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ABSTRACT

In recent years Irrigation Management Transfer policies have received widespread support in policy circles. As part of the strategy management of formerly publicly controlled irrigation systems have been vested with farmer's organizations. Collective action among farmers has been emphasized to perform tasks of water allocation, conflict resolution, water fee collection and routine maintenance of irrigation structures. This paper draws on findings of an empirical study of watershed management in the Himalayan foothills to argue that distribution of interests and endowments within watershed groups may influence potential for collective action. Therefore, of paramount importance in the study of collective action is use of methodological tools that identify relevant variables and link them to behavioural aspects of common pool resource management. This paper demonstrates construction of nature based household endowment and interest scores and explains their usefulness in understanding patterns of collective action in irrigation management in the Shiwalik hills of Haryana.

CONTENTS

1 INTRODUCTION

In recent years decentralized development approaches have gained wide acceptance in policy circles. In the water resources sector in particular, Irrigation Management Transfer (IMT) policies have been promoted with support of multilateral development agencies like the World Bank and Asian Development Bank (ADB). IMT policies typically refer to contraction of government managerial responsibility to encompass only the largest facilities in the irrigation system or vesting management of tertiary distribution facilities with farmer's groups or other private-sector groups (International Water Management Institute (IWMI) 1995:4). Donor supported farmer managed irrigation projects in particular have emphasized the importance of collective action among farmers to achieve tasks of conflict resolution, water allocation, Irrigation Service Fees (ISF) collection and routine maintenance of irrigation structures (Kurian 2001).

Studies have pointed out that farmer's groups that are internally differentiated on the basis of income or resources may not be so successful at collective action when compared to groups that are relatively more homogeneous (Chamber et. al 1992, Bandhopadyay and Eschen 1988). This may especially be the case in the context of management of Common Pool Resources (CPR's) like irrigation canals, fisheries or forests that are characterized by features like non-excludability and subtractibility in use (Ostrom 1990). For instance, a study of 10 irrigation reservoirs in India found that the smaller the variance in farm size among farmers, the more farmers were likely to form water user associations (Easter and Palanisami 1986). Lam reveals a negative relationship between inequality in landholding and irrigation systems performance (Lam 1994). Another study reveals a negative relationship between variance in average family income among irrigators and degree of rule conformance and maintenance activity (Tang 1992).

In addition to endowments collective action may also be influenced by distribution of interests within community groups. For instance, Schlager's case study (in Kanbur 1992) on fisheries underlines the importance of a stable economic environment and moderate to high returns for fishermen in sustaining collective action. Other case studies highlight the role of technology and expansion of markets in creating divergent interests among fishermen that lead to a breakdown in collective action. Studies also emphasize the influence of heterogeneity of skills and ethnicity in collective action. Wade's case study of tank management in South India underlines the influence of scattering of plots of arable land in sustaining interest by both big and small landhold ers in collective action. However, it must be pointed out that Kanbur's review of case studies focuses primarily on distribution of interests. Examination of distribution of interests and its relationship with distribution of endowments is missing in his analysis. But as Baland and Platteau (1996) point out analysis of resources and interests should not be carried out in isolation (see also Oliver and Marwell 1993). From a methodological point of view, therefore we may highlight two questions with implications for research on CPR's:

What *variables* may be used to define distribution of interests and resources and how can they be justified?

What are the local-level *processes* by which distribution of resources and interests combine to influence collective action in common pool resource management?

This paper attempts an answer to the above questions through an empirical analysis of eight watershed[1] management groups- Hill Resource Management Societies (HRMS) with functional dams in the Morni-Pinjore Forest Division of the Haryana Shiwaliks. Community-based watershed organizations in Haryana are responsible for managing fibre and fodder grass, fuelwood and water from earthen dams constructed by the Haryana Forest Department (HFD) as part of a Joint Forest Management (JFM) program. The Haryana forest management program is a particularly good choice for institutional analysis because it is one of three projects worldwide awarded the United Nations Environment Program's *Saving the Drylands* award in 1997 (http://www.unep.org/unep/envpolimp.techcoop/1.htm). The UNEP conferred the award in recognition of the project's institutional and environmental success in eliciting community participation in management of watershed resources like water and forests.

We followed up a rapid survey of 8 HRMS in the Morni-Pinjore Forest Division of Haryana with an in-depth case study of two HRMS- Bharauli and Thadion. Data for the case study was collected over a 10-month period between March and December 2000 using a variety of survey instruments- structured interviews, focused group discussions and review of HRMS records to elicit information on collective action in watershed management. Two rounds of household surveys were undertaken to cover all households in the study sites of the Bharauli and Thadion HRMS.

[1] Only 8 dams of a total of 45 earthen dams that were constructed in Morni-Pinjore Forest Division were functioning when this survey was carried out. Approximately 82% of dams were non-functional as a result of technical failures like poor quality of construction and siltation of structures.

The household surveys collected information on household demography, cropping patterns, asset ownership and participation in management of water harvesting dams. In addition to structured interviews, focused interviews and group discussions were undertaken

The remaining sections of this paper are organized as follows. Section 2 provides a conceptualization of interests and endowments in the context of the discussion on common pool goods and collective action. Section 3 outlines a methodological framework for analysis of collective action in irrigation. The section also describes the evolution of collection action among farmer organizations responsible for management of watershed resources in the Haryana Shiwaliks. Section 4 outlines the method by which the distribution of endowments and interests within watershed management groups were examined. Section 5 applies nature based household endowment and interest scores to explain patterns of collective action in irrigation management in the Shiwalik hills. Section 6 discusses the main conclusions of the paper.

2 COMMON POOL GOODS AND COLLECTIVE ACTION: CONCEPTUALIZING THE ROLE OF ENDOWMENTS AND INTERESTS

'Common pool' goods refer to a physical characteristic of a natural resource. The 'common pool' nature of a forest, grazing pasture or irrigation canal must be distinguished from its 'common property' characteristics – like ownership and access rights which are a human invention. Common pool goods are potential candidates for free-riding behaviour by resource users because they exhibit two characteristics: non-excludability and subtractability. Without institutional mechanisms devised to exclude non-contributing members from common pool resources, these resources are unlikely to elicit maintenance or protection investments. Common pool goods are also subtractable in consumption, which means they can be depleted:

> Without institutional arrangements that address excludability and subtractablity, common pool resources are essentially open-access resources available to anyone – very difficult to protect and very easy to deplete (McKean 2000: 28–29).

The challenges of organizing collective action for management of common pool resources were highlighted by three influential models in social science literature. The first was the *Tragedy of the Commons* model, as exemplified by Hardin's famous statement:

> Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons (Hardin 1968: 1,244).

The second model advanced is that of the Prisoner's Dilemma. The important message here is that it is impossible for rational human beings to cooperate in management of resources that are held in common. A closely held view of the challenge of organizing individuals to pursue their collective welfare, in contrast to individual welfare, was advanced by Mancur Olson in *The Logic of Collective Action*. Olson challenged the optimism expressed in group theory; that individuals with common interests would voluntarily act so as to try to further those interests. Olson underscored his pessimism over group cooperation in the following words:

> Unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests (Olson 1965: 2).

