Environmental Science and Policy 89 (2018) 430–438

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

The influence of information and communication technologies on public participation in urban water governance: A review of place-based research

Farhad Mukhtarov[a,b,*], Carel Dieperink[a], Peter Driessen[a]

[a] Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands
[b] Institute of Water Policy, National University of Singapore, 469C Bukit Timah Road, 259772, Singapore

ARTICLE INFO

Keywords:
Participation
Urban
Water
ICT
Deliberation
Democracy

ABSTRACT

Public participation is a central topic in urban water governance. With the spread of Information and Communication Technologies (ICT), urban water governance has undergone prominent changes, including the process and outcomes of public participation. This paper aims to systematically review existing scientific and grey literature on the use of ICT to facilitate public participation in urban water governance. Based on a search in Google Scholar, we have collected 33 published texts and discerned 32 case studies, which we analysed according to the Cochrane systematic review methodology. We found that ICT tools allow many citizens to be better informed and co-produce water services with a government. Furthermore, ICT tools have the potential to help in efficiency and effectiveness of urban water service provision. However, such tools provide few opportunities for higher modes of discussion and deliberation, and grant limited authority to participants to influence decision-making processes. This finding raises concerns about the unwarranted optimism of "digital democracy" proponents in the urban water sector. Public participation at the end of the day is political by nature, which cannot be cancelled out by ICT tools alone.

1. Introduction

Public participation and deliberation are key components of democratic decision-making (Ingram and Rathgeb-Smith, 1993; Huitema et al., 2009; Pahl-Wostl et al., 2012). In addition to advancing democracy, public participation may contribute to effective, efficient and legitimate decision-making, (Fung et al., 2013; Glucker et al., 2013). In environmental and water governance, public participation has been strongly advocated within such concepts as Integrated Water Resources Management (IWRM), water security, water user associations, and river basin organisations (e.g. Mollinga et al., 2008; Huitema et al., 2009).

With the rapid spread of information and communication technologies (ICTs), the intensity and nature of public participation in water governance may have shifted (Pedregal et al., 2015). Firstly, crowdsourcing and 'citizen science' have become options for the generation of, for instance, weather data (Bonney et al., 2009; Dickinson et al., 2010; Buytaert et al., 2014; Wehn et al., 2015). Secondly, the Internet and various open-source geo-web tools are used to support social movements and global advocacy for water justice (Kishimoto, 2014; Hernandez-Mora et al., 2015). Finally, mobile device applications and online forums have been developed to monitor public service delivery and hold governments accountable to citizens (Hellstrom, 2010; Jimenez and Perez-Foguet, 2011; Wesselink et al., 2015).

The most common definition of public participation is "the redistribution of power that enables the have-not citizens, presently excluded from the political and economic processes, to be deliberately included in the future" (Arnstein, 1969: 216). Feldman et al. (2006) used the term "inclusive management" to emphasise joint deliberation as a necessary condition of public participation, from which a common judgment emerges (Thacher, 2001: 5). Terms such as "citizen observatories" (Wehn et al., 2015), "citizen co-production", and "citizen-government interactions" (Linders, 2012) have been used to refer to public participation involving digital tools. So far, there is no systematic review of the literature on the impact of ICT tools on public participation in urban water governance. Laspidou (2014) touched upon stakeholder engagement only passingly, nor did Pedregal et al. (2015) pay specific attention to public participation and deliberation in their editorial of the special issue on ICT in water governance. The aim of this article is to fill in this gap by providing a systematic review of the literature on ICT and public participation in urban water governance, and by formulating avenues for future inquiry. More specifically, we wonder to what extent ICT initiatives in urban water governance reflect the ideals of inclusiveness to engage all willing citizens in governing a particular resource or an issue; afford authority and power in decision-

* Corresponding author at: Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands.
E-mail addresses: f.mukhtarov@uu.nl (F. Mukhtarov), c.dieperink@uu.nl (C. Dieperink), p.driessen@uu.nl (P. Driessen).

https://doi.org/10.1016/j.envsci.2018.08.015
Received 6 April 2018; Received in revised form 27 August 2018; Accepted 28 August 2018
Available online 20 September 2018

making to relevant stakeholders; and allow for deliberative and consensus-based governance modes (Fung, 2006).

The paper proceeds as follows – section two introduces the framework we developed for a systematic review of our case studies. In section three, we explain the methodology, whereas section four characterises citizen-government and citizen-citizen interactions from our dataset. In section five we discuss the results of our review in the context of debates on digital participation, and section six concludes the paper with three avenues for future research.

2. Conceptualising citizen participation via ICT-enabled interactions

Two existing frameworks were modified to fit the purposes of our review. The first framework is developed by Linders (2012) and examines various types of ICT-facilitated interactions between citizens and a government, including interactions between citizens. The second framework has been initially developed by Fung (2006) to analyse the extent to which initiatives are participatory, and subsequently modified by Wehn et al. (2015) to apply it to digital initiatives. While the framework of Linders helps discern patterns in citizen–government interactions, the framework of Fung (2006) and Wehn et al. (2015) helps to assess these interactions against the criteria of public participation. We explain these two frameworks in the text below.

Linders (2012) offers a useful typology of information flows between citizens and a government in the context of ICT-facilitated public service provision. He distinguished between information flows from a citizen to a government (C2G), from a government to a citizen (G2C), and from a citizen to a citizen (C2C). We modify this framework by adding a fourth type of interaction – "collaborative planning and groupware" or "government with citizens" (GwC). Here, government officials regularly meet with citizens to discuss and design policy options with the use of ICT technologies (Forester, 2012; Hoyt et al., 2005). We added this type of interaction to account for the whole spectrum of joint planning approaches. Table 1 illustrates the framework with examples.

The first type of interaction is citizen sourcing when "the public helps government to be more responsive and effective" (Linders, 2012: 447). It is a part of a broader trend of crowdsourcing, which can be defined as "collective generation of media, ideas, and data undertaken voluntarily by many people" (Dodge and Kitchin, 2013: 19). While citizens contribute their knowledge, it is a responsibility of the government to manage systems and services (Fung et al., 2013). One well-publicized example of citizen sourcing is PeertoPatent, in which patents are examined not only by experts, but by all with relevant knowledge, to determine if an innovation warrants a new patent (Noveck, 2009).

The second type of citizen-government interaction is called "government as a platform", in which information and knowledge passes from a government to citizens (e.g. O'Reilly, 2010). In this interaction, the government helps citizens to improve their productivity or achieve their goals, such as better healthcare or more sustainable water and electricity consumption. While at first this may not appear to be a form of public participation, it may play an important role in establishing government as open and transparent, and increasing trust in government.

