Rule Compliance in Participatory Watershed Management- Is it a Sufficient Guarantee of Sustainable Rural Livelihoods?

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ABSTRACT

Donor supported participatory watershed management projects have emphasized the importance of collective action among farmer groups to ensure that tasks of water allocation, collection of Irrigation Service Fees (ISF's) and routine maintenance are undertaken. New Institutional Economics analysis of collective action has underlined the importance of rule compliance in participatory natural resources management. A failure to ensure rule compliance it is argued would result in resource conflicts and elicit poor cost recovery leading to poor investment in routine maintenance of physical infrastructure like dams and distribution channels. However, based on a case study of two water user groups engaged in management of earthen dams in Haryana we argue that rule compliance may be a necessary though insufficient guarantee of institutional success. We point out that the impact of rule compliance on rural livelihoods- farmer incomes, environmental regeneration or gender equity would be a more durable indicator of institutional success. No less important in institutional analysis is the role of external conditions- changes in State policies, market prices and alterations in stock of community and household assets in bringing about sustainable improvements in rural livelihoods that extend beyond the life of an externally supported watershed project.

Keywords: Rule Compliance/Participatory Watershed Management/Sustainable Rural Livelihoods/Collective Action/Equity

1. INTRODUCTION

In recent years decentralized development approaches have gained wide acceptance in policy circles. In the agriculture sector in particular, Irrigation Management Transfer (IMT) and Joint Forest Management (JFM) policies have been promoted with a view to facilitate integrated management of natural resources in a watershed[1] context. Joint management approaches typically involve devolving management of previously government controlled forests and irrigation systems to farmer's groups or other private-sector entities (International Water Management Institute (IWMI) 1995:4)[2]. Donor supported community based natural resource management projects have also emphasized the importance of clearly defined institutional rules to ensure that tasks of water allocation, monitoring of forest use, collection of Irrigation Service Fees (ISF's) and routine maintenance are undertaken by farmer's groups.(ADB, 2001)[3].

Rule compliance in the case of watershed management may be reflected in factors like degree of compliance with water allocation rules, payment of irrigation service fees or contributions towards routine maintenance of catchment areas of irrigation systems. Most evaluations of participatory watershed management projects assume that compliance with institutional rules would facilitate greater cost- recovery and may therefore be viewed as an indicator of institutional success (Kerr and Chung, 2001)[4]. But rule compliance is not a sufficient condition for evaluating institutional success. We argue instead that institutional success may be judged by how much rule compliance has contributed towards achievement of sustainable rural livelihoods- increases in agricultural productivity and farm incomes, environmental regeneration, investment in routine maintenance of physical infrastructure or gender equity. (DFID 1998)[5]. In doing so we highlight the role that changes in exogenenous conditions- State fiscal policy, market prices and alternations in the stock of community or household assets can play in influencing potential for rule compliance in watershed management, especially in the wake of an external intervention (see Molinas 1998)[6].

New Institutional Economics (NIE) analysis of collective action has been criticized for overlooking the importance of external conditions in fostering management of Common Pool Resources (CPR's) like forests and irrigation systems. NIE analyzes of collective action have also been criticized for two additional reasons. First, most analyses of collective action in CPR management has been criticized for being tautologous. For instance, transaction cost analysis suggests that "existing institutions minimize transaction costs because transaction cost minimization is their function" (Leach et al. 1999: 237)[7]. Second, even in cases where rule compliance is achieved equity issues may remain unaddressed. For example, farmers in water management groups may comply with rules relating to allocation, collection of ISF or routine maintenance and yet the interests of disadvantaged groups like women and landless households may be overlooked (see Kurian 2003)[8].

In this paper we undertake a case study of two micro-watershed groups known as Hill Resource Management Societies (HRMS) in Panchkula district of Haryana state. The first micro-watershed group- Thadion has failed over a period of three years to elicit rule compliance in management of an earthen dam[9] built by the Haryana Forest Department (HFD). By contrast the second group- Bharuali has succeeded in relative terms in eliciting rule compliance in water allocation, ISF collection and routine maintenance of earthen dams. In this context we examine the effect that three years of sustained rule compliance in dam management has had on rural livelihood indicators- land use patterns, catchment regeneration, gender equity, cropping intensity, agricultural productivity and household incomes.

The remaining sections of the paper are organized as follows. The following section highlights the salient features of the Sustainable Livelihoods approach to natural resources management. Section Three discusses the evolution of participatory watershed management in the Haryana Shiwaliks. Section Four presents case study evidence on rule compliance in participatory watershed management in the Haryana Shiwaliks. Section Five outlines the livelihood implications of rule compliance in the case study area of Bharuali and Thadion micro-watersheds. Section six highlights the main conclusions of the study.