An alternative to the policy prescription that advocated centralization was offered by analysts who argued for the imposition of private property rights whenever resources are owned in common (Demsetz 1967, Johnson 1972). Hardin's famous thesis on the tragedy of the commons led analysts to suggest that the only way to avoid the tragedy of the commons in natural resources and wildlife was to end the common-property system by creating a system of private property rights (Smith 1981: 467). Welch advocated the creation of full private property rights as necessary to avoid the inefficiency of over grazing (Welch 1983: 171).

In recent years New Institutional Economics (NIE) has argued that collective action by community groups may be possible in the case of common pool resources (see Runge 1992, Wade 1987). Scholarship has highlighted three features of developing societies that make the collective action in CPR management a distinct possibility. First, the cost of enforcing a system of private property rights would be expensive. By comparison, the cost of enforcing customary arrangements (understood as some private rights enforced locally), as well as common rights and a variety of 'joint' arrangements would be lower (Runge 1992: 20). Second, the distribution of basic natural resources being skewed in developing societies, assignment of exclusive use rights to a given land area can yield an unfair distribution of resources. By contrast, assignment of joint access rights to CPRs may mitigate the potential for increasing levels of inequality in rural communities. Third, uncertainty of income streams that result from dependence on low-value-added outputs and randomised distribution of natural resources such as soil and water increases the possibility for creation of common property institutions.

An important tenet of the argument put forward by NIE scholars is that collective action by groups is characterized by interdependence:

> When multiple appropriators are dependent on a given CPR as a source of economic activity, they are jointly affected by almost everything they do. If one fisher occupies a good fishing site, a second fisher arriving at the same location must invest more resources to travel to another site, or else fight for the first site. If one irrigator allocates time and materials to repairing a broken control gate in an irrigation canal, all other irrigators using that canal are affected by that action, whether or not they want the control gate fixed and whether or not they contribute anything to the repair (Ostrom 1990: 38).

Oliver and Marwell take the assertion regarding interdependence a step further by stressing the importance of *difference* in distribution of key variables within groups and their implications for collective action:

> Everyone who has taken the task of analysing interdependent action seriously should realize that assumptions must be made about the distributions of key variables across group members, and that the results are always affected by these distributions (Oliver and Marwell 1993: 10).

In articulating their organizer-cantered model of collective action, Oliver and Marwell emphasise Olson's view that in a situation of resource scarcity "large contributors" – those who are highly interested and highly resourceful – play special roles in collective action. Individuals within groups, whether *large* or *small*, are characterized primarily by their *interest* in the collective good and the *resources* they have available to contribute (Oliver and Marwell 1993: 15).

Interests and resources are always defined with respect to a particular process for achieving a particular collective good. There are essentially two processes involved with regard to collective goods: production and provision (Schroeder 1997: 7). Production refers to the process of transforming inputs into outputs. In cases where infrastructure like irrigation canals are constructed by the state the public sector may play an important role in production of the resource. In other cases, state parastatals may mandate other enterprises to produce the service. There are several steps involved in the production of a collective good. These may include facility design, facility construction, deciding how the facility is to be operated and maintained and financing mechanisms.

In addition to the issue of production of collective goods, NIE scholars point to the importance of provision issues. These may include kinds, quantity and quality of services to be provided, arranging for their execution and financing and monitoring or regulating their production or use. Oliver and Marwell point out that institutional analysis of collective good provision should not overlook the role of individual entrepreneurs. They state that “most scholars implicitly restrict their attention to actions that are collective in an older sense, so that the working definition of collective action is *actions taken by two or more people in pursuit of the same collective good”* (Oliver and Marwell 1993: 4). But collective action may also be evident in actions of an individual entrepreneur who bears risks and meets up front costs of organizing co-operation.

3 ANALYZING COLLECTIVE ACTION IN IRRIGATION: TOWARDS A METHODOLOGICAL FRAMEWORK

3.1 Rural Livelihoods in the Haryana Shiwaliks

Haryana is situated in north-western India. Most of Haryana’s natural forests are concentrated along the Shiwalik hills that run along the State’s eastern periphery. The Shiwalik hills consist of a belt of geologically young and fragile low hills that are sandwiched between the Himalayas and the Indo-Gangetic plain. The Shiwalik hills cover three million hectares in the foothill region of Punjab, Haryana, Himachal Pradesh and Jammu and Kashmir. The Shiwalik range is divided into a series of ridges and spurs running in all directions, further spreading out in numerous subsidiary spurs resulting in a broken, steep and precipitous terrain. Panchkula district located in the north-eastern part of the State has the largest area under natural forests located in the Shiwalik hills (GoH 2000). Management of Shiwalik forests in the Panchkula district is vested with the Morni-Pinjore Forest Division. For administrative purposes the Morni-Pinjore Forest Division is further subdivided into four forest ranges: Pinjore, Morni, Panchkula and Raipur Rani.

It has been estimated that about 60% of land in the Shiwalik hills is under agriculture, 30% is forests and 10% is under miscellaneous uses (Arya and Samra 1995). The farmlands are generally rainfed. Productivity of rainfed lands is about half that in irrigated areas, the reasons being inadequate distribution of precipitation, poor soil fertility, erosion hazards and the small size of landholdings (Kensington 1893, Arya and Samra 1995). Low levels of agricultural productivity in the region has made reliance on crop-based incomes as a sole means of livelihood impossible. Rural livelihoods are therefore a product of both agriculture and animal husbandry. Settlement documents and historical studies reveal the intricate land tenure systems that were crafted by communities in the region to balance livelihoods based on rainfed agriculture and pastoralism (Whitehead 1921).

3.2 The Shiwalik hills in Panchkula district: Rainfall, climate and drainage patterns

Panchkula district is mainly drained by the river Ghaggar and its tributaries. The climate of the district is characterized by a hot and dry summer, a south-west monsoon season and relatively cold winters. The period from mid November to February is the winter season. The mean daily temperature in January, which is the coldest month, is 3 degrees Centigrade. This is followed by the summer season, which extends from March to end June. During summer the mean average daily temperature is about 45 degrees Centigrade. The south-west monsoon season begins in late June and continues to about mid September. Mean daily temperatures are lower than in the summer but relative humidity during this period is as high as 70%. In addition to climatic variations, rainfall in Panchkula district exhibits seasonal variation. In fact, most of the rainfall in Panchkula district occurs during the monsoon period. Average annual rainfall in the district is in the range of 1,200 mm.

3.3 Forests, agriculture and non-farm employment

Crop agriculture is the main source of livelihood for populations in Panchkula district. The principal agricultural crops grown in the district are paddy, wheat, maize and pulses (Table 1)

TABLE 1

Area under Cereal Crops in Panchkula District

Crop	Area in sq. kilometres
Paddy	36
Wheat	108
Maize	70
Pulses	43

Source: Central Groundwater Board, North-Western Region, Chandigarh.

Sunflower, onions, groundnuts and fodder grass are also grown by farmers in the region. In recent years though, farmers have introduced radish, cabbage seed and carrot seed. The production of these crops, which are commercially more remunerative, has been aided by expansion of both markets for them and by tubewell irrigation.

