, Gleick, 2003, Marso, J. N., 2013, Lavigne, Thouret, et al., 2000, Wisner, Blaikie, et al., 2004, Weichselgartner, 2001, Dove, 2008)	Interrelation of resources (Graefe, 2011, Savenije and Zaag, 2008, Gleick, 2003, Marso, J. N., 2013, Lavigne, Thouret, et al., 2000, Wisner, Blaikie, et al., 2004, Weichselgartner, 2001, Dove, 2008)	Existence of interrelation of management for: (1) Atmosphere (2) Water (3) Land and volcano	Behaviors: Implementation of management in actions, i.e. projects, plans. Patterns of interactions: Mood in organizations in managing interrelated resources Scenes: Water infrastructure projects in context of IWRM	Is there evidence of resources interrelatedness in the water-air-land management? How is the current interrelation takes form?
		Interrelated processes (Graefe, 2011, Savenije and Zaag, 2008, Gleick, 2003, Marso, J. N., 2013, Lavigne, Thouret, et al., 2000, Wisner, Blaikie, et al., 2004, Weichselgartner, 2001, Dove, 2008)	Existence of management in the following processes: (1) Hydro-meteorology (2) Hydro-geology	Behaviors: Actions based on the integration of processes as base of Patterns of interactions: Understanding in coordination of processes Scenes: Evidence of lahar occurrences in location	Is there evidence of managing the interrelated processes: Water and climate condition? What is the form of this management? Water and geological condition? What is the form of this management? Occurrence of lahar? What is the form of this management? Does the interrelation these three processes exist in management? How does it function?
		Interlinking of hydro-geomorphological characters (Molle, 2009, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003, Pierson, Wood, et al., 2014, Sumaryono, 2011)	Existence of management in the inter-linking of hydro-geomorphological characters: (1) Up stream (2) Down stream (3) Type of rivers	Behaviors: Actions in addressing links of hydro-geomorphological characters Patterns of interactions: Accommodating or ignorance Scenes: River location and forms of rivers	Does the spatial plans interlink hydro-geomorphological characters of the location? How does it describe the up and down stream relation? How does it explain the spatial type of rivers in regard to water and volcano?
	Interlinking of spatial dimensions (Molle, 2009, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003, Pierson, Wood, et al., 2014, Sumaryono, 2011)	Interlinking of spatial scales (Molle, 2009, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003, Pierson, Wood, et al., 2014, Sumaryono, 2011)	Existence of management linking of scales: (1) Watershed (2) River basin (3) Inter-basin	Behaviors: Actions based on interlinking of scales Patterns of interactions: Accommodating or ignorance Scenes: Managerial scenes in the location depicting scales relationship	Does the spatial plans includes these different scales (watershed-river basin- inter-basin) in an interlinking way? How is the form of these interrelations being described?
		Interlinking of functions (Molle, 2009, Graefe, 2011, White, 1963, Hofwegen and Jaspers, 1999, Jaspers, 2003, Pierson, Wood, et al., 2014, Sumaryono, 2011)	Existence of management of interlinking of functions: (1) Land use (2) Hazard map (3) Administrative delineation	Behaviors: Acceptance of denial of functions Patterns of interactions: Accommodating or ignorance Scenes: Multi-functionality of space in location	Does the spatial plans take account (land use, hazard map and administrative boundary) in a synchronized way? How is the interrelation of spatial function in IWRM akes form?
	Holistic interrelation of temporal (Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009, Lavigne and Thouret, 2003, Case, Ardiansyah, et al., 2007)	Interrelation of natural rhythm to integrated water resources (Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009, Lavigne and Thouret, 2003, Case, Ardiansyah, et al., 2007)	Existence of management interrelation in: (1) Annual hydrological cycle (2) Seasonal pattern (3) Volcanic periodical cycle	Behaviors: Activities in deciphering these cycles in management Patterns of interactions: Supporting or ignorance Scenes: Discussion of related data on natural cycles	Does the current management take into account the following timing and how are these being observed: Annual hydrological cycle and its changes? Seasonal pattern and its changing trend? Volcanic periodical cycle, short and long term? Is there an interrelation of these three rhythms being acknowledge?
		Interrelation of social pace to integrated water resources (Jaspers, 2014, Savenije and Zaag, 2008, Ndirangu, Kabubi, et al., 2009, Lavigne and Thouret	Existence of management interrelation in: (1) Water balance (2) Hazard prediction	Behaviors: Activities on deciding water balance, hazard prediction, early warning measures, formulating term plans Patterns of interactions:	Is there exist a form of management in controlling and how does it function in: Water balance: supply and demand function over time?