2. SUSTAINABLE RURAL LIVELIHOODS- FOCUS ON EQUITY CONCERNS AND EXTERNAL CONDITIONS

Most evaluations of externally supported watershed projects are upbeat about achieving institutional change (Kerr and Chung, 2001, IWMI, 1995). Such evaluations are based on information relating to establishment of water user groups, conflict free water allocation, collection of water user fees and beneficiary contribution towards routine maintenance of physical assets. Moreover, information collected during "project phase" serves as the basis on which such evaluations are conducted. However, we argue that to arrive at a fair understanding of whether external interventions have succeeded in bringing about sustainable institutional change we must shift the focus of analysis from project to "post-project" phase. Such a methodological re-orientation would have two consequences:

- An improved understanding of equity issues in participatory watershed management
- An appreciation of the role of external conditions in influencing trajectory of institutional change

2.1 Equity Concerns

By adopting a long term view of institutional change we focus on examining whether compliance with rules established during project phase are capable of being "repeated" in decentralized settings devoid of the monitoring presence of donors, field staff of State parastatals and NGO field agents" (Biggs et.al, 2001)[10]. Further, we ask to what extent compliance with institutional rules in decentralized settings ensure:

- Access of traditionally disadvantaged groups like landless and women to decision making forums like community organizations? and
- That equity concerns are addressed in patterns of benefit distribution (water from irrigation systems or fuelwood and fodder grass from catchment areas) under management of community organizations?

The concern with sustainable rural livelihoods stems from the rather belated realization, by international donors in particular, that poverty reduction is about more than income and employment generation (UNDP 1993)[11].

Despite the stated commitments to poverty reduction, the immediate focus of much donor and government effort has been on resources and facilities (water, land, clinics, infrastructure) or structures that provide services (education, ministries, livestock services, NGOs) rather than people themselves. Sustainable livelihood approaches place people firmly at the centre, the benchmark for their success is whether sustainable improvements in people's livelihoods have taken place (Ashley and Carney 1999: 5)[12].

Poverty reduction is also closely tied to understanding how entitlements, like income from use of household assets, are derived. How can people's *access* to livelihood resources be ensured

in a manner that does not compromise the natural resources base? Which groups (like women or the landless) are excluded from entitlements like non-farm income or access to natural resources? What types of interventions can be designed to target such asset-poor groups? A prerequisite for designing effective interventions that target asset-poor groups is to recognize that assets are "more than resources" (Bebbington 1999: 2,022)[13].

Assets include an individual's capabilities (like education, skills) that would assist him/her to transform resources like land or labour into income, dignity or power. In other words, assets refer to people's capability to transform their resources into "consumption levels that would reduce their poverty or living conditions that imply an improved quality of life according to people's own criteria" (Bebbington 1999: 2,029). Feminist scholars have highlighted the role of women's agency in changing rules and facilitating social transformation (Nuitjen, 1992)[14]. For example, it has been argued that merely reserving a certain portion of seats in local government organizations would not ensure women's participation in decision making on development issues. This is because the social and cultural milieu in many parts of the developing world prevents women from actively participating in public life. For example, in parts of South Asia factors like ***purdah***[15] may prevent women from speaking out in front of men at public meetings. As a result, feminist scholars argue that vesting land rights (through grants of formal usufruct rights) to women can go a long way in empowering them.

2.2 Role of External Conditions

External conditions like inter-sectoral policy change and changes in market structure or factor prices can influence potential for rule compliance in watershed management. Further, rule compliance may be achieved as a consequence of monitoring by external agents like NGOs, international donors or national governments. For example, a study of the Yanesha Forestry Cooperative project in Peru notes:

> [T]he financial clout of USAID was critical in forcing the government to officially recognize and legally title all Yanesha communities in the area to help protect them from colonist invasion. Thus external assistance was needed to protect Yanesha resources from outsiders and subsidize the costs of transforming a system of resource extraction (Morrow and Hull 1996: 1,652)[16].

In the coastal provinces of Turkey, where cash crop production predominates, irrigation services fees represented only three percent of the variable cost of production. As long as public irrigation agencies did not increase irrigation fees further, farmers were able to comply with user charges (Svendsen et al. 2000)[17]. On the other hand, farmers' ability to comply with Irrigation Service Fees (ISF's) may be influenced by the degree of government subsidization of agriculture. For instance, in Bangladesh and Indonesia when government subsidies were withdrawn in the wake of an irrigation management transfer programme, farmers became unable to pay irrigation service fees (IWMI 1997)[18]. Likewise analysis of community based tree planting projects have concluded that the long term viability of such ventures may be linked to whether secure markets for tree products can be sustained (Utting 1993)[19].

Recent work in Latin America points out that changes in 'capitals': physical, produced, natural, social and cultural that are "external" to the household sphere may affect peasant livelihoods (Bebbington 1999: 2,029). Physical capital may include infrastructure like dams or irrigation systems. Natural capital may include forests and underground water aquifers. Social capital may include trust and reciprocity that is embedded in kinship networks, or social relations with functionaries of State parastatals, NGO field staff and market agents.

Cultural capital may include membership in a particular caste or religious group or division of labour within households and communities based on perceived differences in caste and gender status. Produced capital may include assets like agricultural or forestry crops that have been produced using inputs like irrigation and fertilizers. The important point to underline here is that when one or all of these forms of capital (or exogenous factors) deteriorate they constitute a threat to a household's ability to access natural resources and in turn influence potential for rule compliance in watershed management.

2.3 Methodological Implications

A re-orientation from a singular focus on institutional change occurring during the life of an external project to change that extends to post-project phase has certain methodological implications. First, we are now no longer interested exclusively in changes in variables like household income and cropping intensity that have conventionally been used in project evaluations (Kerr and Chung, 2001). Instead we focus additionally on external conditions and how changes in those conditions- State policies, market prices or deterioration of physical, natural, social, produced or cultural capitals can potentially influence rule compliance. Second, we focus on equity issues relating to: distribution of benefits arising from participatory watershed management and access to decision making forums that could potentially remedy anomalies in benefit distribution.