In the third type of interaction, through social media, open source software, such as OpenStreetMaps (OSM), blogs, and virtual learning platforms, citizens may play games, exchange experiences and self-organise for learning and action (Medema et al., 2014). Citizens can share useful information with each other in real time format, and this potentially presents a substitute for traditional government responsibilities to protect and help citizens, including in the times of crises such as floods and earthquakes (Palen and Liu, 2007). Examples of such collective action include self-monitoring, whereby citizens help each other by reviewing hotels, restaurants or government services (Linders, 2012). Examples of fully independent citizen initiatives include

Table 1
A typology of ICT-enabled citizen-government and citizen-citizen interactions with relevance to public service provision.
Source: Adapted from Linders (2012).

	Citizen sourcing (C2G)	Government as platform (G2C)	"Do It Yourself "government (C2C)	Collaborative planning & groupware (GwC)
Description of interaction	Citizens share their opinion among themselves and with government for planning purposes; Citizens provide intelligence to government to identify and fix emerging problems	Government supplies data for informed decisions by citizens; Government discloses data to win trust and legitimacy of the public; Government uses decision heuristics to encourage sustainable behaviour of citizens	Citizens self-organize to produce and consume services with no or little involvement of the government; Online citizen testimonials, sharing of sustainable practices, online advocacy for justice	Joint discussion of problems and solutions in workshops with visualising tools and scenario building, training of citizen scientists; Cultivating engaged citizens with on-going face-to-face contact with government representatives
Traditional examples	Town hall meetings, letters, election boards, park volunteer, charter schools, emergency services	Academic alliance, embedded community health workers, bill boards, government newspapers	Word of mouth, private schools, carpooling, activist meetings	Community volunteers and neighbourhood watch, participatory modelling
ICT examples	eRulemaking, IdeaScale, eDemocracy party, CrisisCommons, Challenge.gov, PeerToPatent, SeeClickFix	Geographical Positioning Systems (GPS), GovOpen Sourcing Data.gov, Recovery.gov	Open Source, SETI@HomeYelp, NHS Choice, Email, Community websites, social media	"CommunityViz" software tool for planning, weather networks funded or facilitated by government, virtual learning platforms, touch-tables and visual scenario-building

Wikipedia, computer operational systems and coding languages LINUX and SETI.

The fourth type of interaction, which we added, refers to ICT-induced participatory forms of planning with face-to-face interaction between citizens and a government representative. Here, technologies may play an important role in facilitating and qualitatively shifting interactions. Examples of such ICT-facilitated participatory processes include spatial decision support for collaborative planning such as "touch tables" (Arciniegas and Janssen, 2012), and participatory modelling (Forester, 2012). Further methods may include participatory forms of mapping, transect walks, focus group discussions producing knowledge, community-based mapping, and NGOs producing knowledge in contested local governance processes (Hoyt et al., 2005). The term "groupware" is used for "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment" (Hanzl, 2007: 297).

Once we have systematically categorized observed interactions in our case studies, we apply a three axes framework developed by Wehn et al. (2015) to explore how participatory such initiatives are. This framework is based on earlier work by Fung (2006) that Wehn et al. (2015) modified by renaming categories along the "participants" axis, and by adding two categories of "implicit" and "explicit data collection" to the "communication and decision mode" axis. "Implicit data collection" means expression of opinion and ideas by citizens in a generic form, whereas "explicit data collection" is the provision of crowdsourced information by citizens in a more targeted fashion. The third axis shows the authority that participants exercise in decision-making as a result of participatory events and has been unchanged by Wehn et al. (2015).

3. Methods for literature review

The review methodology is divided into five steps in an adapted Cochrane Systematic Review process discussed in Bilotta et al. (2014). After formulating the research question and a framework for analysis, we conducted a number of searches in Scopus, Web of Science and Google Scholar to locate scientific and grey literature on the subject (Cox, 2015). We searched various combinations of the terms "online", "ICT", and "digital" on the one hand, and "urban water governance", "public participation" and "stakeholder engagement" on the other. We performed the search in 2016 and selected articles published in 2000 and later for entry in the dataset. In deciding whether to include a research in the dataset, we ascertained if the research dealt with all three issues as follows: a) application of ICT tools in the context of urban or semi-urban water governance; b) relevance of the ICT tools to public participation; and c) presence of primary empirical data. As a result, we collected 33 papers, from which we discerned 32 "case studies" of either ICT initiatives, or aggregate discussions of plural initiatives in a particular place, such as in Brazil (e.g. Pereira et al., 2003). The full dataset can be found in Appendix B.

Out of 32 case studies, 22 deal exclusively with urban water governance and nine cases discuss semi-urban water service provision. One case study discusses water governance in rural areas, which we have included due to its relevance to urban areas (Wesselink et al., 2015). We annotated 32 case studies and assigned codes according to the types of citizen-government and citizen-citizen interactions. Some case studies have been coded for multiple types of interactions, such as for example, both "citizen sourcing" and "government as a platform". This is why the total number of coded case studies may exceed 32. Finally, we coded 32 projects against the criteria of public participation according to the framework displayed in Fig. 1, and interpreted and discussed the results of our analysis. The results are not specific to any particular place as case studies come from all around the world.

This research has some limitations. We targeted published material that dealt with all three components, namely, ICT, public participation, and urban water governance. These criteria proved restrictive and yielded relatively few results in Scopus or the Web of Knowledge. We have hence relied on Google Scholar for a broader search. The limitations of relying on Google Scholar include indexing non-peer reviewed publications and ranking search results according to search frequency in Google. However, most of the articles in the dataset are peer-reviewed and Google search rankings had no bearing on compilation of the dataset. Furthermore, we reviewed secondary literature with a varying degree of explanatory detail of case studies – an inevitable limitation of secondary data. Moreover, we have only searched for case studies in English, which has undoubtedly left out many relevant case studies reported in other languages. Finally, we are aware that public participation is a contested concept with much criticism focused on its value and even feasibility (e.g. Turnhout et al., 2010; Irvin and Stansbury, 2004; Arnstein, 1969). Without engaging in these debates, we have assumed that public participation and deliberation are essential for good urban water governance (Ingram and Rathgeb-Smith, 1993) and deserve research attention. Despite these limitations, we believe that this systematic literature review offers important insights into the impact of ICT in the field of urban water governance and public participation as well as to broader debates on "digital participation".

4. ICT enabled interactions in urban water governance practice

In this section we first present our findings related to the different types of ICT-enabled interactions. Table 2 gives some selected examples of these different types. Secondly, we analyse the extent to which public participation in the cases we studied reflects the scope of participation, the mode of communication and decision-making, and the authority and power bestowed to citizens in the process of participation.

4.1. Citizen sourcing: providing governments with necessary information (C2G)

In our dataset, 16 out of 32 cases had a citizen sourcing component to them. Citizen sourcing is discussed in the context of monitoring water supply and sanitation services, such as the quantity and quality of tap water supply (e.g. Lallana, 2004). In China, the Institute of Public & Environmental Affairs (IPE) gathers hard-to-find public environmental data on water and air quality and environmental violations through a web-based platform that makes pollution information widely available (Pedregal et al., 2015), and in sub-Saharan Africa, the Water Point Mapper is a free tool to report and map the status of water supply and sanitation services (Welle, 2010).