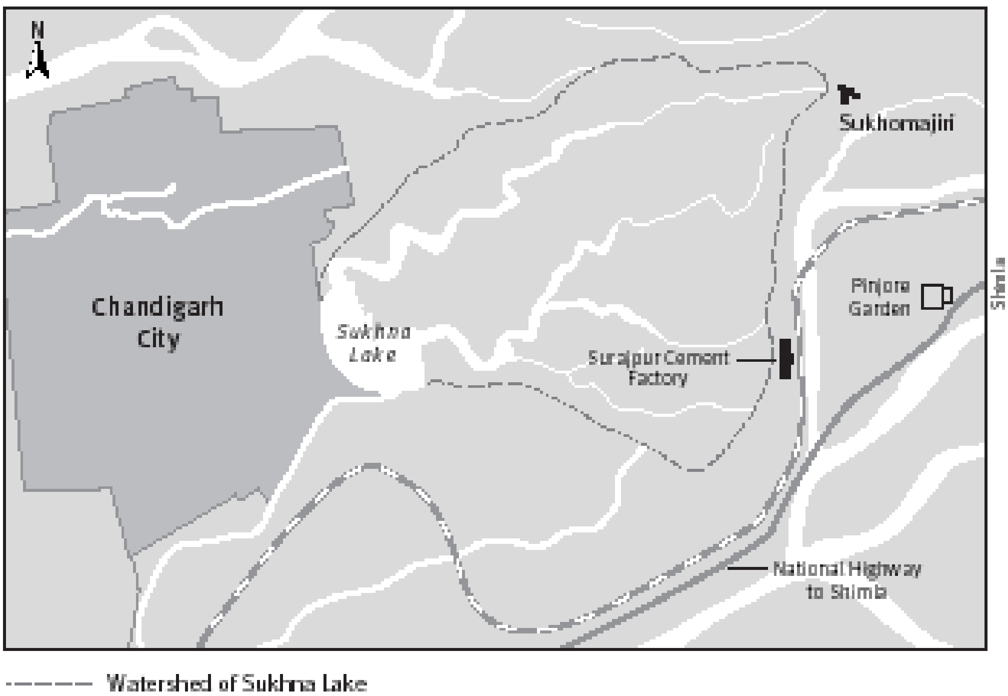
The Shiwalik forests have played a major role in sustaining local economies by serving as a source of timber for both house construction and manufacture of agricultural implements. Fuelwood for cooking purposes also comes from forest areas. Further, the torrents or *chos* that emerge from the Shiwalik hills have played both a positive and a destructive role in agriculture. The torrents have been responsible for flash floods that destroy crops in lower-lying agricultural fields. On the other hand, the waters have also deposited a fine layer of silt that over time has improved soil fertility in the agricultural areas (Whitehead 1921). Forests have also been an important source of fodder grass for livestock. People in the region have traditionally grazed their animals in forest areas rather than growing fodder grass on private fields or purchasing fodder grass in local markets (Grewal et al. 1995). However, the forest department considers open grazing of animals, especially small ruminants like goats, to be a main cause of soil erosion (see Pring 1944, Whitehead 1921).

3.4 The Sukhomajiri Watershed Project: Institutionalizing a Link Between Forests and Agriculture

Shiwalik hill forests in Panchkula district perform the important function of mitigating the effects of soil erosion. But in the early seventies there was a realization that open grazing of cattle and fuelwood collection by local communities endangered the soil conservation function of the Shiwalik forests. The most visible manifestation of forest degradation was the increasing rate of siltation of the Sukhna reservoir in the State capital, Chandigarh (Figure 1*)*. Sukhna reservoir was an important source of tourism revenues. Urgent steps were required to save the reservoir from complete siltation. Preliminary studies indicated that soil erosion caused by deforestation in the watershed areas surrounding Sukhomajiri, Dhamala and Lohgarh villages was responsible for the high rates of siltation of the Sukhna reservoir. For example, in 1982 51.2% of total rainfall in the Sukhomajiri watershed was lost as run-off (Dhar 1994:20). Higher rates of run-off from the watershed area was attributed to reduced tree stocking and poor grass cover. The Haryana Forest Department (HFD), with whom ownership of forests in the watershed areas was vested, was mandated to find a solution to the problem of soil erosion.

From the mid-seventies onwards the Central Government, the HFD and the Central Soil and Water Conservation Research and Training Institute (CSWCRTI) with support from the Ford Foundation were involved in undertaking soil and water conser vation activities in the vicinity of Sukhomajiri village. Initially check dams were constructed to arrest the movement of silt from catchment areas. However, when villagers destroyed the check dams and continued to open graze cattle in forest areas, a more comprehensive dialogue was initiated with local communities. Discussions revealed that inadequate irrigation facilities caused fodder scarcity, resulting in villagers open grazing their cattle in state forests. One of the significant decisions taken as an outcome of those discussions was to construct two earthen dams in 1978. The dams provided supplemental irrigation to wheat crop and thus helped to increase agricultural productivity in the *rabi* season. Further, production of wheat straw increased farmer's disposable income by enabling them to reduce their fodder grass purchases from external sources. The improved supply of wheat straw fodder also led to an increase in cattle dung, which was used as a cooking fuel, and thus lessened pressure on state forests for fuelwood (Figure 1).

FIGURE 1
Making of a Model: Watershed Management in Sukhomajiri



In subsequent years two more earthen dams were constructed in Sukhomajiri village. The increased fodder production resulting from the reliable provision of water from the dams led to changes in livestock composition. For instance, people gradually began substituting buffaloes for goats (Sarin, 1996). The reduction in goat numbers was spurred as well by a simultaneous expansion in markets for buffalo milk (Varalakshmi, 1993). Increased availability of fodder grass from private fields as a result of access to irrigation also led to an increase in stall feeding of cattle (Tata Energy Research Institute (TERI) 1998). Post-project evaluation studies carried out in subsequent years revealed that due to reduced open grazing of goats in forest areas, browsing of tender saplings decreased thereby permitting their faster regeneration. Improved forest condition, as reflected in increased tree and grass regeneration, ameliorated sediment run-off from the catchment, dramatically reducing siltation of the Sukhna reservoir (See Grewal et. al 1995). This initial success with eliciting people's participation in watershed management in Sukhomajiri led the forest department to contemplate scaling up (*replicating*) the program to cover a much larger number of villages in the Shiwalik hills.

3.4.1 Replicating the Sukhomajiri Watershed Model: Focus on Irrigation Management

Between 1990 and 1998 the HFD with support from the Ford Foundation and Tata Energy Research Institute (TERI), an NGO scaled up (replicated) the Sukhomajiri watershed management model. In the process a well defined set of institutional rules were laid down regarding management of water from earthen dams. An important principle followed in the case of distribution of water from earthen dams was that every family was to get an equal share of water upon payment of an hourly Irrigation Service Fee (ISF). The equal share principle was to be based on either a time or area criteria (ie. Acre or hourly basis). Annual water auctions are held at which rights to water allocation are leased out to the HRMS which acts as the authority responsible for allocation of water and collection of ISF's. An alternative scenario is that an individual farmer bids for water allocation rights at the auction. The highest bidder is awarded an annual contract to allocate water, collect ISF's and undertake routine maintenance of the dam.