Notwithstanding the importance of concerns outlined above institutional analysis remains focused on process variables (Feeny 1992: 280)[20]. This is primarily because such variables are easier to focus on and they involve less time and effort in collecting data than seeking out linkages between, for example, power relations at the community level and access to decision making forums within community groups. For instance, it is easier to focus on issues such as number of organizational meetings arranged and number of women attending them (see Agrawal and Yadama 1997: 456)[21]. In so doing, it is usually wrongly assumed that everyone's interests are articulated at such meetings and conflicts resolved. For example, research into community decision making in Tanzania revealed that "when women spoke at public meetings, they were representing other women. When men spoke they were speaking as individuals" (Cleaver 1999: 602)[22].

The inequities involved in a focus on rule compliance may become apparent using the example of participatory watershed management. For example, a group of powerful farmers with plots at the head-end of an irrigation system may 'evolve rules and monitor them' in a way that effectively excludes other, poorer farmers from using water from the system. This is not uncommon in societies in developing countries, as the following example from West Bengal indicates.

One instance of a deliberate effort to prevent cooperation took place in a village where several small cultivators tried to cooperate informally to irrigate their land by bringing water from a nearby source. Two of the rich farmers in the area, however, opposed this idea, claiming that the interest on money they had earlier lent these cultivators was greater than the amount the latter intended to invest for irrigation, and demanding immediate repayment instead. The small cultivators felt the reason was that, if their irrigation efforts had succeeded, they would no longer have been dependent on the rich farmers... the two rich farmers in question successfully frustrated the efforts at cooperation by first lodging false charges with the police of theft and trespassing, and then going to court to seek an injunction against digging irrigation channels on the grounds that they would pass over the land which they owned (Bandopadhyay and Eschen 1988: 134)[23].

Another example of how a focus on rule compliance may conceal inequities inherent in institutional structures relates to gender relations. A group of landowning farmers may comply with rules regarding payment of irrigation service fees, allocation of water and performance of routine maintenance. As a result, farmers may gain predictable access to water enabling them to optimise their cropping strategies. In the process agricultural productivity may improve and subsequently farmer incomes may increase in aggregate terms. But notwithstanding improved access to irrigation workload for women as reflected in activities such as transporting and harvesting of fodder grass and fibre grass and rearing livestock may undergo an increase (see Arya 1994: 184)[24]. The potentially adverse distributive effects of rule compliance in watershed management have been overlooked by studies on common pool resource management.

3. EVOLUTION OF PARTICIPATORY WATERSHED MANAGEMENT IN THE HARYANA SHIWALIKS

3.1 Key Features of the Joint Management Contract

Panchkula district situated in Haryana State in north-western India has the largest proportion of land under forests in the state. As a result the district has been a particularly important focus of participatory forestry projects. Since the early 1980s a spate of community forestry initiatives have been undertaken: social forestry, joint forest management and the Haryana community forestry project. The Morni-Pinjore Forest Division composed in turn of sub-divisions like Morni, Pinjore, Panchkula and Raipur Rani Forest Ranges was responsible for administering such community forestry projects.

The Haryana Joint Forest Management Project was responsible for developing an integrated model of watershed management based on experiments in the village of Sukhomajiri. The Sukhomajiri watershed model was premised on the idea that a linear relationship existed between the condition of forests located in the Shiwalik hills and agricultural productivity in low lying plains (see *Appendix 1*). As a result fodder production on private fields was encouraged through provision of irrigation from earthen dams in the expectation that greater fodder and dung production from irrigated fields would obviate the need to use State owned forests for fodder and fuelwood collection (Saxena, 1996)[25].

An important feature of the joint forest management project was the creation of institutional mechanisms for sharing revenue from state forests with local communities.
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. HRMS were given the opportunity to lease out rights to harvest fibre grass from State owned forests once year located in the catchment area of earthen dams. The lease price was fixed at the average of the previous three years revenue of the HFD from designated forest area. Lease rights purchased by the HRMS could then be further sublet to private contractors at auctions held annually. In such situations it was mandatory that private contractors ensure that every household received two head loads of fibre grass free to meet subsistence requirements.

- 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 a proportion of profits derived by the water contractor from the sale of water from dams (and fibre and fodder grasses) were to be deposited in the HRMS common fund. A proportion of these funds could then be used for community development activities such as 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. 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.

- 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.

- Profits from the sale water from earthen dams (and fibre and fodder grasses) constructed in areas under joint management were to be shared on a 50:50 basis between the HFD and the HRMS.

3.2 Functioning of Earthen Dams in Post-Project Phase

Thirty five HRMS were established in Morni-Pinjore Forest Division of Panchkula District in Haryana. These thirty five HRMS were responsible for managing fifty four earthen dams. However, due to logistical constraints (roads being washed away in the monsoon rains) we could visit only 28 HRMS. This reduced our sample to 28 HRMS responsible for managing 45 earthen dams. Our survey of the 28 HRMS in the Morni-Pinjore Forest Division was undertaken over a period of six months in 2000 during which information was collected on variables like sources of fuel for domestic household purposes and participation in management of earthen dams.