One key example of citizen sourcing comes from flood risk management (e.g. Wehn et al., 2015; Aggrawal, 2016; Smith et al., 2015; Holderness and Turpin, 2015). Using the Brisbane example, Aggrawal (2016) shows that the open source data available through Google Earth, Geographic Resource Analysis Support System and the Landsat datasets can help emergency agencies to delineate flooded areas and deliver relief and aid (Holderness and Turpin, 2015). Smith et al. (2015) further discuss the potential of social media to verify flood models of emergency relief agencies in real-time. An initiative called PetaJakarta gained much acclaim and media attention in 2016 with appearances in *The Guardian*, *CNN*, *BBC*, *The Wall Street Journal* among other outlets (Holderness and Turpin, 2015). The White Paper summarizes this platform as follows (Holderness and Turpin, 2015: 1–2):

> the project enabled Jakarta's citizens to report the locations of flood events using the social media network Twitter, thereby contributing to a web-based, publicly accessible, real-time map of flood conditions at PetaJakarta.org. These data were used by BPBD DKI Jakarta to cross-validate formal reports of flooding from traditional data sources, supporting the creation of information for flood assessment, response, and PetaJakarta.org management in real-time.

Similarly to citizen sourcing, citizen science plays an important role in providing day-to-day information to the government. Good examples

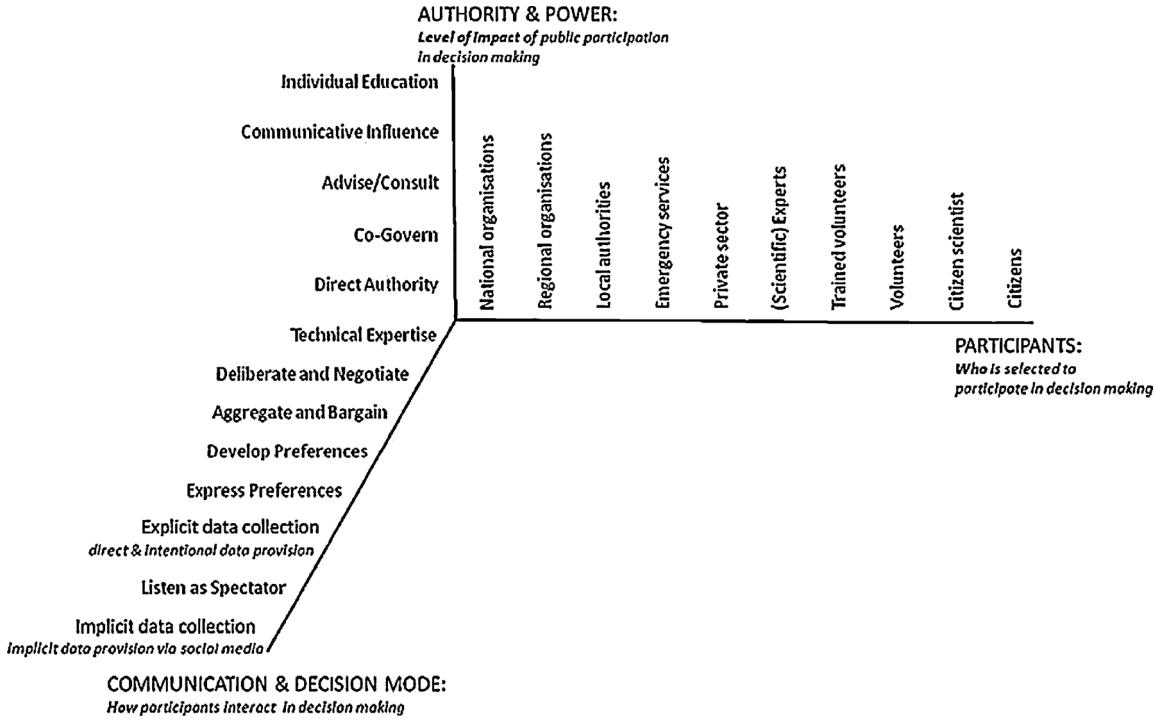

Fig. 1. "Adjusted Democracy Cube": citizen participation via ICT -enabled interactions.
Source: Wehn et al. (2015).

come from Gharesifard et al. (2017) and Wehn et al. (2015) who reviewed the operation of citizen weather networks globally and "citizen observatories" in three case studies in the United Kingdom, The Netherlands, and Italy respectively. While not targeted at providing information on weather to the government alone, but to the public at large, these networks have been funded by public institutions and, in some cases, information has been used by government officials in their services Gharesifard et al. (2017). These networks are examples of citizen sourcing with support from the government. Wesselink et al. (2015) further demonstrate how a mobile app may be successful, although not without challenges, in crowdsourcing and monitoring of water supply and standpipes in rural Tanzania.

Another form of citizen sourcing is soliciting comments and ideas of citizens online regarding particular policy or legal proposals (Chadwick, 2011; Dawes, 2008). Fung et al. (2013) referred to this type of interaction as "direct digital democracy" in which citizens can provide opinions and comments to the government, potentially facilitating more democratic forms of governance. "Tech-County" (Chadwick, 2011) and UrbanWins (Elelman et al., 2017) projects have attempted to collect the ideas and opinions of citizens in order to modify designs of services and policies.

4.2. Government as a platform: informing, educating and nudging citizens (G2C)

Government as a platform also occurs in 19 out of 32 cases in our dataset. In the majority of these, the goal has been to educate citizens to conserve water, prepare for floods, or report leakages (e.g. García-Sánchez et al., 2013; Hanzl, 2007; Pereira et al., 2003; Laspidou, 2014, Lai et al., 2017). Projects such as the municipal websites of the Flemish government (Elelman et al., 2017), and the website of a water utility in Malaysia (Lai et al., 2017) provide examples of widely spread means of communicating, educating, and changing the behaviour of citizens. Studies in environmental communication show that the provision of real-time comparative data on water consumption to households is a powerful tool to achieve behavioural change, such as water conservation (Seyranian et al., 2015). However, such a mode of communication is rather conventional with no feedback from citizens to the government.

In addition to educating citizens, governments can use digital social platforms to make their activities transparent to citizens in a spirit of information disclosure, and promote more trust, and legitimacy (e.g. Chadwick, 2011). As a hypothetical example, Wilk (2006: 319) suggested more transparency about public drinking water treatment,

Table 2
Selected examples of ICT enabled participatory projects in urban water governance.