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
		Ndirangu, Kabubi, et al., 2009, Lavigne and Thouret, 2003, Case, Ardiansyah, et al., 2007, Jousset, Pallister, et al., 2012)	(3) Early warning (4) Term plan	Supporting or ignorance Scenes: Discussion of related data to decide action	In terms timing of hazard prediction related to water and volcano? In regard to early warning of volcanic eruption, lahar hazard, and flood? In regard to water in term planning (either short, medium or long) of volcanic river basin?
	Human: organizational relationship (Edelenbos, Bressers, et al., 2013, Jaspers, 2003, Watson, 2004, Medema, McIntosh, et al., 2008, Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004, Savenije and Zaag, 2008)	Interrelatedness of organization structure (Edelenbos, Bressers, et al., 2013, Jaspers, 2003, Watson, 2004, Medema, McIntosh, et al., 2008, Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004)	Existence of interrelatedness of: (1) Leader with integrated orientation, (2) Types: local community groups and manager organization	Behaviors: Integration structure of organization Activities accommodating interaction of groups and managers Patterns of interactions: Accommodating or hindering Scenes: Discussion on structure and interrelation of managers and local communities	Is there evidence of interrelatedness in organization structure in: Managing water with integrated visionary leader? Is there many related stakeholders being led? How is this leader chosen? Who are the main stakeholders? Is there a forum for these stakeholders to congregate? Does it consist of agency and community representative? Who are these representatives and how are they chosen?
		Interrelatedness of organization components (Edelenbos, Bressers, et al., 2013, Jaspers, 2003, Watson, 2004, Medema, McIntosh, et al., 2008, Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004)	Existence of interrelation of organization components: (1) Connective capacity in norm and rules (2) Rights (3) Responsibility	Behaviors: Inter-organization connective activities Actions based on responsibility rights in interrelated resources Patterns of interactions: Accommodating or hindering Scenes: Discussion on components in of organization in interrelated resources between managers and local communities	Is there evidence of interrelation to one another? Are they behaving under some connective norms and rules? What are these norms and rules? How are they being used and what are the origins of these norms and rules? Are there rights and responsibilities being introduced in the interrelation? How are these being imposed?
	Natural: The management of ecological agent of change, which may induce potential of disaster (Dove, 2008, Wisner, Blaikie, et al., 2004, Weichselgartner, 2001)	Monitoring of volcanic activities (Chester, 1994, Lavigne and Thouret, 2003, Pierson, Wood, et al., 2014, Leung, Santos, et al., 2003)	Existence of management on monitoring the volcanic activities: (1) Eruption (2) Pyroclastic flow (3) Lahar	Activities: Measuring and quantifying volcanic activities Scenes: Experts monitoring volcano	Is there evidence of measuring volcanic activities? Who are in charge of this? Is there relation to water management?
		Monitoring geomophorlogy characters in relation to lahar (Rodolfo, 1991, Lavigne and Thouret, 2003)	Existence of monitoring processes in management and policies in relation to lahar production: (1) Geology (2) Morphology	Behaviors: Ways of measuring geology and morphology and its relations Scenes: Experts monitoring these processes	Is there evidence of measuring hydrology and meteorological activities in relation of monitoring lahar? Who is doing what? Is there relation to geological conditions of a river basin? Is there relation to water management?
		Monitoring in understanding of lahar characteristics (Lavigne and Thouret, 2003, Marso, J. N., 2013, Rodolfo, 1991)	Existence of monitoring processes in management of lahar's: (1) Speed (3) Composition (DF, HSF, SF)	Behaviors: Ways of measuring lahar characteristics, method and tools Scenes: Experts monitoring these processes	Is there evidence of measuring lahar characteristics? Who is doing what?
	Spatial: The management of geographical attributes of a hazard zone map (Pierson, Wood, et al., 2014, Sumaryono, 2011)	Historical hazard record map (Newhall, C. G., et. al., 2000, Newhall, Bronto, et al., 2000 Voight, Constantine, et al., 2000)	Existence of: (1) Implementation of plan (2) Monitoring In hazard map	Activities: Spatial recording or archives on history of lahar hazard Scenes: Archiving of lahar reach history map	What spatial policies are implemented during the course of lahard hazard history? Who are responsible for the map? What was the result in terms of lahar impacts? What spatial ways of monitoring during the course of lahard hazard history? Who are responsible this? Are there results of this monitoring?
		Future hazard map (Pierson, Wood, et al., 2014, Sumaryono, 2011, Voight, Constantine, et al., 2000)	Existence of planning in hazard map	Activities: Spatial prediction of lahar reach in the future Scenes: Projecting future lahar map	What spatial policies are used in defining the future hazard maps? Are there other related policies used? Who are responsible in determining it? What is the aim of the map in terms of risk management?