The issue of participation in management of earthen dams needs to be examined in the context of the number of dams that were functioning when this survey was undertaken. Our survey revealed that only 8[26] of the 45 earthen dams that were constructed in Morni Pinjore Forest Division were functioning in 2000. We find that in cases where the catchment stabilization principle was followed earthen dams continued to function. The catchment stabilization principle basically emphasizes the need to form village forest management organizations prior to dam construction. Village-based organizations were to institute rules regulating access to state forests for fuelwood, fodder and fibre grass. In response to regulated use of forest areas, earthen dams could be built. The assumption was that the regulated forest use would have stabilized rates of soil erosion and, as a result, increased the lifespan of the dams. Discussions with soil scientists responsible for the design and construction of earthen dams revealed that if the catchment stabilization principle was followed the life span of a dam could extend up to twenty years *(Table 1)*.

Our survey of earthen dams in Morni-Pinjore forest Division revealed that approximately 31% of all dams that were constructed silted up within five years of construction and 33% within ten years of construction. Interestingly 20% of dams constructed functioned for less than a year. We notice there are two clear periods of dam construction in which it is possible to discern a relationship between watershed institutions and the lifespan of dams. The first period covering Panchkula Forest Range extended from 1984 to 1989. This was a period in which scant attention was paid to institutional issues related to setting up water user groups. Instead emphasis was purely on constructing earthen dams. As a result half of the dams silted up within five years of construction. The first phase of dam construction contrasts with the initial experiments in Sukhomajiri village. Dams constructed in Sukhomajiri with the aim of preventing siltation of the Sukhna reservoir in Chandigarh paid sufficient attention to the issue of catchment stabilization. As a result one of the dams constructed in Sukhomajiri in the early eighties was still functioning when data for this study was collected in 2000.

Table 1: Post-Project Analysis of Earthen Dams in Morni-Pinjore Forest Division

Indicator	**Dams for Entire Forest Division**	**Pinjore Forest Range** *(1975-83)*	**Dams for Range**	**Panchkula Forest Range** *(1984-1989)*	**Dams for Range**	**Raipur Rani Forest Range** *(1990-98)*	**Dams for Range**
Number of Dams Silted within 5 Years of Construction	(45) 31.3%	4	(18) 22.2%	7	(14) 50%	3	(14) 21.4%
Number of Dams Silted within 10 Years of Construction	33.3%	5	27.7%	3	21.4%	7	50%
Number of Dams Functioning for less than 1 Year	20%	6	33.3%	1	7.1%	1	7.1%
Number of Dams Functioning in 2000	17.7%	4	22.2%	2	14.2%	2	14.2%

During the second phase of dam construction, which extended from 1990 to 1998, we note a gradual movement towards Raipur Rani forest range. During this phase new dams were constructed and community-based organizations were also established. The various stakeholders- Ford Foundation, Tata Energy Research Institute (TERI) and the HFD closely monitored the process. As a result of closer monitoring and greater transparency, dams surviving beyond five years increased by fifty percent. Further, the proportion of dams silting up within five years of construction fell from 50% in the previous phase to 21.4%. Nevertheless, we must emphasize that when compared to the Sukhomajiri pilot phase, dam performance had undergone a marked decline in Raipur Rani. This is evident from figures on numbers of dams surviving beyond 10 years from construction. This we argue is because of the failure to ensure catchment stabilization prior to dam construction.

The principle of catchment stabilization is critical as soil erosion has the potential to silt up earthen dams and compromise their functioning. However, we noted that catchment stabilization was dependent on micro-level community institutions that effectively regulated access to fuelwood and fodder grass from catchment areas. Regulation of access to fuelwood from catchment areas is an enormous institutional challenge. This is because a considerable proportion of the population in Shiwalik villages rely on forest areas for their supply of fuelwood *(Table 2)*. By contrast fewer households rely on use of Liquefied Petroleum Gas (LPG) technology for cooking and water heating.

3.3 Case Study Approach

Two of the 8 HRMS with functioning dams-Bharuali and Thadion were selected for a comparative case study[27]. Two rounds of household surveys were undertaken to cover all households in the study sites of the Bharauli and Thadion HRMS. The household surveys collected information on household demography, cropping patterns, asset ownership and participation in management of earthen dams. Socio-economic data was collected using structured interviews, focused interviews and group discussions. In addition to socio-economic data we collected data on forest condition in catchment areas by laying 33 plots for detailed information on tree density, sapling regeneration and grass cover. Forest plots were laid in areas that were closest to human settlements and therefore prone to biotic pressure. Satellite imagery of 1999 was overlaid on Survey of India topographic maps to examine changes in land use between 1966 and 1999 using Map Info computer software (NRSA, 1999)[28].

4. RULE COMPLIANCE IN PARTICIPATORY WATERSHED MANAGEMENT-CASE STUDY EVIDENCE

4.1 The Architecture of Earthen Dam Management in Bharauli and Thadion HRMS

4.1.1 Group size and forest area

Bharauli HRMS is composed of two settlements- Bharauli- a relatively large village with 80 households and Sher Gujran with about 25 households. Sher Gujran village is located in the catchment of the earthen dam while Bharauli lies downstream of the dam. On the other hand Thadion HRMS is composed of two villages- Thadion with 50 households and Rethi village with twenty five households. Shiwalik forests in the vicinity of Bharauli and Thadion have been classified as 'open scrub' according to Survey of India topography maps (Survey of India 1965)[29]. With the introduction of joint forest management in the Shiwalik hills a total of 712 ha of forest area was allotted to Bharauli HRMS. This area comprises five forest compartments. On the other hand, Thadion HRMS was allotted a forest area of 354 ha which includes three forest compartments. Both Bharauli and Thadion have one forest guard who is appointed by the HFD and responsible for monitoring forest use by local villagers.