C2G	G2C	C2C	GwC
AGORA research project in Brazil for "flood citizen observatory" (Degrossi et al., 2014); Peta-Jakarta online platform for crowdsourced flood mapping (Holderness and Turpin, 2015); Citizen weather networks (Gharesifard et al., 2017)	Municipal governments in Spain use websites to inform citizens (Garcia et al., 2013); Water utilities in Europe and in Malaysia use websites and social media to reduce water losses in the pipelines and in homes (Laspidou, 2014; Lai et al., 2017); Platform to inform citizens, solicit opinion, and spread sustainability tips for water quality (Chadwick, 2011)	Use of email and social media by activist networks in Spain to build support (Hernandez-Mora et al., 2015; Mancilla-García, 2015); Peer-to-peer communication in the U.S. for crises relief (Palen and Liu, 2007); Collective community action to manage an aqueduct in Colombia (Llano-Arias, 2015);	Multi-media platforms for discussions in Southern France (Pereira et al., 2003); Digital Workshop in Canada to visualize planning options (Salter et al., 2009); Virtual Learning Platforms and gaming for better water planning (Medema et al., 2014)

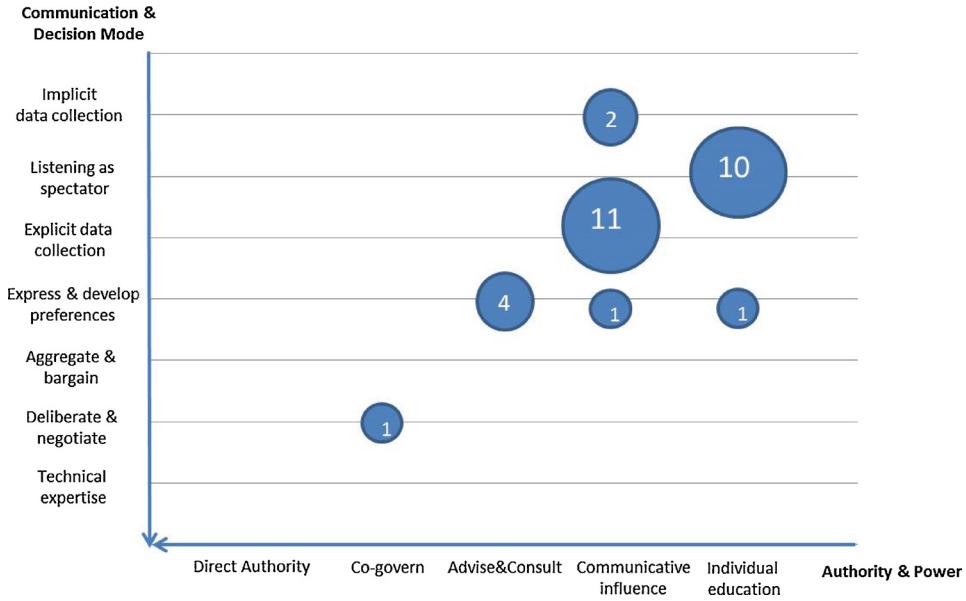

Fig. 2. Communication & Decision Mode versus Authority & Power in the ICT-enabled interactions in urban water governance practices.

which, in concert with other public policy actions, could lead to cuts in bottled water consumption and reduced environmental impacts. More transparency may also help overcome the "yuck" factor in water re-use (e.g. Lejano and Leong, 2012) as well as help to understand the role of emotions in public acceptance of controversial water policies (Leong, 2016a).

4.3. "Do it yourself" government: exchanging information among citizens and community initiatives (C2C)

This type of interaction occurs only eight times in our dataset. ICTs can provide new avenues for political activism (Morell and Subirats, 2012), encourage citizens to share peer-to-peer information and knowledge during flooding or hurricanes (e.g. Palen and Liu, 2007), and as a means of building social movements and coalitions in order to lobby for a particular water issue (e.g. Hernandez-Mora et al., 2015; Laspidou, 2014; Pedregal et al., 2015). Hernandez-Mora et al. (2015), for example, discussed how environmental groups, citizen organisations, activists, scholars, and local municipalities used ICT to organize themselves and lobby decision-making processes in Spain. Similarly, Laspidou (2014) and Mancilla-García (2015) discuss the use of social media and ICT in building advocacy networks and lobbying for water issues, such as the website www.righ2water.eu – a platform used to collect nearly 1,9 million signatures for putting human right to water on European Commission's agenda (Parks, 2014).

Another use of ICT of this type is collective action in cases where government has either withdrawn or lacks the capacity to provide services. One such project relates to a community managing an aqueduct in Colombia using ICT tools to communicate and monitor water levels (Llano-Arias, 2015). Another example comes from Southern France where multiple actors come together to manage rivers with the use of a multi-media platform with visualisation and simulating functionalities (Pereira et al., 2003).

4.4. Collaborative planning and groupware: government-citizen co-production (GwC)

This is the least common type of interaction in the dataset with only three case studies. Pfeffer et al. (2011) discussed the use of Geographic Information Systems (GIS) in promoting deliberative urban governance in India through tapping into local knowledge as an input in planning. According to the authors, a combination of GIS-based qualitative and quantitative approaches can include the local embedded knowledge in the process of urban governance. In a digital workshop in Bowen Island, British Columbia, digital visualization tool *CommunityViz* has been used to help citizens and professionals envision possible landscapes as input in their decision-making (Salter et al., 2009). Similarly, virtual learning platforms can be used in building trust and a common vision among citizens, governments and various other actors (Medema et al., 2014). Pereira et al. (2003) reported positive results of using digital multimedia application to facilitate discussions among various actors in river basin planning in Southern France and similar initiatives appear in the literature more broadly, such as interactive land use planning in Bodegraven Polder in The Netherlands (Janssen et al., 2013).

5. How participatory are ICT-enabled interactions in urban water governance?

In this section we discuss the case studies in our database against three criteria for public participation as in Fig. 1, namely, the scope of participation, the authority of citizens to influence decision-making, and the communication and decision mode.

In terms of the scope of participants, the cases provide a good opportunity for inclusion, especially with citizen sourcing. We characterized 30 cases out of 32 as involving all willing citizens. One case involved citizen scientists with equipment and training, and one involved trained volunteers. Such openness of ICT platforms to citizens is an advantage of many-to-many communication. It offers many opportunities during a crisis event or in the context where monitoring is prohibitively expensive or impractical.

Given the open scope of participation in most of the case studies in our dataset, we have reduced the framework in Fig. 1 to two dimensions as presented in Fig. 2 below, where we plotted the distribution of the 30 cases across the authority and power axis and the communication and decision mode axis. In Fig. 2, the arrows of the axes show the increase in either the mode of communication and decision-making towards more participatory or that of authority and power in decision-making; the closer case studies are located to the cross-point of two axes, the more participatory they are. A table with the results of our coding per all three axes of the "adjusted democracy cube" of Wehn et al. (2015) can be found in Appendix C.

With regard to the mode of communication and decision-making in participatory initiatives, we observed that in 11 cases citizens supplied explicitly requested data to the government through citizen sourcing. In

further 10 cases, citizens took up a role to "listen as a spectator", and in two cases citizens provided implicit data to the government, such as generic opinions and ideas on water service provision or policies. Remarkably, only one case allowed for some form of deliberation and negotiation in the interactions. A further six cases allowed for expressing and developing preferences during citizens-government interactions; again, the majority of these cases relate to "do-it-yourself government", which does not typically involve deliberations with the government.