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Lahar Risks Management	Temporal: The management of redefined forms of volcanic eruption periodical cycle(Lavigne and Thouret, 2003) and seasonal patterns with their variations(Case, Ardiansyah, et al., 2007)	Natural time functions: volcanic (Gaillard, 2008, Lavigne, De Coster, et al., 2008, Chester, 1994, Lavigne, Thouret, et al., 2000, Gertisser and Keller, 2003, Voight, Constantine, et al., 2000) and annual and periodical hydro-meteorological cycle (Ndirangu, Kabubi, et al., 2009, Viviroli, Archer, et al., 2011, Zalewski, 2013, Voight, Constantine, et al., 2000)	Existence of management form on volcanic eruption cycle: (1) Planning (2) Implementation (3) Monitoring	Activities on managing eruption cycle in form of: (1) Time planning (2) Implementation of time plan (3) Monitoring of time plan Scenes: Discussion on time management in regard to lahar and volcanic eruptions	What are the policies used to plan, implement and monitor the volcanic eruption cycle? What are the forms of these policies? Who is responsible to establish these policies?
			Existence of management in annual and periodical hydro-meteorological cycle: (1) Planning (2) Implementation (3) Monitoring	Activities on managing hydro-meteorological cycle in form of: (1) Time planning (2) Implementation of time plan (3) Monitoring of time plan Scenes: Discussion on time management in regard to hydro-meteorological cycle	What are the policies used to plan, implement and monitor the hydro-meteorological cycle? What are the forms of these policies? Who is responsible to establish these policies?
		Human-nature relation time scales: (1) Before (Leung, Santos, et al., 2003, Weichselgartner, 2001, Paton, Smith, et al., 2008, Keys and Green, 2008 (Gaillard, 2008, Mei, Lavigne, et al., 2013, Lavigne, Thouret, et al., 2000)	Existence of: (1) Mitigation plans (2) Early warning	Activities: Setting up plans Monitoring eruption, rainwater and lahar Scenes: Discussions on setting up the plan and early warning	Who are responsible for this plans? How are they being implemented? What are the policies use in setting of mitigation plans? What are the policies used in the setting of early warning plan?
		(2) During (Jousset, Pallister, et al., 2012, Mei, Lavigne, et al., 2013, Mei, Lavigne, et al., 2013)	Existence of: (1) Evacuation plans, (2) Emergency response	Activities: Setting up plans Dealing with lahar occurrence Scenes: Evacuation in progress Emergency response in progress	Who are responsible for this plans? How are they being implemented? Who are responsible during emergency response? How are they being implemented?
		(3) After (Thouret, Lavigne, et al., 2000, Lavigne, De Coster, et al., 2008, Boudon, Camus, et al., 1993, Gertisser, Charbonnier, et al., 2012, Newhall, C. G., et. al., 2000)	Existence of: (1) Long term projections (2) Sediment management	Activities: Projecting eruption and lahar occurences Monitoring sediment transports balance Scenes: Projection decissions making process Sediment mining control and permission	What forms of projections are avalaible? Who are responsible for them? What kinds of sediment management policies are implemented? Who are responible for these policies?
	Human: The management of organizations in managing disaster, which are affiliated to different institution(Birkmann and von Teichman, 2010, Wisner, Blaikie, et al., 2004, Cardona, 2004)	Components of relationship in organization (Birkmann and von Teichman, 2010)	Existence of relationship components: (1) Norm and rules (2) Rights (3) Responsibilities	Activities: Interreactions between organizations Scenes: Discussion forums	What are the norms and rules obeyed in interrelation between organizations? What are the rights and responsibilities of each organizations? How do they relate to one another? Any problems arisen in the relationship?
		Types of stakeholders (Cardona, 2004, Wisner, Blaikie, et al., 2004)	Existence of stakeholders: (1) Agencies (2) Communities	Activities: Actions in relation to prepare, during and after lahar disasters Scenes: Discussion forums	
		Generation of knowledge (Daldjoeni, 1984, Berkes, Colding, et al., 2000)	Existence of experiences in: (1) Reinterpreting physical-environmental signs, Revival of local knowledge	Behaviors: Act of reinterpretation Act of finding old knowledge Pattern of interactions: Relation of signs to daily life	What is the history of the knowledge origin? How does the knowledge keep alive in society? Is this experience based on record? Does it come from the 'reading the meaning' of signs given by nature? Has it been used in older generations?