4.1.2 Caste and occupational specialization

Given the greater diversity of castes in Bharauli, some occupational specialization based on caste identity is evident. For instance, the Tarkhans or blacksmiths undertake work for other caste groups. In return for their services they are usually paid in grain. Only two Tarkhan households own arable land and they avoid rearing livestock. Likewise, the Harijans have traditionally worked as hired labour on other people's fields or as domestic helpers in the homes of large landholders. The Rajput caste households in the village form a distinct group because they have monopolized the petty transport business. No such caste-based pattern of occupational specialization exists in Thadion.

Table 2: Household Access to Fuelwood in Select HRMS of Morni-Pinjore Forest Division

HRMS	Firewood	Dungcake	Kerosine	Liquefied Petroluem Gas (LPG)
Bharuali	76	64	3	-
Chowki	35	-	4	-
Damdama	62	60	14	2
Dhamala	113	57	68	10
Dulopur	14	12	2	-
Gobindpur	42	42	10	2
Gumthala	20	15	2	2
Harijan Nada	24	2	8	7
Jattamajiri	66	61	17	10
Kheda	81	81	40	7
Kiratpur	100	95	15	3
Lohgarh	73	71	27	2
Masoompur	57	48	1	-
Mirpur	57	55	7	1
Moginand	56	57	3	-
Nada Vas	131	121	13	17
Prempura	49	-	5	-
Rana	19	17	2	-
Sukhomajiri	89	87	31	5
Surajpur	165	116	58	11
Thadion	43	43	1	1
Trilokpur	71	48	13	-

Source: TERI, 1998

4.1.3 Earthen dams

There are two earthen dams in the study area, each constructed by the state forest department. In both cases the Shiwalik forests serve as their catchment. The earthen dam at Bharauli was constructed in 1990 at a cost of Rs 578,000, while the dam at Thadion was constructed in 1993 at a cost of Rs 653,000. Although the dam in Bharauli was built in 1990 the dam became functional only in 1995/96 after repairs had been made to it. The catchment area of the dam at Bharauli is 39 ha, while the area of the dam at Thadion is 15 ha. Further, the command area of the dam at Bharauli is 40 ha compared to 20 ha at Thadion. Thirty five households benefit from irrigation from the dam in Bharauli while fifteen households benefit from dam assisted irrigation in Thadion.

4.1.4 Water use rules

Water in earthen dams is harvested during the monsoon period (June to September). Harvested water is then used during the *rabi* season primarily for the wheat crop. During the *rabi* season and in the two months immediately following the wheat harvest (mid-April onwards) other crops like radishes, onions and chillies are grown under irrigated conditions.

Water users in Bharauli are charged Rs 20 per hour of water used from the dam compared to Rs 10 in Thadion. Three to four rounds of watering are possible in both Bharauli and Thadion. Rules stipulate that water allocation should take place on a rotational (hourly) basis for the wheat crop. During each round farmers whose lands are situated closer to the dam are supplied water first, after which water is released for use by farmers farther down the distribution channel[30].

4.1.5 Water transport

Water is transported by plastic pipe from earthen dams. The pipes are buried about three feet in the ground. At strategic locations in the command area, vertical exit valves are placed. At the ends of the plastic pipeline, farmers dig artificial water courses to transport water to their fields. Water transport is dependent on gravity flow and usually has to crisscross several fields. As a result, water transport in some cases involves negotiations between farmers to facilitate the digging of channels to divert water towards their fields.

4.1.6 Alternative irrigation on dam-irrigated land

None of the water-using households in Bharauli have access to private tubewells as an alternative source 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.

4.2 Rule Compliance in Participatory Watershed Management- Some Efficiency and Equity Considerations

4.2.1 Water Allocation Rules

We examine rule compliance relating to management of earthen dams by focussing on three issues: water allocation, compliance with water user charges and participation in repair and maintenance. In so doing, we examine *efficiency*[31] and *equity* implications of collective action rules in Bharauli and Thadion.

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)[32].The difference in predictability of water supply between head-end and tail-end peasants was lower in Bharauli than in Thadion *(Table 3)*. This we argue reflects the higher level of efficiency associated with lower level of conflict among peasants and greater clarity about water usage rules.

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[33]. In Bharauli

Table 3: Water Predictability Difference

HRMS	Water Predictability among Users at Head of Distribution Network	Water Predictability among Users at Tail of Distribution Network	Difference in Water Predictability Between Head-End and Tail-End Users
Bharauli	1.8	1.3	0.5
Thadion	1.7	0.1	1.6

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 water contractor responsible for water allocation 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.

In Thadion by contrast, the proliferation of tubewells lead many head end water users to utilize water from the earthen dam to cultivate paddy (*Table 4*). 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[34] at the head-end of the irrigation system. This is primarily because

Table 4: 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

their ability to raise crops other than rice to meet household food requirements is affected.

4.2.2 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 (winter season) 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 5*). We observe that in 1995-96 the HRMS monitored water allocation from dams in Bharauli and Thadion. In Bharauli water users complied with payment of hourly water charges of Rs. 20 while in Thadion compliance was nil. In the 1996-97 too both dams were under HRMS management and the trends with compliance with user charges were similar. In 1997-98 both HRMS adopted contractor based water provisioning. In Bharauli the contractor paid the lease amount of Rs. 3000 to the HRMS whereas in Thadion the contractor failed to do so. However, due to poor rains that year the contractor could not net a profit from water sales in 1997 (*Table 6*).