Finally, regarding the authority and power to influence decision-making as a result of public participation, we observe that the majority of cases fall within the categories of individual education (11 cases) and communicative influence (14 cases). Only one case falls within the category of co-governing; this is a case study of managing an aqueduct by local communities in Colombia in the absence of the government (Llano-Arias, 2015). The further six cases where advisory and consultative functions have taken place come from the cases under "collaborative planning and groupware" type of interaction.

The biggest "bubbles" with 11 and 10 cases are located at the lower ends of the two axes of communication and decision mode and authority and power mode. A further seven case studies are located in adjacent lower categories. These indicate a relatively weak involvement of citizens in participatory processes through ICT-enabled interactions across the study's two axes. There is only one exception as an example of the more deliberative and authoritative governance – a combination of co-governing with the mode of deliberation and negotiation. Thus, two most common types of interactions in our dataset, as discussed above, "citizen sourcing" and "government as a platform", tend to produce lower forms of participation with regard to deliberation and authority of citizens to exercise influence in decision-making.

6. Discussion

Fig. 2 is illustrative of the relatively limited power of ICT tools to provide deliberative modes of governance and give stakeholders authority and power in the decision-making process. However, it would be unfair to expect project designs in urban water governance to be excellent in all three dimensions, as Fung (2006) warned in his discussion of the "democracy cube" presented in a modified version in Fig. 1. Special participatory designs need to be developed in the future to focus on more authoritative and deliberative modes of participation, perhaps at the cost of inclusiveness. Gerlak (2017), for example, explained the success of inclusive water governance in the International Boundary and Water Commission (IBWC) between US and Mexico, by the priority given to maintenance of an active network of limited stakeholders rather than focusing on involving all stakeholders, and by the early involvement of such stakeholders and broadening participation to other actors later, if necessary. It remains to be seen if these insights can be applied to digital forms of public participation. In any case, experimentation with designs for inclusive water governance with ICT tools would provide important insights into understanding "digital participation" in water governance in the future.

These findings are in line with existing literature and the arguments of Fung et al. (2013) and Wesselink et al. (2015) that democratization and public deliberation are political issues at their core, and ICT tools alone are not sufficient to trigger change towards participatory governance. Echoing this argument, Wehn et al. (2015: 234), in their review of the literature on "citizen observatories", claimed that "the examined case studies do not yet present strong ICT-enabled participation (eParticipation)". The reluctance of public managers to relinquish control over decision-making, the longer implementation times under deliberative forms of governance, and the possibility of extra work for public managers to engage citizens in decision-making are among plausible institutional barriers to deliberation in governance (e.g. Chadwick, 2011).

The key lesson from this review is that the rise of ICT tools will not do away with the politics of participation in urban water governance, and the higher forms of authoritative and deliberative participation can only be possible given the political will to implement these. We echo Fung et al. (2013: 37) who claimed that "the failure to realize e-democracy is not in the first instance a technological problem, but a political one. Solutions, for those desiring greater direct e-democracy, require political innovations much more than technological ones". In this regard, we would like to call the attention of scholars to a few key topics to study in the future.

Firstly, Dawes (2008: 91) claimed that "IT (information technology) considerations must be appreciated as being nested within a variety of organisations, sociological, ideological, and political contexts that all need considerable attention." More in-depth place-based case studies are needed with a focus on how institutional and socio-political factors mediate the relationship between ICT and public participation in urban water governance. One way to engage with these issues is by paying attention to the broader inter- and intra-organisational policy networks, which process input from participatory events to produce policy decisions (Lejano et al., 2013; Feldman et al., 2006). Second, Wesselink et al. (2015) and Fung et al. (2013: 44) demonstrated how individual incentives may hinder the fulfilment of the full potential of the Internet in deliberative urban governance. Scholars would profit from paying greater attention to such incentives in designing and implementing participatory initiatives. These incentives may lie in the area of effectiveness and efficiency, but may also include bureaucratic politics, and the logic of appropriateness to encourage public managers to engage with the public through the Internet (Lim and Tang, 2008; Livingston and Walter-Drop, 2012). ICT tools may also help in understanding social and political realities in water governance, for example through collecting public opinion, public narratives and lived experiences of citizens, and playing a broader role than just enabling or hindering public participation (Leong, 2016b)

Finally, an important subject of digital participation is the ability of citizens to utilise ICT tools and have appropriate levels of connection and equipment in order to participate in governance. With more emphasis on digitalisation in urban water governance, a potential "digital divide" between the rich and the poor requires more attention from scholars and policymakers alike. It remains important to ask the question of who are the winners and losers of digitalisation, and whether ICT tools serve the preservation of the status-quo of power relations or could be used to empower the marginalised groups of society.

7. Conclusion

In this paper the literature on ICT tools for public participation in urban water governance has been systematically reviewed to explore to what extent the collected cases are participatory. Overall, we observe that most cases fall into two types of citizen-government interaction, namely, "government as a platform", and "citizen sourcing". We further observe that ICT tools help to improve effectiveness and efficiency in urban water governance while opening up opportunities for citizens to co-produce knowledge and services with the government. However, ICT tools provide few opportunities for citizens to engage in deliberations and exercise authority over decisions on urban water governance. Control over decision-making, policy design, and to a great extent, policy implementation, remains in the hands of the government. Our findings are in line with the literature on "digital participation" that claims the ICT tools, on their own, do not have the capacity to enhance deliberative governance, and political willingness to involve citizens is required to achieve more authoritative and deliberative modes of participation.

Acknowledgements

We gratefully acknowledge The European Commission for funding this research within the POWER project in H2020-Water Under Grant

Agreement No. 687809. We also thank two anonymous reviewers and the editor for valuable comments on an earlier version of this paper.

Appendix A. Coding Scheme for analysis

	Coding field	Decision rule	Type of entry
1	Case study ID		Text
2	Coder's Initials		Text
3	Author/s last name, year, title of article, journal/book/report		Text
4	Urban, semi-urban or rural: 1 = urban; 2 = semi-urban; 3 = rural		Typology (multiple codes possible)
5	ICT enabled interactions: 1 = Crowdsourcing; 2 = government as platform; 3 = do it yourself government; 4 = collaborative planning and groupware	Based on typology in Table 1	Typology (multiple codes possible)
6	Participants: 1 = national organisations; 2 = regional organisations; 3 = local authorities; 4 = emergency services; 5 = scientific experts; 6 = trained volunteers; 7 = volunteers; 8 = citizen scientists; 9 = citizens	based on typology in Fig. 1	Typology (multiple codes possible)
7	Communication and decision mode: 1 = technical expertise; 2 = deliberate and negotiate; 3 = aggregate and bargain; 4 = develop preferences; 5 = express preferences; 6 = explicit data collection (targeted information); 7 = listen as spectator; 8 = implicit data collection (general information via social media etc.)	based on typology in Fig. 1	Typology (multiple codes possible)
8	Authority and power: 1 = direct authority; 2 = co-govern; 3 = advise/consult; 4 = communicative influence; 5 = individual education	based on typology in Fig. 1	Typology (multiple codes possible)

Appendix B. Reference details of reviewed research

Aggrawal, A. 2016. Exposure hazard and risk mapping during a flood event using open source geospatial technology. *Geomatics, Natural Hazards and Risk* 7(4): 1426–1441.