Six features of the institutional contracts that characterized formation of community organizations are notable:

- Water user associations were constituted as Hill Resource Management Societies (HRMS) under the Registration of Societies Act. 1900.
- Landless households were given a share of water from dams provided they were members of the HRMS. Attempts were made to institute a system of tradable water shares so that landless households could sell their share of water to other households.

- An important principle followed regarding use of HRMS funds was that profits from the sale of water from dams (and fibre and fodder grasses) could be used for community development activities. Such activities could take the form of construction of village roads, repair of school buildings or construction of rest areas for labourers.
- The HFD was to facilitate annual elections of the HRMS managing committee.
- Membership issues were tackled, especially in cases where not all members in a village could benefit from water supply from dams. Further, where the HRMS comprised two or more villages, attention was paid to issues like how revenue raised from sale of water (and fibre and fodder grasses) could be spent. At least a third of positions in the managing committee of the HRMS are to be reserved for women. Every woman in a household was entitled to membership distinct from membership of the male head of household in the general body of HRMS.
- Profits from the sale water from earthen dams (and fibre and fodder grasses) constructed in areas under joint management were to be shared between the HFD and the HRMS.

3.5 Collective Action in Earthen Dam Management: How Distribution of Interests and Endowments Matter

Our review of eight HRMS with functioning dams revealed two systems of water provisioning. The first system is that of the HRMS being involved in framing water allocation rules, collection of irrigation service fees and undertaking of routine maintenance. The second system is contractor-based provision. Under this system, an individual leases out water allocation rights at an annual auction organized by the HRMS. The contractor is then held accountable for water allocation, collection of irrigation service fees and undertaking routine maintenance.

An examination of the socio-economic profile of HRMS reveals some interesting facts relating to collective action (Table 2). For instance, we find that of the eight groups with functioning dams, five showed evidence of collective action.[2] Of these five groups, four were heterogeneous in caste composition and one was homogeneous. Further, of the four heterogeneous groups, all had adopted a system of contractor-based

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[2] Collective action was evident in relatively higher levels of compliance with water allocation rules, expenditure on repairs and labour contributions towards maintenance of dams. The criteria we used to evaluate compliance with water use rules were as follows: number of water users as a percentage of total complying with irrigation service fees.

water provisioning. In the case of the homogeneous group as well (Govindpur Mandpa), a contractor had assumed responsibility for water provisioning.

It is also interesting to note that of the three groups that showed little or no evidence of collective action, two were homogeneous and one was heterogeneous. In the case of the two homogeneous groups, the HRMS was responsible for water provisioning. In the heterogeneous group (Kiratpur) too the HRMS was responsible for water provisioning. So emerging quite clearly is a distinct relationship between group composition, type of water provisioning and evidence of collective action. Groups that are heterogeneous tend to end up with a water allocation system administered by a private contractor, the result being that compliance with collective action rules tends to be greater. On the contrary, groups that are relatively homogeneous tend to rely on HRMS provisioning and consequently fail to ensure compliance with collective action rules. However, two groups in our sample appear as exceptions to the general rule: Govindpur Mandpa, despite being homogeneous, has resorted to a private contractor and succeeded in collective action. Kiratpur, despite being heterogeneous, has relied on HRMS provisioning and failed to provide evidence of collective action.

TABLE 2

Profile of HRMS Groups by Mode of Water Provisioning from Earthen Dams

HRMS	Land ownwership pattern *(proxy for endowments)*	More than 50% of water users do not rely on agriculture as primary source of income *(proxy for interest)*	Private alternatives to earthen dam exist *(proxy for interest)*	Caste composition *(proxy for asymmetrical power relations linked to land ownership)*	Evidence of collective action to manage earthen dams	Mode of Provision from earthen dams
Sukhomajiri	Even	Yes	Yes	Single-caste	No	HRMS
Dhamala	Skewed	No	No	Multi-caste	Yes	Contractor
Lohgarh	Skewed	No	No	Multi-caste	Yes	Contractor
Nada	Skewed	No	No	Multi-caste	Yes	Contractor
Bharauli	Skewed	No	No	Multi-caste	Yes	Contractor
Thadion	Even	Yes	Yes	Single-caste	No	HRMS
Govindpur Mandpa	Even	No	No	Single-caste	Yes	Contractor
Kiratpur	Skewed	Yes	Yes	Multi-caste	No	HRMS

Notes: 1. Where more than one dam was functioning in a HRMS, we focused on the dam which the larger number of households relied on for water. We also overlooked dams that were choked but which households continued to use using a siphoning system. 2. Average number of beneficiaries of earthen dams.

Each of these two cases offers lessons on the importance of group composition in analysing collective action. First, the Govindpur Mandpa case highlights a meth odological issue. Previous analyses of group heterogeneity in CPR management have tended to rely on land ownership or caste composition to define heterogeneity (see Baker 1998, Bardhan 2000). But we argue that collective action, particularly in irrigation management, must consider other variables as well. For example, land size, family size, type of land (rainfed or irrigated), livestock composition and quantum of non-farm income are important in understanding the role of endowments in influencing collective action. This is especially since nature based endowments such as those outlined above have the potential to influence patterns of peasant differentiation as reflected in income, labour hiring or cropping intensity that may go a long way in defining potential for peasant accumulation. Accumulation strategies adopted by peasants, perhaps including their participation as water contractors, could in turn be mediated by historical power relations that revolve around ownership of arable land, a fact highlighted by other studies in the South Asian context (Sharma 1994).

Second, the Kiratpur case highlights the importance of factoring in ecological variation and non-farm employment in understanding the role of interests in shaping collective action. We note that Kiratpur despite being a heterogeneous group has relied on HRMS water provisioning. This we argue is primarily due to two reasons. One is that less than half of water users in Kiratpur rely on agriculture as their primary source of income. This reflects their involvement in non-farm labour markets. Engagement in non-farm labour markets could imply that landholders spend considerable time away from the settlement and are therefore in no position to monitor water use rules, should they decide to serve as water contractor. The second reason is that peasants' interest in using water from earthen dams is not as intense as it would be in the absence of non-farm alternatives. Most peasants using water from the earthen dam also have access to a private tubewell. Access to private tubewells in the Haryana Shiwalik hills is strongly influenced by cost of drilling, which in turn is determined by groundwater depth. Discussions revealed that drilling costs become prohibitive beyond a depth of 60 feet for peasants in the Shiwalik region. Therefore, we argue that variations in local ecology as reflected in factors like groundwater depth may influence potential for peasant cooperation in joint management of CPRs.

4 CONSTRUCTING NATURE-BASED HOUSEHOLD ENDOWMENT AND INTEREST SCORES

4.1 Nature Based Household Endowment Scores

From our discussion in the previous section it becomes clear that crop agriculture and animal husbandry are important sources of rural livelihoods in the Morni-Pinjore Forest Division in Haryana. Off-farm employment as casual labour in stone quarrying and forest department afforestation activities are important in that they supplement income from agriculture-based activity. This is particularly the case with land-owning households. Landless households it must be emphasized derive a significant part of their income from off-farm and non-farm sources. Considering that landless households do not constitute more than 15% to 25% of households in Shiwalik villages, we can safely assume that most households derive their livelihoods from farm-based activity (TERI 1998). This is why we chose to construct household endowment scores based on agriculture and animal husbandry.