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
				Scenes: Location and conditions of signs and knowledge used	
		Responding to environmental condition (Berkes, Colding, et al., 2000)	Existence of experiences in: (1) Monitoring change, (2) Resource abundance/ scarce Managing ecological disturbances/ hazards	Behaviors: Keeping track of change either by note, memory, etc. Activities to adapt to future hazards; flood, lahar, eruption Pattern of interactions: Relation of change and hazard to daily life decisions Scenes: Implementation of adaptation and coping strategies for change and hazards	Are there experiences in following environmental changes, in qualitative way? How does it measure the quantity of resources? Are these changes being recorded? Are there experiences in handling hazards? What kind of hazards? How is it being handled?
	Historical experiences (Daldjoeni, 1984, Berkes, Colding, et al., 2000).	Protection or conservation of resources (Brush, 1993, Berkes, Colding, et al., 2000, Gadgil, Berkes, et al., 1993, Ross and Pickering, 2002, Berkes, 2012)	Existence of experiences in conserving the nature: (1) Sources of material, (2) Vulnerable life, (3) Sacred locations	Behaviors: Protecting certain area, sources and biotic components Pattern of decision: Relate to protection areas, avoidance or honoring decisions Scenes: Location where the protection areas are defined and 'marked'	Are there experiences in protecting the nature? How is the method? What kinds of sources are being conserved? Does it concern protecting exposed life condition? Are there locations being protected due to its sacredness? What are these locations usually consists of? Where are they located? Why are they being protected?
		Temporal (Daldjoeni, 1984, Berkes and Folke, 1998, Naylor, Battisti, et al., 2007, Brush, 1993)	Existence of experiences in: (1) Restriction of harvest, (2) Resource rotation, (3) Periodic cycle of nature	Behaviors: Activities in farming and natural resources management consider certain calendar Activities honoring timing of natural cycle of water, volcano and season Pattern of interactions: Relate to protection areas, avoidance or honoring decisions Scenes: Location where the protection areas are defined and 'marked'	Are there experiences in managing time in regard to nature? How are these being done and when? Does it consist of harvest time restriction? Is there resource rotation management? Is there other periodic cycle of nature being managed?
		Managing dynamics of complex system (Brush, 1993, Berkes, Colding, et al., 2000, Steward, 1972, Capra, 1996, Daldjoeni, 1984, Flanagan and Laituri, 2004)	Existence of experiences in: (1) Managing the water-shed (2) Collection of resources (3) Ecological process at multiple scales	Behaviors: Activities in managing watershed Activities of resources collecting; water harvesting, mining, farm harvesting Activities in managing natural cycle of water, seasonal pattern, volcano Pattern of interactions: Relate to ecologically friendly attitudes Scenes: Picturing attempts in managing the ecology Context of resources collection activities	Are there experiences in managing nature's dynamics? How are these being done? Is it consists of managing land and its relation to water? Is it concerns acquiring of resources? Is there also management in complex scales of nature processes?
		Cultural institutions structure (Berkes, Colding, et al., 2000)	Existence of: (1) Stewards (2) Local tasks groups	Behaviors: Acted as the wise person Acted as groups of function in water management and related resources Patterns of interactions: Detect honoring relations from members of groups to stewards and tasks groups Scenes: The steward and task groups performs it action	Is there a 'wise person' in the community with cultural importance? How and why was he/she being elected? What is his/her main responsibility? Is there group who manage certain tasks in relation to the nature? Why are they selected to belong in this group? How are the people in this group being selected? What are their responsibilities?
Cultural ecological knowledge: the collective body of knowledge and beliefs passed through generations, which explain about the human – nature relationships.		Cultural institutional dynamic (Inglis, 1993, Berkes, Colding, et al., 2000)	Evidence of: (1) Integration of knowledge into every day life especially in regard to water and volcano (2) Social/religious sanctions in regard to natural resources management	Behaviors: Activities as living traditions related to water Implementation of sanctions Patterns of interactions:	Is there a living tradition in direct relation to water and volcano? How are these traditions being held? Are there sanctions if one violates certain tradition toward the nature? How are these sanctions being implemented? Is it still effective?