Table 5: Rule Compliance in Earthen Dam Management: Comparison of HRMS Groups
a): HRMS Bharauli

Head	**1995/96**	**1996/97**	**1997/98**	**1998/99**	**1999/2000**
Lease amount paid 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

Table 5: cont.

b: HRMS Thadion

Head	1995/96	1996/97	1997/98	1998/99	1999/2000
Lease amount paid 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

Table 6: Annual Rainfall in the Study Area (1995-2000)

Year	Annual Rainfall (mm)
1995	1395.8
1996	1372.7
1997	1188.5
1998	1555.6
1999	1642.8

Source: Central Soil and Water Conservation Research and Training Institute Research Centre, Chandigarh.

In 1998-99 both water user groups adopted contractor based provisioning once more. In Bharauli the contractor paid up the lease amount to the HRMS while in Thadion three individuals who combined to bid for the lease could only pay 22 percent of the lease amount due to the HRMS. That same year higher levels of compliance with payment of water user fees enabled the contractor in Bharauli to net a profit of Rs. 7500. The same trend was repeated for 1999-2000 but in Thadion a history non-compliance with water user charges resulted in reversion to HRMS water provisioning. But by 1999-2000 repeated failure of the

institutional mechanism for managing the dam in Thadion led to a complete siltation of the dam in the village.

4.2.3 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 7*).

Table 7: 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.

5. RULE COMPLIANCE: IMPLICATIONS FOR SUSTAINABLE RURAL LIVELIHOODS

We pointed out in section 3 that livelihood enhancement is dependent on micro-level institutions that focus on poverty reduction. Livelihood enhancement we argued could be achieved when people's asset base is strengthened through increases in agricultural productivity or household incomes. Rural livelihood enhancement may also be facilitated by a replenishment or creation of new assets that may incorporate natural resources, social assets like norms of reciprocity and fairness and collective capability to transform resources. In this section we examine some of these issues in the context of our Bharauli case study of participatory watershed management.

5.1 On-farm Production Relations

5.1.1 Crop Productivity

To examine the distribution of benefits from irrigation from earthen dams in Bharauli we stratified households into high, medium and low categories on the basis of a composite index of household endowments (*Appendix 2).* We find that per acre productivity of wheat is highest among households in the high endowment category in Bharauli. In fact, households in the high endowment category had the largest area under irrigation. Large aggregate area under irrigation by dams was reflected in higher cropping intensity, per acre application of fertilizers and use of hired labour (*Table 8*).

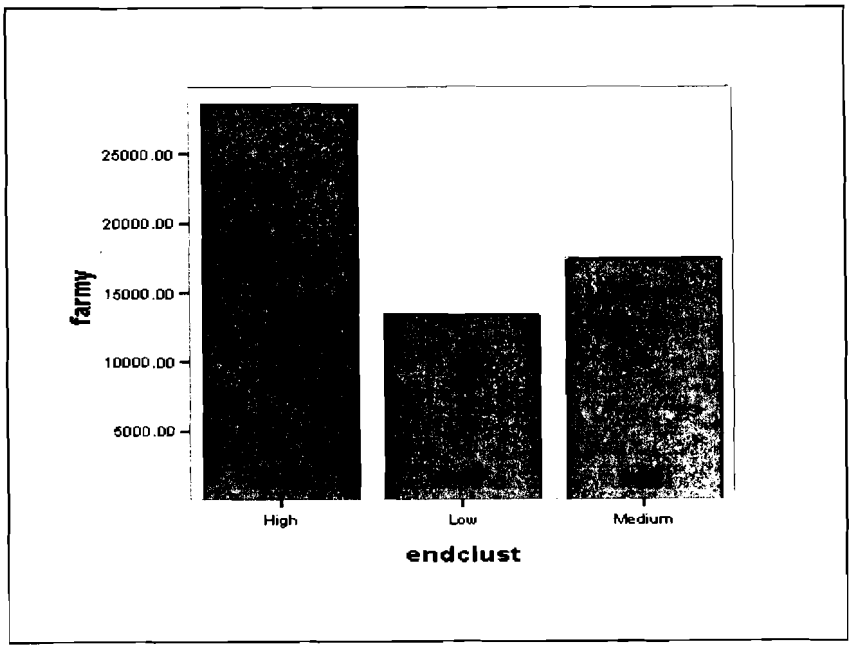
Table 8: Intensity of Agricultural Operations in Bharauli Micro-Watershed

Endowment Cluster	Cropping Intensity Rate	Per Acre Fertilizer Application	Percentage of Households Hiring in Labour	Area Irrigated by Earthen Dam (in acres)
High	196.0	216.6	100	3.0
Medium	175.4	211.1	66.6	2.1
Low	185.7	191.5	60.0	1.2

5.1.2 Farm-Based Income

Income from the sale of agricultural crops and from animal husbandry may be included under farm-based income. In Bharauli, mean farm-based incomes are the highest for households in the high endowment cluster (*Figure 1*). Livestock incomes constitute 7.1%, 15.8% and 27% of farm-based incomes, respectively, for households in high, middle and low endowment clusters. By contrast in Thadion livestock incomes constitute only 7.8% of total farm-based income for households in the medium category. We may therefore conclude that livelihood diversification is a strategy pursued by relatively poor households as an insulation against risk.