4.1.1 Variables

In the process of constructing household endowment scores we considered four variables: (i) total rainfed land owned, (ii) total irrigated land owned, (iii) type of livestock owned and (iv) size of household. Total irrigated land owned refers to land irrigated by tubewells, earthen dams and *kuhls* (seasonal water channels). The principal livestock types considered in constructing the endowment scores are adult cows, buffaloes, bullocks, goats and camels. Household size refers to total number of members in a household.

4.1.2 Weights

In constructing household endowment scores we devised weights for each of the assets outlined above. The weights were decided based on food productivity assessments undertaken in Shiwalik villages. Four criteria guided the allocation of weights for variables:

- per-acre productivity of corn/rice and wheat under non-irrigated conditions
- per-acre productivity of corn/rice and wheat under irrigated conditions
- average milk production by buffaloes in summer, monsoon and winter months
- average milk production by cows in summer, monsoon and winter months

4.1.3 Assumptions

In devising weights for caloric value of cereal crops and average milk production we made five assumptions:

- Each adult requires a minimum of 2,300 kilocalories per day.
- The annual average kilocalorie requirement for an individual would therefore be some 850,000 kilocalories.
- A kilo of a cereal like corn, wheat or rice contains on average 3,500 kilocalories.
- Cow's milk contains 700 kilocalories per litre.
- Buffalo milk contains 900 kilocalories per litre.

4.1.4 Cereal crops caloric equivalent

Household-level assessments of crop and milk production were undertaken for which the following measures based on production under irrigated and non-irrigated conditions were used:

- One acre of rice or corn in *kharif* season under non-irrigated conditions yields 1,200 kilos per acre on average.
- One acre of wheat in *rabi* season under non-irrigated conditions yields 500 kilos per acre.
- Therefore, under non-irrigated conditions annual average yields per acre are approximately 1,700 kilos (i.e. 1,200 + 500).
- A yield of 1,700 kilos per acre under non-irrigated conditions is equivalent to some six million kilocalories per acre per year (i.e. 1,700 * 3,500 kilocalories per kilo).
- Following from our earlier assumption regarding a minimum calorie requirement per individual of 850,000 kilocalories per year, six million kilo calories would sustain seven members of a family.
- Under irrigated conditions one acre of corn in *kharif* season yields 1,800 kilos per acre.
- Under irrigated conditions one acre of wheat in *rabi* season yields 1,600 kilos per acre.
- Therefore, under irrigated conditions total yield per acre is approximately 3,400 kilos (i.e. 1,800 + 1,600).
- A yield of 3,400 kilos per acre under irrigated conditions yields a caloric equivalent of 11,900,000 kilocalories per year (i.e. 3,500 * 3,400).

- Assuming a minimum annual calorie requirement of 850,000 per individual, 11,900,000 kilocalories would sustain 14 members of a family.

4.1.5 Milk production and calorie equivalent

Milk production in Shiwalik villages varies by season. In the summer months between March and May an adult buffalo produces about 5 litres of milk per day. During the monsoon period between June and October, milk production peaks at about 10 litres per day. In the winter, between November and February, average milk production per day is about 4 litres. However, as no milk is produced for a few weeks in a year we assume that average annual milk production is approximately 2,000 litres. Two thousand litres of milk produced by an adult buffalo translates into a caloric equivalent of 1.8 million kilocalories annually; thus the 1.8 million kilocalories contained in buffalo milk can sustain 2.5 persons annually.

On the other hand during the monsoon season, a cow produces some 750 litres of milk. During the summer season, milk production falls to approximately 450 litres. Therefore, total annual milk production by a cow would be in the range of 1,200 litres. This 1,200 litres of cows milk translates into a caloric equivalent of 840,000 kilocalories. This 840,000 kilocalories contained in cows milk could sustain one family member annually.

Based on average food productivity assessments for cereal crops and milk we calculated household endowment scores as follows:

$$(7Lr + 14Li + 2.5B + 1C + 0.5C = 0.1G) / H.H.\ Size$$

where *Lr* = acres of rainfed land, *Li* = acres of irrigated land, *B* = no. of adult buffaloes, *C* = no. of adult cows, *C* = no. of camels, *G* = no. of goats, *H.H. Size* = no. of members in a household.

4.2 Nature Based Household Interest Scores

4.2.1 Peasant interest: Some observations

Assumptions: To examine patterns of peasant interest in earthen dams, we constructed interest scores for water-using households in Bharauli and Thadion HRMS. In calculating interest scores[3] for peasant households (Table 3) we made some assumptions based on preliminary data analysis and discussions with key informants.

TABLE 3
Determination of scores for interest in dams

a: Weights for interest in dams

Area irrigated by dam	Score
a) Less than 1 acre	1
b) Between 1 and 3 acres	2
c) Between 3 and 5 acres	4
d) Greater than 5 acres	8
Alternative sources of irrigation for dam-irrigated land	**Score**
a) Tubewell	1
b) Tal Kuhl/Tal Nadi	2
c) None	4
Land irrigated outside dam command area	**Score**
a) Greater than 3 acres	1
b) Between 2 and 3 acres	2
c) Between 1 and 2 acres	4
d) Between 0.5 and 1 acre	8
e) None	16

b: Parameters for calculation of interest scores

Parameter	Non-irrigated Land	Irrigated Land	Increase by factor of
Food (wheat)	500 kg/acre	1,000 kg/acre	2
Wheat from 1 acre can feed	7 people	14 people	2
Fodder grass can sustain	2.5 people if milk is consumed	5 people if milk is consumed	2

First, we assumed that the larger the area irrigated by the earthen dam the greater the interest in its use; conversely, the smaller the area the lower the interest. Second, the greater the *reliability*[4] afforded by alternative sources of irrigation for dam-irrigated land, the less peasants potential interest would be in participating in manage

[3] Recent research has pointed to the importance of rigorous appraisal methods to enhance the quality of project selection and the financial viability of donor-supported interventions (see Walle and Gunawardene 2001). As a result in recent years multilateral development banks have begun to experiment with the use of qualitative codes and weights to predict farmer participation in management of common pool resources and project monitoring (see Dev and Ranade 1999, Dayal et al. 2000, Pincus 1996).

[4] By reliability we refer to the number of months irrigation is forthcoming from different sources. Tubewells provide water all year round and Tal kuhl/Nadi (river) for eight months between July and early February.

ment activities like repair and maintenance. This relates to our third assumption: the greater the area under irrigation outside the dam command area, the lower the potential interest would be in participating in collective action (e.g. purchasing water allocation rights, complying with water user charges, water allocation rules).

Interest scores of 1, 2, 4, 8 and 16 were decided based on findings of household food productivity assessments. We noted that access to irrigation could increase wheat production per acre by a factor of two. Likewise, irrigation could increase the number of people who can be fed from one acre of land by a factor of two.

4.3 Applying Endowment and Interest Scores: Some Empirical Considerations

We may recall that of the eight HRMS with functional dams only five showed evidence of collective action. With a view to test whether our methodology for computation of household interest and endowment scores explain the underlying reasons for collection action or its absence we undertook a case study of two HRMS- Bharauli and Thadion. Bharauli HRMS had succeeded in eliciting collective action in earthen dam management while Thadion had failed. Both HRMS are situated adjacent to each other and characterized by similarities in soil type, access to markets, quality of dam construction and nature of HFD involvement in monitoring use of forests located in catchment areas of earthen dams.