Concepts	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
				Detect patterns of works in tasks groups and the locals Scenes: Traditional activities in dynamic setting Social sanctions forms, if any	
	Forms as mechanisms of transfer (Berkes, Colding, et al., 2000)	Cultural internalization (Berkes, Colding, et al., 2000, Inglis, 1993, Berkes, Folke, et al., 1995, Mulder, 2005)	Existence of: (1) Rituals (2) Cultural frameworks (3) Folklore/myth (4) Regulations/taboos	Behaviors: Activities in rituals Accepted cultural frameworks and its implementation Living folklores Accepted taboos and regulations in relation to water Patterns of interactions: Human interactions in performing the rituals, in implementing cultural frameworks, ways of transmitting folklores and regulations Scenes: Ritual performance Forms of cultural frameworks into motto of life and implementation Story telling	Are there special rituals in honoring the nature? How are they being held? When? What is the meaning behind the rituals? Is there cultural core regarding the perception of nature? Are there myths used to manage the environment, especially related to water or volcano, or both? Are there regulations and taboos related to water and volcano? What they and their meanings?
		Worldview (Geertz, 1973, Dradjat, 2009, McArthur and Baron, 1983, Mulder, 2005)	Existence of: (1) Symbol/physical artifacts: material realm (2) Cosmology	Behaviors: Interpreting symbols and cosmology into every day life Patterns of activities in life related to water: working, learning, washing, etc. Patterns of interactions: Discovery of symbols Scenes: Artefact on worlview	Is there symbol being used to express worldview in the physical realm? How is it used? Is there cosmological concept toward worldview? How is this represented in the real world?
		Cultural values (Endraswara, 2013, Geertz, 1973, Geertz, 1976)	Existence of: (1) Set of ethics advised as correct ways (2) Reciprocity towards community	Behaviors: Forms of honoring the nature and people Patterns of interactions: Roles of ethics in daily life Scenes: Artefact of values	Are there norms of relationship exist in the society? Does it consist of rules, values of right and wrong? How is it being implemented? Is there mutual cooperation to local community? How does it function?
	Wisdom in human-nature relationship (Berkes, Folke, et al., 1995, Geertz, 2000, Agrawal, 1995, Howes and Chambers, 1980)	Substantive (Agrawal, 1995, Berkes, 1993, Capra, 1996, Geertz, 2000, Geertz, 1976)	Existence of substance limitation in: (1) Context of location (2) Territoriality (3) Place meaning (4) Geographic specific	Behaviors: Contextualizing location with territorial boundary Giving meaning to places Patterns of interactions: Discussion in context of wisdom Scenes: Context of location as setting for certain wisdom	Is there wisdom of human and nature relation, which is specific to certain location? Does it have special context? Is the wisdom having a territorial boundary? Would the place have a meaning in terms of human nature relations? What would the mean be? In what specific geographical description does the wisdom apply?
		Methodological (Berkes, Colding, et al., 2000, Agrawal, 1995, Howes and Chambers, 1980)	Evidence of relying on intuitions available to the senses (1) Visual (2) Smell (3) Hear (4) Touch/feel (5) Taste	Behaviors: Practice of methodologically discerning wisdom through the senses Patterns of interactions: Human-nature interactions in using this methods, i.e. water through visual and touch, air through smell and feel, etc. Scenes: Depicting the setting of practice of methods	How does the wisdom being used? Is it based on the human senses? What are the examples of these procedures? Does each of the five senses being used? Are there supporting tool for measuring? Is the measurement in quantitative or qualitative form?