Figure 1: Household Farm-Based Incomes by Endowment Category

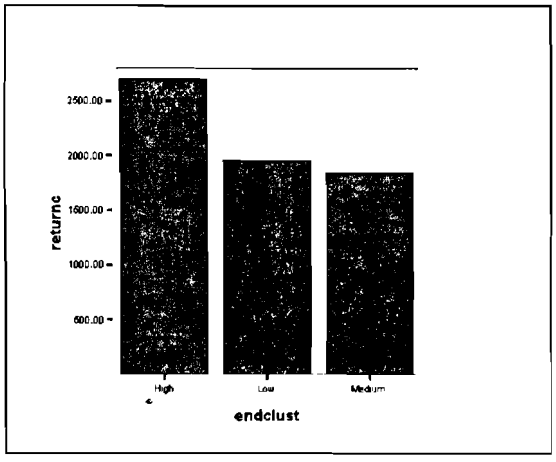


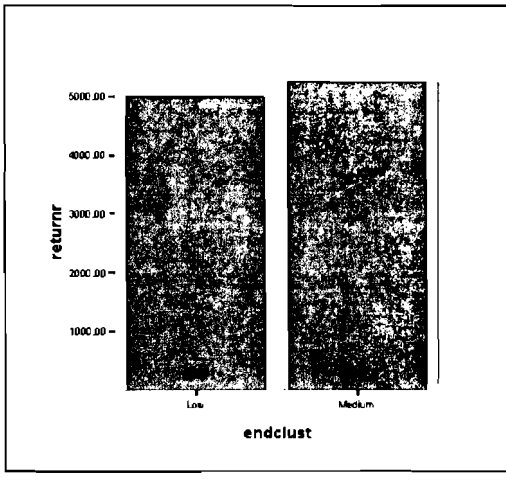
5.1.3 Agricultural Returns

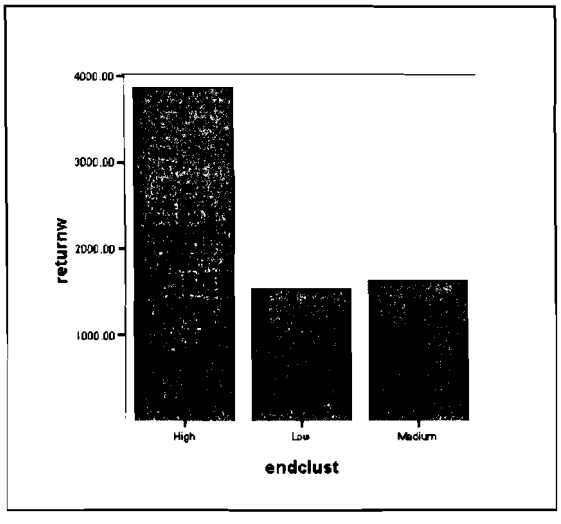
Returns to agricultural activity are a function of price, per acre productivity and acreage. In Panchkula district, farmers receive similar prices for most major agricultural crops. Therefore, returns are primarily a function of per acre productivity and acreage. In Bharauli agricultural returns were consistently higher for peasants in the high endowment cluster for all crops with the exception of returns to the radish crop (*Figure 2*). It is important to emphasize that higher levels of agricultural returns and farm based incomes that high endowment households were deriving under irrigated conditions was aided by favourable terms of trade for agricultural

crops. Our analysis indicates that harvest prices of wheat and maize have experienced positive increases in the period between 1995-96 and 1998-99. (*Table 9*):

Figure 2: Returns to Major Agricultural Crops by Endowment Category







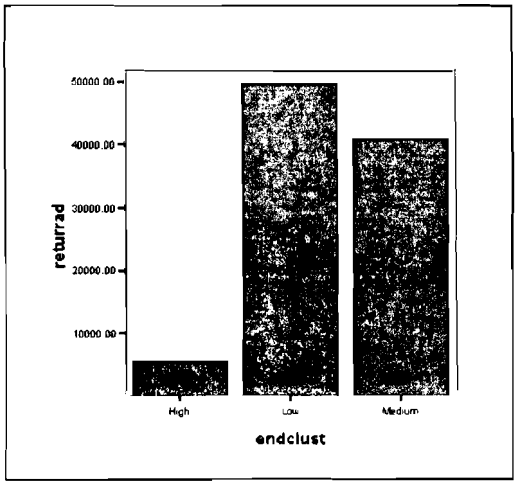


Table 9: Change in Harvest Price of Agricultural Crops (1995–96 to 1998–99)[1]

Crop	1995/96 (base year)	1996/97	1997/98	1998/99	Average Change in Harvest Price[2]
Rice (unhusked)	423.15	425.8 (–3%)	442.2 (–2.7%)	464.2 (0.6%)	–1.7%
Wheat	407.10	480.3 (+3.2%)	502.6 (–2.6%)	582 (+3.9%)	+1.5%
Bajra	385.8	374.4 (–4.3%)	336.5 (–7.3%)	413.5 (+6.3%)	–1.7%
Jowar	402.7	420.8 (–1.6%)	485.7 (+0.7%)	467.9 (–1.9%)	–2.8%
Maize	432.4	460.5 (–0.9%)	442.5 (–5.3%)	543.6 (+6.3%)	+0.1%

Notes: 1. *Figures in parentheses indicate percentage change in harvest price (adjusted for consumer prices of food of agricultural labourers) over the previous year.* 2. *Adjusted for change in consumer price of food for agricultural labourers.*

Source: Haryana Statistical Abstract, GoH 2000.