4.3.1 Interest Scores

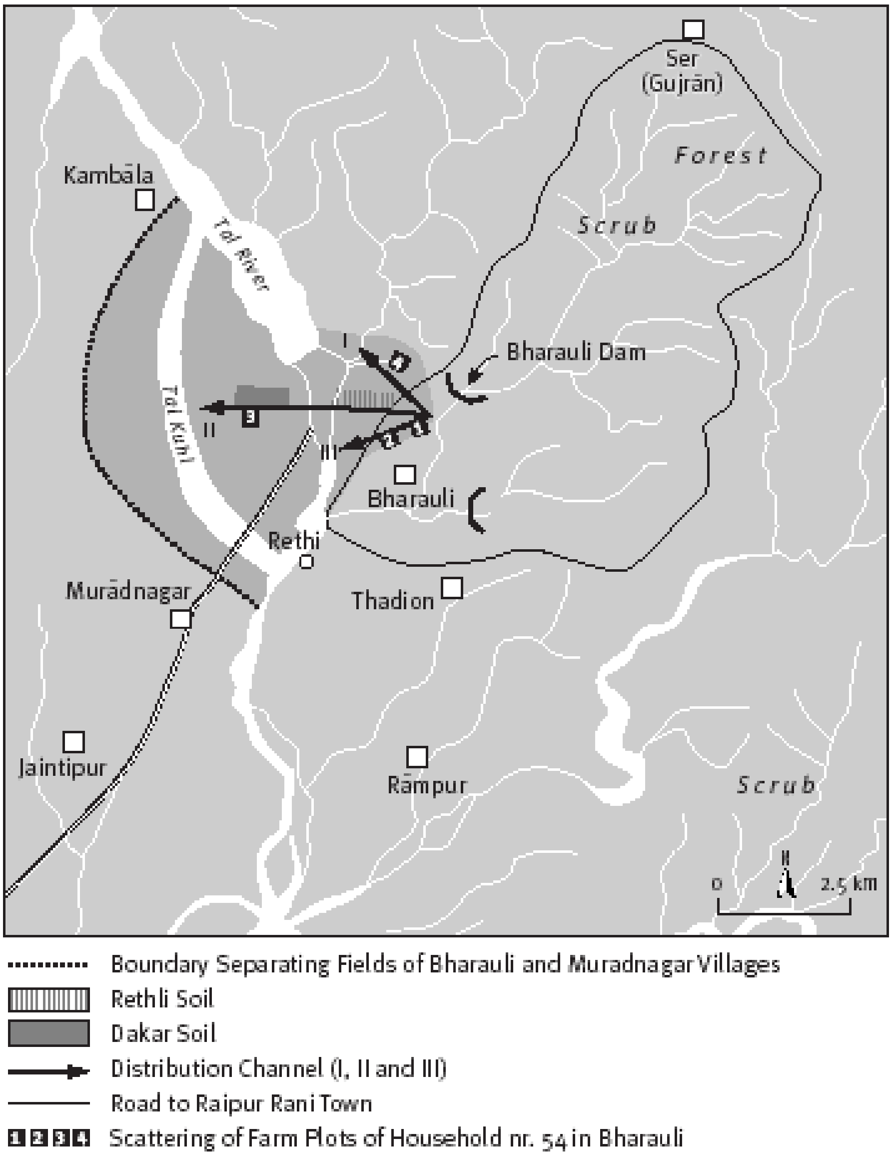
Group size and composition

Bharauli HRMS has more water users than Thadion. Water users in Bharauli are drawn from up to three different caste groups whereas in the Thadion group all water users belong to a single caste. Ethnic heterogeneity of water users in Bharauli is compounded by the fact that only 35% of water-using households belong to a same *gotra* or family lineage. This contrasts with Thadion HRMS where up to 61% of water-using households belong to a single *gotra*.

Area irrigated by earthen dams

We observe that the water user group in Bharauli is mostly composed of marginal and small farmers. Half of water users here have land parcels in the size range of one to three acres while 42% own parcels of less than one acre. Some 8% of water users own land parcels in the size range of between three and five acres. By contrast, in Thadion we observe that water from the dam is used by peasants who are drawn rela tively evenly from all land-size categories. Half of water users have land parcels of less than one acre, 24% between one and three acres and another 25% between three and five acres.

FIGURE 2
Land Scattering and Soil Types in Command Area of Bharauli Dam



Land scattering

In addition to area irrigated by dams, peasants' interest in the use of dams may be influenced by land scattering. For example, Household 54 in Bharauli, which has the largest area of irrigated land, has parcels located at three different locations in the command area of the dam (Figure 2). Further, all plots belonging to this particular peasant are located at the end of each of the three distribution channels. The fact that this peasant household has all its arable land located within the dam command area and none outside heightens its reliance on the earthen dam for supply of water for irrigation purposes.

Alternative irrigation on dam-irrigated land

None of the water-using households in Bharauli have alternative sources of irrigation for dam-irrigated land. In Thadion, by contrast, 53% of water users have access to tubewells. Tubewell irrigation provides farmers the option of growing up to four crops in a year: corn (during the *rabi* season) and radishes, wheat and paddy (during the *kharif* season). Farmers with access to tubewell irrigation share certain basic characteristics: integration into crop markets, cultivation of water-intensive crops like paddy, exposure to the risk of price fluctuation and rising input costs associated with use of fertilizers and pesticides.

4.3.2 Endowment Scores: A Commentary on Nutrition and Well-Being

Household endowment scores based on food productivity assessments illustrate not only the nutritional levels of households. Endowment scores are also a commentary on household well-being in general. This is because nutritional levels attained by households may determine the extent and nature of their participation in off-farm and non-farm labour markets. For example, landless households with no access to arable land would tend to derive most of their income to purchase food items from engaging in markets for non-farm labour. The nature of off-farm jobs performed by them may determine the quantum of income and, particularly, patterns of natural resources use.

Off-farm jobs like stone loading and daily wage labour may result in lower mean income levels compared to groups with large landholdings. Lower mean incomes may constrain households from purchasing fodder grass in local markets or adopting non-biomass energy cooking technologies like Liquefied Petroleum Gas (LPG). As a result, landless households may depend on state forests for fuelwood and fodder grass considerably more than households with larger endowments of arable land. Further, engagement in petty off-farm jobs with no stipulated work conditions may also prevent male members from devoting time to household tasks like fuelwood collection. A number of previous studies note that the onus for such tasks usually falls on women and children in the household (Agarwal 2000). Involvement of women and children in such tasks prevents them from participating in formal education, thus resulting in lower levels of literacy among such groups.

Household endowment scores implicitly acknowledge that access to irrigation can boost per acre productivity of cereal crops. This has two implications. First, households meeting minimum caloric requirements may sell their surplus and spend income from the proceeds on non-food consumption. Non-food consumption could take a variety of forms, like construction of *pucca* (modern) houses, purchase of livestock or investment in a family business. Second, households who do not meet their caloric requirements from on-farm production may still meet their food requirements by selling agricultural produce in markets and using the proceeds to purchase food items. But in either case, access to irrigation can prove critical in determining the extent of household well-being.