Appendix 2 Operationalization of Overlapping of LRM in IWRM

Level of Interrelations	Variables	Indicators	Measurements	Things to be observed	Guiding Questions
Overlapping in Organization Level (Gustafsson and Lidskog, 2017, O'Mahony and Bechky, 2008)	Overlapping Organizational Actors	The ability of organizations in:	Existence of organizations with:		Who are the main organizations to link IWRM and LRM? How do they operate?
		(1) Connective capacity between communities to organizations and between organizations	(1) Connection of organizations between IWRM and LRM	Behavior: Main organizations, which extend their boundaries between IWRM and LRM	
		(2) Providing platform of negotiation	(2) Platform of negotiation: ability in 'brokering' different interests	Scenes: interaction forums initiated by organizations which extend between IWRM and LRM	
Overlapping in individual Level (Van Meerkerk and Edelenbos, 2014, Pennington, 2008, Williams, 2002, Levina and Vaast, 2005)	Overlapping Individual Actors	The ability of a person with:	Existence of:	Behavior:	Who are the individuals between IWRM and LRM? How do they operate in a non-hierarchical way? Who gave access to it?
		(1) Network performance	Operates in non-hierarchical power	Activities of networking inter-hierarchies	
			Improver in cognitive ability: individuals with understanding of IWRM and LRM	Activities on enhancing the IWRM and LRM	
		(2) Trust building	Builders of trust: important position hold by these individuals	Activities on trust building and networking between non-government and government	How the individual gain trust?
			Legitimately appointed (when applicable)	Persons with appointed role as boundary spanners	

This operationalization is used to answer the second part of sub-RQ in chapter 7. It stemmed in the interrelations, especially focusing on the overlapping of actors' jurisdiction and capacity in connecting and networking within the interaction attempts. At the organizational level, the overlapping revolves on the connective capacity and negotiation platform. Meanwhile, for the individual level, it relates on the ability of the individual in network performance and trust building. The overlapping in this chapter is taking place between IWRM actors and LRM actors.

The analysis also uses Atlas.ti by going back to the data and added the coding from this operationalization to the existing axial coding (CEK, IWRM, and LRM). Thus, a selection of data, which were coded earlier to construct chapter 5 and 6 were analyzed in a meta-level. The results of the analysis based on this table are presented in chapter 7 on the summary of water and lahar interrelations. Earlier section 7.4 still uses the terminologies in the Appendix 2. However, by the end of chapter 7, the overlapping is found to relate strongly with the boundary spanning activities phenomena. Thus, the reference was made to readjust the terms, which later on is also used in chapter 8 with a different context. The overlapping activities in this chapter is termed 'sectorial boundary spanning activities.'

Epilogue

This research starts as a personal inquiry, as a surviving victim of the 2010 eruption, also a form of sympathy for the inhabitants of Yogyakarta Special Region for the condition of 2010 Mt. Merapi eruption. Seeing the condition in 2010, the community helped each other and used their local knowledge to evacuate from hazard zones and rebuild their homes, made the researcher realized there is knowledge to be harvest there for future generation, to learn about this condition. The 100-year cycle will surely repeat and hopefully by then this research contributes to what is little known in the current management on the sensitivity of the cultural ecological knowledge for coping and sustaining life for the volcanic river basin inhabitants.

As the researcher 'poked' around on different levels or water management organization, be it in the community or government, the leaders or decision makers were included as respondents in this research. This may add to the increasing trend of CEK utilization in the water management practices in including the participative approach for the community to actively engage and supported by the RBO. Also, at the end of 2018, there were initiatives by one of the water councils in discussing on loses of current regulations and practices not to include the CEK. This is seen as an improvement to the assessed one-way discussion that is usually held by the water councils. Also, an increase trend in the river community's activities hopefully will provide better integration of CEK in the management of volcanic river basin.

With the results of this study, the researcher wish to add the knowledge on how CEK can be used for other river basins under volcanic conditions, and potentially to any kind of disaster-prone river basins in the world.