Chadwick, A. 2011. Explaining the failure of an online citizen engagement initiative: the role of internal institutional variables. *Journal of Information Technology & Politics* 8: 21–40.

Degrossi, L. C., Albuquerque, J. P. de, Fava, M. C., and Mendiondo, E. M. 2014. "Flood Citizen Observatory: a crowdsourcing-based approach for flood risk management in Brazil," in Proceedings of the 26th International Conference on Software Engineering and Knowledge Engineering, pp. 570-575. Vancouver, Canada, 1–3 July, 2014.

Elelman, R., Espi, J.J., and Antolin, A. 2017. Report on the Current Situation Regarding DSP Application. Report within the "Political and social awareness on water environmental challenges" (POWER) project. Brussels: European Commission.

García-Sánchez, I. M., Rodríguez-Domínguez, L., & Frias-Aceituno, J. V. 2013. Evolutions in e-governance: evidence from Spanish local governments. *Environmental Policy and Governance*, *23*(5), 323–340.

Gharesifard, M., Wehn, U., & van der Zaag, P. 2017. Towards benchmarking citizen observatories: Features and functioning of online amateur weather networks. *Journal of Environmental Management*, *193*, 381–393.

Hanzl, M. (2007). Information technology as a tool for public participation in urban planning: a review of experiments and potentials. *Design Studies*, *28*(3), 289–307.

Hernandez-Mora, N., Cabello, V., de Stefano, L., Del Moral, L. 2015. Networked water citizen organisations in Spain: Potential for transformation of existing power structures in water management. *Water Alternatives* 8(2): 99-124.

Hernández-Mora, N., & Ballester, A. 2011. Public participation and the role of social networks in the implementation of the Water Framework Directive in Spain.

Holderness, T., and Turpin, E. 2015. White paper—PetaJakarta. org: Assessing the role of social media for civic co-management during monsoon flooding in Jakarta, Indonesia. *University of Wollongong, Wollongong*.

Lai, C. H., Chan, N. W., and Roy, R. 2017. Understanding Public Perception of and Participation in Non-Revenue Water Management in Malaysia to Support Urban Water Policy. *Water*, *9*(1), 26.

Laspidou, C. 2014. ICT and stakeholder participation for improved urban water management in the cities of the future. *Water Utility Journal* 8: 79–85.

Liu, H. K. 2017. Crowdsourcing Government: Lessons from Multiple Disciplines. *Public Administration Review*, *77*(5), 656–667.

Llano-Arias, V. 2015. Community knowledge sharing and co-production of water services: Two cases of community aqueduct associations in Colombia. Water Alternatives 8(2): 77–98

Mancilla-García, M. 2015. Does social media benefit dominant or alternative water discourses? Water Alternatives 8(2): 125–146.

Mazumdar, S., Lanfranchi, V., Ireson, N., Wrigley, S., Bagnasco, C., Wehn, U., McDonagh, R. Ferri, M., McCarthy, S. Huwald, H, and Ciravegna, F. 2016. Citizens observatories for effective Earth observations: the WeSenseIt approach. *Environmental Scientist*, *25*(2), 56–61.

Medema, W., Wals, J., Adamowski, J. 2014. Virtual learning platforms for effective facilitation of water Governance: Towards a research agenda on the potential of virtual learning platforms. *NJAS Wageningen Journal of Life Sciences* 69: 23–38.

Micheel, I., and Novak, J. 2013. Elocal: An exploratory approach to designing for civic participation. Vortrag im Workshop Participatory Publics at ECSCW 2013 – European Conference for Computer-supported Work. Paphos, Zypern, 22 September 2013.

Minkman, E. 2015. Citizen Science in Water Quality Monitoring: Developing Guidelines for Dutch Water Authorities for Contributory Mobile Crowd Sensing.

Minkman, E., Rutten, M. M., & van der Sanden, M. C. 2016. Acceptance of Mobile Technology for Citizen Science in Water Resource Management. *Journal of Irrigation and Drainage Engineering, 143*(3), B6016001.

Palen, L., and Liu, S. 2007. Citizen communications in crisis: anticipating a future of ICT-supported public participation. CHI Proceedings, Emergency Action. San Jose, California, USA, 28 April -3 May 2007.

Pedregal, B., Cabello, V., Hernandez-Mora, N., Limones, N., and Del Moral, L. 2015. Information and Knowledge for Water Governance in the Networked Society. *Water Alternatives* 8 (2): 1–19.

Pereira, V., Cunha, M., Lampoltshammer, T., Parycek, P., and Testa, M. 2017. Increasing collaboration and participation in smart city governance: a cross-case analysis of smart city initiatives. *Information Technology for Development*, *23*(3), 526–553.

Pereira, A., Rinaudo, J., Jeffrey, P., Blasquez, J., Quintana, S., Courtios, N., Funtowitz, S., and Petit, V. 2003. ICT Tools to support public participation in water resources governance and planning: experiences from the design and testing of a multi-media platform. *Journal of Environmental Assessment Policy and Management* 5 (3): 395–420.

Pfeffer, K., Martínez, J.A., Baud, I.S.A., Sridharan, N. 2011. Knowledge production in urban governance systems through qualitative geographical information systems, GIS. Environment and urbanization ASIA 2 (2): 235–250.

Salter, J., Campbell, C., Journeay, M., and Sheppard, S. 2009. The digital workshop: Exploring the use of interactive and immersive visualization tools in participatory planning. *Journal of Environmental Management,* 90(6): 2090–2101.

Smith, L., Liang, Q., James, P. and Lin, W. 2015. Assessing the utility of social media as a data source for flood risk management using a real-time modelling framework. *CIWEM Journal of Flood Risk Management,* 10: 370–380.

Wehn, U., and Evers, J. 2015. The social innovation potential of ICT-enabled citizen observatories to increase eParticipation in local flood risk management. *Technology in Society*, *42*, 187–198.

Wehn, U., Rusca, M., Evers, J., and Lanfranchi, V. 2015. Participation in flood risk management and the potential of citizen observatories: A governance analysis. *Environmental Science & Policy*, *48*, 225–236.

Wehn, U., and Evers, J. 2014. Citizen observatories of water: Social innovation via eParticipation. The 2nd International Conference on ICT for Sustainability, Stockholm, Sweden, 24–27 August 2014.