This point has clear implications for our formulation of household interest in collective good provision. In particular, we propose two hypotheses in relation to household interest in use of water from earthen dams:

- Individuals with substantial acreage under irrigation from common pool sources have an interest in complying with water allocation rules and user charges. Further, individuals with substantial land-based endowments may also participate in leasing out water allocation rights under joint forest management.
- The corollary is that individuals with access to alternative sources of irrigation (like private tubewells) may have a relatively less interest in participating in collective action.

Household endowment scores, by acknowledging household size as a variable of critical importance improves over previous studies that examined the issue of group heterogeneity. For instance, previous studies, by focusing on land ownership as an endowment, ignored the size of the family that such an endowment could sustain (see Baker 1998). Groups with large landholdings and large family sizes may not necessarily be well off in terms of per capita income or food consumption compared with families in a similar land-owning strata but with smaller household sizes. Further, large land-owing households may have access to larger irrigated area in absolute terms. But in Haryana when the proportion of cropped area irrigated is examined, households with smaller farm sizes have tended to have a higher area under irrigation (Patnaik 1987).

Relatively smaller family size of larger landholding groups may endow households in these groups with the enormous economic clout that results in great measure from greater engagement in markets for agricultural products. Further, a confluence of factors like caste identity and educational levels may propel individuals in such households to positions of power in local government bodies like *panchayats.* Leadership skills possessed by such individuals may make them community spokespersons in the process of negotiating with state parastatals or NGO representatives on new development projects (Bebbington 1999).

5 WHAT DO NATURE BASED HOUSEHOLD ENDOWMENT AND INTEREST SCORES TELL US ABOUT COLLECTIVE ACTION?

5.1 Distribution of Interest and Conflicts over Water Use

The constraints associated with groundwater exploitation in Bharauli make tubewell expansion difficult. As a result, irrigation, especially during the *rabi* season is critically dependent on water supply from *kuhls* and the earthen dam. The *kuhls* run dry by early February and if rains do not arrive by early March, the supply of the last round of supplemental irrigation for wheat depends on water from the earthen dam. If the rains fail altogether (in the period from November to March), reliance on water from the dam becomes even more critical.

The limited access to private sources of irrigation like tubewells in Bharauli has meant that dependence on common pool resources like dams is critical for the supply of supplemental irrigation during the *rabi* season. This is reflected in a relatively high mean level of interest in earthen dams in Bharauli (Table 4).

TABLE 4

Distribution of Household Interest

HRMS	Coefficient of variation	Mean	Standard deviation
Bharauli	51.34	13.4	6.88
Thadion	59.44	10.93	6.06

In Thadion, by contrast, we found a lower mean level of interest in use of the earthen dam. This is primarily because half the water users have access to tubewells.

The same group of water users with access to tubewells also has their farm plots located at the head of the command area of the earthen dam. Further, most of the households with access to tubewells are drawn from a single *gotra* or family lineage. These facts indicate that households at the head-end of the earthen dam command area could cooperate among themselves to monopolize water and deny farmers with plots located at the tail-end their share of water from the dam. Other studies have documented such examples of powerful families co-opting the benefits of irrigation projects (see Bandopadhyay and Eschen 1988). However, our Thadion case study offers a slightly different perspective.

Our Thadion case study reveals that powerful households, drawn from a single family and with access to tubewells were bogged down by in-fighting. For example, in Thadion two households removed distribution pipes to level their fields and never replaced them. Despite repeated requests by others with fields at the tail-end of the distribution channel the pipes were not replaced. In response to this violation, Somnath, a large landholder, installed a siphon and pumped water out from the dam to his field using a circuitous route. Pumping water using a siphon can silt the dam, and so other farmers rejected the idea of siphoning water. As a result, Amarjeet, Somnath's uncle, offered to desilt the dam using his own funds. Amarjeet promised to charge for use of water after the dam was repaired in order to recover his investment. However, he failed to undertake the de-silting but instead installed a siphon himself and began charging other farmers for water use. Somnath rejected this practice by Amarjeet. He began a parallel scheme of siphoning water and selling it to other farmers. But Amarjeet objected to Somnath siphoning water saying that he had committed himself to de-silting the dam. Somnath offered to stop siphoning water only if Amarjeet would begin the de-silting work. The continuous conflict between the two households drawn from the same lineage resulted in the eventual silting of the dam in March 2001.

Conflicts arise primarily due to differences in priorities of water users. For example, in Thadion differences in priorities have been reflected in some households using water from dams to irrigate rice during the *kharif* season (Table 5). Farmers with access to tubewells tend to view earthen dams as a supplemental source of irrigation for rice cultivation. Households belonging to a single family that constitutes about 60% of all water users utilize water in an unregulated manner, thereby depriving other households of their share during the *rabi* season. Households without access to tubewells are adversely affected by conflicts at the head-end of the irrigation system. This is prima rily because their ability to raise crops other than rice to meet household food requirements is affected.

TABLE 5
Rice Cultivation: HRMS Comparison

HRMS	Percentage of water-using households growing rice	Mean gross cropped area under rice (in acres)
Bharauli	9	8.3
Thadion	46.6	30.9

5.2 Potential for Irrigation Service Provision

Success with dam management in Bharauli is explained in large part by the the mode of water provisioning. In Bharauli a water contractor has been in charge of water allocation, collection of ISF's and routine maintenance for three years (1997-2000). The ability of the contractor to successfully bid for water allocation rights at open auctions has been aided by surpluses he has derived from irrigated agriculture.[5] From a livelihood perspective agricultural surplus that the contractor derives is critical to ensuring well being especially since income from non-farm employment did not arise due to absence of another male member within the household.[6] From the contractor's point of view sustaining agricultural surplus is critically tied to ensuring compliance with institutional rules that regulate use of the dam. This is primarily because of two factors:

- Alternative irrigation sources in the form of private tubewells did not exist in Bharauli due to the high drilling costs associated with accessing groundwater. This was in contrast to Thadion where groundwater drilling costs were comparatively lower due to easier access to groundwater.
- We may recall from our discussion earlier that farm plots of household no. 54 (the water contractor's) were located at the end of each of the three distributory channels. Incidentally the water contractor had the largest acreage under irrigation from the dam in Bharuali. Distribution of land with access to irrigation from the dam was relatively less skewed in Thadion (Table 6).

[5] Surplus from irrigated agriculture have been possible because of secular increases in agricultural terms of trade for wheat and maize, two principal crops grown in the region.

TABLE 6

Distribution of Household Endowments: A Comparison

HRMS	Coefficient of variation	Gini-coefficient
Bharauli	96	0.49
Thadion	64.2	0.35

5.3 Compliance with Irrigation Service Rules

The relatively greater access of the water contractor to arable land and more specifically to irrigated land has accorded him a powerful place in the village power structure. Historically the water contractor has been a source of credit for landless households especially in times of droughts and floods. He has also been a source of employment for marginal land owning households. The contractor has played an important role in regional politics by being leader of Bharauli panchayat between 1995 and 2000. The contractor's power within the village has influenced level of compliance of water using households with water use rules in two ways. First, the contractor has devised an intricate web of exchange relationships whereby payment of water dues is tied to services like agricultural labour that marginal land owners owe the water contractor. Second, due to his predominant position in the power structure, the contractor has been able to prevent other peasants from bidding at water auctions. Such local level processes have serious implications for equity and efficiency of water use as we shall in the ensuing discussion.