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Activities During Ph.D. Trajectory
Guest Lectures
Volcano Tourism, Bauhaus University Weimar, Germany, December 2015
Call for Transdisciplinary Approach in Dams Management, Indelftnesia, TU Delft – UNESCO IHE – Indonesian Embassy, 2015
Indonesian Committee of Large Dam (INACOLD) Young Engineers' Writing Workshop, 2016
Urban River Design and Management, Universitas Teknologi Yogyakarta, 2016

Involvement at Institute for Housing and Urban Development Studies
UN-Habitat workshop moderator in 2015
UECC workshop moderator in 2017
Master Thesis supervisor in 2018

Collaboration Works with the Indonesian Ministry of Public Works and Housing
Initiation of Project Yogya (2015 - 2016): Recommendations for the continued pursuit of a safe, durable and sustainable Tanjung Adikarto Port – an Interdisciplinary Master Student Research with TU Delft
https://repository.tudelft.nl/islandora/object/uuid:fb8f1c90-91d1-4d08-a161-395cd29cc26c?collection=education

Conferences Attendance as Oral Presenter
International Commission on Large Dam (ICOLD) 2015 Stavanger Norway
ICOLD 2016 Johannesburg, South Africa
Dresden Nexus, 2017, UNU Flores, Dresden, Germany
ICOLD 2017 Prague, Czech Republic
Regional Studies Association Winter Conference 2017, London, UK
ICOLD 2018 Vienna, Austria
ISOCARP 2018, Bodo, Norway
Earth System Governance 2018, Utrecht, The Netherlands
ISOCARP 2019, Jakarta, Indonesia
ICID 2019, Denpasar, Bali, Indonesia

Publications
Conference Proceedings
The Use of Cultural Ecological Knowledge, The Pranata Mangsa as Comparative Tool for Shifted Seasonal Pattern in Sermo Dam Operation, Yogyakarta, Indonesia. Ariyanti, Vicky; Wicaksono, A.A.; Adji, T.B.; Anung, A. ICOLD, Johannesburg, South Africa, 2016.

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Addressing Food, Energy and Water Nexus in A Volcanic Area Case Study: Kalibawang Irrigation Channel, Yogyakarta Special Region. Purwadi, H.; Adji, T.B.; Ariyanti, V. ICID, Chiang Mai, Thailand, 2016. (Inspired by the indicators of IWRM from literature review in chapter 2 on irrigation in Mt. Merapi, using different case study of Progo River Basin) https://www.icid.org/wif2_full_papers/wif2_w.1.1.14.pdf

The Importance of Sabo Dams System in Volcanic Catchment Management; Case of Tambakboyo Small Dam, Yogyakarta, Indonesia Authors: Ariyanti, V.; Yulinsa, N.; Tiamono, R. ICOLD, 2017. (Inspired by the lahar management in chapter 6, but using different case study and different data for interviews)

Future Direction for a Volcanic Basin Planning (Case Study of Opak Sub-Basin, Yogyakarta, Indonesia). Ariyanti, V., Edelenbos, J., Scholten, P., ISOCARP, Norway, 2018 (based on chapter 7 VRBM, presented at ISOCARP 2018)

Irrigation Self-governance under Volcanic Conditions. Lessons from Progo and Opak Sub-Basins, Indonesia. Vicky Ariyanti, Rigakittyndya Tiamono, Shakti Rahadiansyah, Agus Rudyanto and Pramono Pramono. ICID 2019, Denpasar, Bali, Indonesia.

Journal Article– on revision process 2019

By the Regional Studies Association (RSA) - Journal of Regional Development and Policy
Advancing the Integration of Water Resources Management in a Volcanic River Basin. Ariyanti, V., Edelenbos, J., Scholten, P., Taylor and Francis (based on chapter 5 IWRM in a VRB, the draft was presented at RSA Winter Conference 2017)

By the European Water Resources Association (EWRA) – Journal of Water Resources Management
Boundary-Spanning Activities in Cultural Ecological Knowledge towards the Integration of Volcanic River Basins Management Case Study: Opak Sub-Basin, Indonesia. Ariyanti, V., Edelenbos, J., Scholten, P., Springer Nature, Switzerland (based on chapter 8 CEK in VRBM, partly presented at Utrecht Earth System Governance 2018)

Book Chapter – *publication process 2019*

By United Nation University Institute for Integrated Management of Material Fluxes and of Resources (UNU-Flores)
The Potential Contribution of Cultural Ecological Knowledge in Resources Management of a Volcanic River Basin; Improving the integrated resources management in the case study of Opak Sub-basin, Yogyakarta, Indonesia. Ariyanti, V., Scholten, P., Edelenbos, J. Springer, Germany. (based on chapter 4 CEK, the draft was presented at Dresden Nexus Conference, 2017)

By United Nations Industrial Development Organization (UNIDO)
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World Small Hydropower Development Report 2019. Indonesia, Country Profile. Ariyanti, V.