Welle, K. 2010. Strategic review of WaterAid's water point mapping in East Africa Based on a review of Ethiopia, Tanzania, Kenya and Uganda. WaterAid Report. www.wateraid.org/~/.../east-africa-water-point-mapping.pdf (accessed 21 October 2017).

Wesselink, A., Hoppe, R. and Lemmens, R. 2015. Not just a tool. Taking context into account in the development of a mobile app for rural water supply in Tanzania. *Water Alternatives* 8 (2): 57–76.

Wilk, R. 2006. Bottled water: the pure commodity in the age of branding. *Journal of Consumer Culture* 6(3): 303–325.

Appendix C. Citizen participation and ICT-enabled interaction

Axis	Scale	Description	N out of 32	Percent %
Participants	Citizens	Everyone to participate	30	94
	Citizen scientists	Everyone with skills & equipment	1	3
	Trained volunteers	Activists and volunteers with technical knowledge	1	3
Authority and Power	Individual education	One-way information flow to educate the citizen	11	34
	Communicative influence	Ability to provide necessary data	14	44
	Advise/consult	Ability to discuss and advise in an interactive manner	6	19
	Co-govern	Ability to exercise authority to govern	1	3
Communication and Decision Mode	Deliberate and negotiate	Discussions to form a joint decision	2	6
	Express and develop preferences	Ability to formulate and express ideas and preferences	7	22
	Explicit data collection	Provision of requested data for specific use by the government	11	34
	Listen as spectator	One-way information flow from government to educate citizens	10	33
	Implicit data collection	Provision on data in a more open-ended fashion	2	6

References

Aggrawal, A., 2016. Exposure hazard and risk mapping during a flood event using open source geospatial technology. Geomat. Nat. Hazards Risk 7 (4), 1426–1441.

Arciniegas, G., Janssen, R., 2012. Spatial decision support for collaborative land use planning workshops. Landsc. Urban Plann. 107, 332–342.

Arnstein, S., 1969. A ladder of citizen participation. J. Am. Inst. Plann. 35 (4), 216–224.

Bilotta, G., Milner, A., Boyd, I., 2014. On the use of systematic reviews to inform environmental policies. Environ. Sci. Policy 42, 67–77.

Bonney, R., Cooper, C., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K., Shirk, J., 2009. Citizen science: a developing tool for expanding science knowledge and scientific literacy. Bioscience 59 (11), 977–984.

Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Bastiaensen, J., De Bièvre, B., Bhusal, J., Chanie, T., Clark, J., Dewulf, A., Foggin, M., Hannah, D.M., Hergarten, C., Isaeva, A., Karpouzoglou, T., Pandey, B., Paudel, D., Sharma, K., Steenhuis, T., Tilahun, S., Van Hecken, G., Zhumanova, M., 2014. Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. Front. Earth Sci. 2 (26) (Accessed 20 October 2017). http://journal.frontiersin.org/article/10.3389/feart.2014.00026/full.

Chadwick, A., 2011. Explaining the failure of an online citizen engagement initiative: the role of internal institutional variables. J. Inf. Technol. Polit. 8, 21–40.

Cox, M., 2015. A basic guide for empirical environmental social science. Ecol. Soc. 20 (1).

Dawes, S., 2008. The evolution and continuing challenges of E-governance. Publ. Adm. Rev. 68 (Issue Supplements), S86–S102.

Degrossi, L.C., de Albuquerque, J.P., Fava, M.C., Mendiondo, E.M., 2014. Flood citizen observatory: a crowdsourcing-based approach for flood risk management in Brazil.