Water allocation rules

We adapted Ostrom's use of "water availability difference" to examine predictability in availability of water among peasants at the head-end and tail-end of the dam distribution network (Ostrom 1994: 552).[7] The difference in predictability of water supply between head-end and tail-end peasants was lower in Bharauli than in Thadion (Table 7). This we argue reflects the higher level of efficiency associated with lower level of conflict among peasants and greater clarity about water usage rules.

[6] Customarily women in the Shiwalik region do not participate in non-farm labour markets. This is primarily because of community norms that prevent them from engaging in work in the presence of men.

[7] We allotted weights to qualitative assessments of how predictable farmers access to water from earthen dams was in Bharauli and Thadion. The weights were allotted based on whether farmer's access to water was high (2), medium (1) or low (0).

TABLE 7

Water Predictability Difference

HRMS	Water predictability among users		Difference in water predictability between head and tail-end users
	at head of distribution network	at tail of distribution network	
Bharauli	1.8	1.3	0.5
Thadion	1.7	0.1	1.6

Another indication of the efficiency of the water distribution system is the difference between average water requirement and water availability. Based on rule of thumb calculations of water requirements during the *rabi* season and mean land sizes we arrived at the difference between water requirements and water availability.[8] In Bharauli relatively efficient water management rules guaranteed a relatively large number of households access to water from the dam. In Thadion, by contrast, because a few households have a monopoly on use of water, the difference between water availability and requirement is double. Greater efficiency in use of the water-harvesting dam is also reflected in the expansion of the Bharauli distribution network.

In response to growing profits from water sales, the contractor expanded the distribution network in 1999/2000 to provide irrigation to 15 additional households. As a result, a total of 19.5 acres was brought under irrigation. We must emphasize here that within the constraints imposed by command area topography and availability of water in the dam, the dam contractor does attempt to balance the needs of a wide constituency of water users. For instance, 40% of the new beneficiaries were either his brothers or belonged to his extended family. Further, the contractor attempts to supply peasants from other caste groups and those with smaller land sizes as well. Finally, the interests of large landholders who can wield enormous political clout are accommodated in the expansion plan.

[8] During a period of normal rainfall three waterings are required for a wheat crop. Four hours are required to water 1 acre of wheat crop from the dam. Mean land size among water users in Bharauli is 4.7 Acres. Therefore, mean per-capita water requirement for water users in Bharauli is 18.8 hours (4.7 x 4). But in 1999-2000 a total of 555 hours of water was supplied in Bharauli at a mean per-capita rate of 16.1 hours. In Thadion mean land size is 5.8 acres. Therefore, mean per-capita water requirement for water

Collection of water fees

Household surveys in Bharauli revealed that 91% of dam users received water for four to five months during the *rabi* season (November to March) compared to only 28% of water users in Thadion. Further, 89% of water-using households in Bharauli reported that supply of water from the dam was predictable, compared to only 83% of households in Thadion. Therefore one may argue that due to the assured supply of water from the earthen dam and a sense of fairness associated with water allocation water users in Bharuali were more likely to comply with rules regarding water fees. Greater compliance with rules regarding payment of water fees is reflected in data on payment of water lease fee by the contractor to the HRMS (Table 8).

TABLE 8

Compliance with Water Fees: Comparison of HRMS Groups

a: HRMS Bharauli

Head	1995/96	1996/97	1997/98	1998/99	1999/2000
Lease amount committed by contractor (in rupees)	N/A (under HRMS provision)	N/A (under HRMS provision)	3,000	2,500	5,000
Amount deposited in HRMS account	Nil		3,000	2,500	5,000
Hourly user charge (in rupees)	25/hr	25/hr	25/hr	25/hr	25/hr
Profit from water leasing (i.e., difference between lease amount and total dues collected by contractor on hourly basis)	N/A (under HRMS provision)	N/A (under HRMS provision)	no profit	7,500	5,000

b: HRMS Thadion

Head	1995/96	1996/97	1997/98	1998/99	1999/2000
Lease amount committed by contractor (in rupees)	N/A	N/A	850	6,800	N/A (under HRMS provision)
Amount deposited in HRMS account	Nil	Nil	Nil	1,500	Zero compliance with irrigation service fees
Hourly user charge (in rupees)	N/A (no charges levied)	N/A (no charges levied)	10/hr	10/hr	10/hr
Profit from water leasing (i.e., difference between lease amount and total dues collected by contractor on hourly basis)	N/A	N/A	Nil	Nil	N/A

users is 23.2 hours (5.8 x 4). But in 1999-2000 a total of 479 hours of water was supplied in Thadion at a mean per capita rate of 32 hours.

Participation in repair and maintenance of earthen dams

We find that peasants in Bharauli cooperate with the contractor in undertaking routine maintenance activities. In Bharauli between 1995 and 2000 the mean number of labour days contributed towards maintenance of the distribution network was 3.7 compared to 2.3 in Thadion. Further, the mean monetary contribution towards maintaining the distribution network was Rs 377 compared to Rs 156 in Thadion. We also observe through regression analysis that large landholding households made the largest monetary contributions towards maintenance of the distribution network; peasants with smaller areas irrigated by the dam made more labour contributions towards maintenance activities (Table 9).

TABLE 9

Monetary Contributions towards Repair of Dam Distribution Network

Independent variable	Regression coefficient	Level of significance
Area irrigated by earthen dam	280.3 (1.51)	10%

Note: Dependent variable is monetary contribution towards repair of the dam distribution network. Number of observations is 35.
Figure in parentheses indicates t value.

6 CONCLUSIONS

Given the growing interest in participatory approaches to management of water resources there is a need to evolve methodologies that capture distribution of benefits and costs among different groups of water users. Distribution of benefits and costs among different categories of water users is critical from the point of view of understanding the potential for collective action in CPR management. It is a fact that distribution of benefits and costs of using a common pool irrigation system may change due to emergence of private alternatives like tubewells or changes in land ownership due to changes in family size or population growth. Likewise secular changes in agricultural terms of trade may make it unviable to undertake production of certain types of crops. Such over-time changes may significantly affect the potential for collective action in irrigation management with implications for conflict resolution or routine maintenance.

This paper has demonstrated through an empirical analysis of watershed organizations in Haryana the usefulness of household endowment and interest scores. Household endowment scores provide a profile of distribution of endowments (irrigated and rainfed land, livestock and family labour) for households that comprise a water user group. In doing so we emphasize the importance of interdependence in fostering collective action. Calculations of benefits and costs for individual households are of limited use unless they are examined in relation to the benefits and costs of other water using households. Such an examination may offer us insights into a household's likelihood to comply with rules regulating water allocation, payment of ISF's or contribution towards routine maintenance. Household interest scores on the other hand provide us with cues to understanding under which set of conditions particular groups of households may channelize their resources towards irrigation service provision.

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