SEKE 570–575.
Dickinson, J.L., Zuckerberg, B., Bonter, D.N., 2010. Citizen science as an ecological research tool: challenges and benefits. Annu. Rev. Ecol. Evol. Syst. 41, 149–172.
Dodge, M., Kitchin, R., 2013. Crowdsourcing cartography: mapping experience and knowledge. Environ. Plann. A 45, 19–36.
Elelman, R., Espi, J.J., Antolin, A., 2017. Report on the Current Situation Regarding DSP Application. Report Within the "Political and Social Awareness on Water Environmental Challenges" (POWER) Project. European Commission, Brussels.
Feldman, M.S., Khademian, A.M., Ingram, H., Schneider, A.S., 2006. Ways of knowing and inclusive management practices. Publ. Adm. Rev. 66, 89–99.
Forester, J., 2012. Learning to improve practice: lessons from practice stories and practitioners; own discourse analyses (or why only the loons show up). Plann. Theory Pract. 12 (1), 11–26.
Fung, A., 2006. Varieties of participation in complex governance. Publ. Adm. Rev. 66 (Issue supplement s1), 66–75.
Fung, A., Gilman, H.R., Shkabatur, J., 2013. Six models for the internet + politics. Int. Stud. Rev. 15, 30–47.
Garcí a-Sánchez, I.M., Rodríguez-Domínguez, L., Frias Aceituno, J.V., 2013. Evolutions in e-governance: evidence from Spanish local governments. Environmental Policy and Governance 23 (5), 323–340.
Gerlak, A.K., 2017. Regional water institutions and participation in water governance: the Colorado River Delta as an exception to the rule? J. Southwest 59 (1–2), 184–203.
Gharesifard, M., Wehn, U., van der Zaag, P., 2017. Towards benchmarking citizen observatories: features and functioning of online amateur weather networks. J. Environ. Manage. 193, 381–393.
Glucker, A., Driessen, P., Kolhoff, A., Runhaar, H., 2013. Public participation in environmental impact assessment: why, who and how? Environ. Impact Assess. Rev. 43, 104–111.
Hanzl, M., 2007. Information technology as a tool for public participation in urban planning: a review of experiments and potentials. Des. Stud. 28, 289–307.
Hellstrom, J., 2010. The Innovative Use of Mobile Applications in East Africa. Sida Review 2010:12. Swedish International Development Cooperation Agency, Stockholm, Sweden (Accessed 20 October 2017). www.sida.se/globalassets/publications/import/pdf/sv/the-innovative-use-of-mobile-applications-in-east-africa.pdf.
Hernandez-Mora, N., Cabello, V., de Stefano, L., Del Moral, L., 2015. Networked water citizen organisations in Spain: potential for transformation of existing power structures in water management. Water Altern. 8 (2), 99–124.
Holderness, T., Turpin, E., 2015. White Paper—PetaJakarta. org: Assessing the Role of Social Media for Civic Co-Management During Monsoon Flooding in Jakarta, Indonesia. University of Wollongong, Wollongong.
Hoyt, L., Khosla, R., Canepa, C., 2005. Leaves, pebbles, and chalk: building a public participation GIS in New Delhi, India. J. Urban Technol. 12 (1), 1–19.
Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., Yalcin, S., 2009. Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. Ecol. Soc. 14 (1), 26.
Ingram, H., Rathgeb-Smith, S. (Eds.), 1993. Public Policy for Democracy. Brookings Institution Press, Washington, DC.
Irvin, R.A., Stansbury, J., 2004. Citizen participation in decision making: is it worth the effort? Publ. Adm. Rev. 64, 55–65.
Janssen, R., Arciniegas, G.A., Verhoeven, J.T., 2013. Spatial evaluation of ecological qualities to support interactive land-use planning. Environ. Plann. B: Plann. Des. 40 (3), 427–446.
Jimenez, A., Perez-Foguet, A., 2011. Water point mapping for the analysis of rural water supply plans: case study from Tanzania. J. Water Resour. Plann. Manag. 137 (5), 439–447.
Kishimoto, S., 2014. Processes of social participation in information: the experience of the water remunicipalization tracker. Paper Presented at the International Conference on Data, Information and Knowledge for Water Governance in the Networked Society (Accessed 20 October 2017). http://www.upo.es/ghf/giest/GIEST/otros_documentos/905_SWAN_International_Conference_Program-Seville-9_10_June_2014.pdf.
Lai, C.H., Chan, N.W., Roy, R., 2017. Understanding Public Perception of and Participation in Non-Revenue Water Management in Malaysia to Support Urban Water Policy. Water 9 (1), 26.
Lallana, E., 2004. eGovernment for Development – mGovernment Applications and Purposes Page. Institute for Development Policy and Management, Manchester University of Manchester.
Laspidou, C., 2014. ICT and stakeholder participation for improved urban water management in the cities of the future. Water Util. J. 8, 79–85.
Lejano, R., Leong, C., 2012. A hermeneutic approach to explaining and understanding public controversies. J. Publ. Adm. Res. Theory 22 (4), 793–814.
Lejano, R., Ingram, M., Ingram, H., 2013. The Power of Environmental Networks. MIT Press, Cambridge Massachusetts.
Leong, C., 2016a. The role of emotions in drinking recycled water. Water 8 (11), 548.
Leong, C., 2016b. A lived experience investigation of narratives. Int. J. Water Resour. Dev. 21 (4).
Lim, L., Tang, Sh., 2008. Urban e-government initiatives and environmental decision performance in Korea. J. Publ. Adm. Res. Theory 18 (1), 109–138.
Linders, D., 2012. From e-government to we-government: defining a typology for citizen coproduction in the age of social media. Gov. Inf. Q. 29 (4), 446–454.
Livingston, S., Walter-Drop, G., 2012. Information and communication technologies in areas of limited statehood. SFB-Governance Working Paper Series. No. 38, September 2012.
Llano-Arias, V., 2015. Community knowledge sharing and co-production of water services: two cases of community aqueduct associations in Colombia. Water Altern. 8 (2), 77–98.
Mancilla-García, M., 2015. Does social media benefit dominant or alternative water discourses? Water Altern. 8 (2), 125–146.
Medema, W., Wals, J., Adamowski, J., 2014. Virtual learning platforms for effective facilitation of water governance: towards a research agenda on the potential of virtual learning platforms. NJAS Wagening. J. Life Sci. 69, 23–38.
Mollinga, P.P., Bhat, A., Cleaver, F., Meinzen-Dick, R., Molle, F., Neef, A., Subramanian, S., Wester, P., 2008. Water, politics and development: framing a political sociology of water resources management. Water Altern. 1 (1), 7–23.
Morell, M., Subirats, J., 2012. Crisis of representation and participation. Are virtual communities new forms of citizen aggregation and participation? ARBOR Ciencia. Pensam. Cult. 188 (756), 641–656.
Noveck, B., 2009. Wiki Government: How Technology Can Make Government Better, Democracy Stronger, and Citizens More Powerful. Brookings Institution Press, Washington, DC.
O'Reilly, T., 2010. Government as a platform. In: Lathrop, I., Ruma, L. (Eds.), Open Government: Collaboration, Transparency, and Participation in Practice. O'Reilly Media, Sebastopol.
Pahl-Wostl, C., Lebel, L., Knieper, C., Nikitina, E., 2012. From applying panaceas to mastering complexity: toward adaptive water governance in river basins. Environ. Sci. Policy 23, 24–34.
Palen, L., Liu, S., 2007. Citizen communications in crisis: anticipating a future of ICT-supported public participation. In: CHI Proceedings, Emergency Action. San Jose, California, USA, 28 April -3 May 2007.
Parks, L., 2014. Framing in the Right2Water European citizens' initiative. Presentation at the ECPR General Conference. pp. 3–6.
Pedregal, B., Cabello, V., Hernandez-Mora, N., Limones, N., Del Moral, L., 2015. Information and knowledge for water governance in the networked society. Water Altern. 8 (2), 1–19.
Pereira, A., Rinaudo, J., Jeffrey, P., Blasquez, J., Quintana, S., Courtios, N., Funtowitz, S., Petit, V., 2003. ICT tools to support public participation in water resources governance and planning: experiences from the design and testing of a multi-media platform. J. Environ. Assess. Policy Manag. 5 (3), 395–420.
Pfeffer, K., Martínez, J.A., Baud, I.S.A., Sridharan, N., 2011. Knowledge production in urban governance systems through qualitative geographical information systems, GIS. Environ. Urban. Asia 2 (2), 235–250.
Salter, J., Campbell, C., Journeay, M., Sheppard, S., 2009. The digital workshop: exploring the use of interactive and immersive visualization tools in participatory planning. J. Environ. Manage. 90 (6), 2090–2101.
Seyranian, V., Sinatra, G., Polikoff, M., 2015. Comparing communication strategies for reducing residential water consumption. J. Environ. Phycol. 41, 81–90.
Smith, L., Liang, Q., James, P., Lin, W., 2015. Assessing the utility of social media as a data source for flood risk management using a real-time modelling framework. CIWEM J. Flood Risk Manag. 10, 370–380.
Thacher, D., 2001. Equity and community policing: a new view of community partnerships. Crim. Justice Ethics 20, 3–16.
Turnhout, E., Van Bommel, S., Aarts, N., 2010. How participation creates citizens: participatory governance as performative practice. Ecol. Soc. 15 (4), 26.
Wehn, U., Rusca, M., Evers, J., Lanfranchi, V., 2015. Participation in flood risk management and the potential of citizen observatories: a governance analysis. Environ. Sci. Policy 48, 225–236.
Welle, K., 2010. Strategic Review of WaterAid's Water Point Mapping in East Africa Based on a Review of Ethiopia, Tanzania, Kenya and Uganda. WaterAid Report. (Accessed 21 October 2017). www.wateraid.org/~/.../east-africa-water-point-mapping.pdf.
Wesselink, A., Hoppe, R., Lemmens, R., 2015. Not just a tool. Taking context into account in the development of a mobile app for rural water supply in Tanzania. Water Altern. 8 (2), 57–76.
Wilk, R., 2006. Bottled water: the pure commodity in the age of branding. J. Consum. Cult. 6 (3), 303–325.