5.2 Land-Use Changes

We pointed out earlier that changes in external conditions may influence a household's access to natural resources and may therefore influence potential for rule compliance. Visual interpretation of satellite imagery acquired in April 1999 and its comparison with Survey of India Maps of 1965 reveals some interesting changes in land use (*natural capital*) in Bharauli. Firstly, as a result of the expansion of the dam distribution network the area under perennial agriculture has increased. Approximately 60 acres of agricultural land has been brought under perennial agriculture as a result of supply of water from the dam in Bharauli. Household surveys in Bharauli indicate that crops like radishes, onions and chillies are sown during the *rabi* period, between December and April. Secondly, expansion of the dam distribution network has resulted in reclamation of riverbed areas for cultivation purposes. Satellite imagery indicates that approximately 30 acres of land was reclaimed and brought under cultivation.

5.3 Catchment Regeneration

We may recall from the discussion in Section 3 that an assumption behind the HFD's decision to construct earthen dams was that increased fodder grass production following from improved access to irrigation from dams can potentially reduce livestock browsing and lead to regeneration of saplings in forest areas. Further, use of dung as an alternative cooking fuel can potentially reduce local residents' felling of saplings in the forest areas for use as fuelwood. Catchment regeneration arising from behavioural changes may be captured in differences in rates of sapling regeneration. Vegetation studies conducted in catchments of dams indicate that in fact forest (*natural capital*) condition was relatively better at Bharauli[35] when compared to Thadion (*Table 10*).

Table 10: Forest Regeneration in Catchments of Earthen Dams

Parameter	Bharauli Forest Catchment	Thadion Forest Catchment
No. of saplings	11	8
Basal area[1] of trees	1.81	0.35
Basal area of saplings	6.42 *(Statistically significant)*	2.78
Diversity of saplings[2]	2.08	1.54
Density of saplings[3]	7.72	3.53

Notes: 1. Basal area is a measure of the woody biomass in a given area (Becker and Leon 2000). 2. Diversity refers to the number of species as a proportion of the total number of species per acre. 3. Density refers to the number of trees in a given area.

5.4 Irrigation Access and Intra-Household Gender Relations

Our analysis of earthen dam management indicates that access to irrigation from earthen dams has improved fodder grass production on agricultural fields. However, focused discussions indicate that increased fodder grass production has meant more work for women (see also Arya and Samra, 1994). For instance, women make more trips transporting fodder grass from fields to their homes. Second, when decisions are made to increase cattle herd sizes to maximize returns from sale of milk, women end up spending more time feeding and bathing cattle. Third, unlike grass from forest areas, fodder grass from agricultural fields has to be threshed in a machine before it is fed to livestock. Women's involvement has increased in this task and will rise with an increase in fodder grass production from agricultural fields. Notwithstanding the increased workload of women there are limited avenues open to them to renegotiate a redistribution of benefits and costs arising from participatory watershed management. This is because women are effectively excluded from participation in decision making forums relating to management of earthen dams. They are not invited to meetings of the HRMS and remain unclear of their membership status in community organizations. Even if they do attend meetings organized by the HRMS cultural norms that prescribe that it is improper for women to speak up in front of men effectively relegate their views on natural resource management priorities to the back burner. This was reflected in expenditure patterns of HRMS that predominantly reflected male priorities (construction of temples and meeting halls for elders from which women are excluded) as against women's priorities like repair of village school and provision of drinking water taps (*Table 11*).

Table 11: Women's Participation in Joint Forest Management in Morni-Pinjore Forest Division, Haryana

HRMS	Women Represented in Managing Committee	Women Attending Managing Committee Meetings	Women Represented in General Body	Women Attending General Body Meetings	Main HRMS Expenditure (1995–2000)
Sukhomajiri	3/12	Nil	50%	Nil	Repair of earthen dam
Dhamala	3/12	–	22%	–	Purchase of diesel engine to pump water from dam pondage area
Lohgarh	3/11	–	18%	–	Repair of earthen dam
Thadion	2/11	–	50%	–	Construction of *dharamshala* (men's meeting place)
Bharauli	2/11	–	40%	–	Repair of earthen dam
Nada	2/11	–	1%	–	Repair of earthen dam
Kiratpur	3/11	–	67%	–	No records available

5.5. Replenishment of Social Capital Assets

A high level of cooperation is evident in the Bharauli water user group, as reflected in compliance with water user charges and payment of the full amount of the water lease. Co-operation in management of the earthen dam in Bharauli has replenished social capital such as norms of reciprocity and trust. At least three forms of social capital replenishment that have arisen from earthen dam management are identifiable in Bharuali. First, a wealth of expertise in management of traditional water channels (*kuhls*) exists in Bharauli. Some 60% of water users in Bharauli have evolved a common set of norms from participating in management of a *kuhl* (water distribution channel) that is over 100 years old[36]. In addition, norms operating at the level of extended families (*gotras*) influence bidding at water auctions. For instance, Singh Ram a nephew of Bant Ram said that he abstained from bidding at water auctions since it went against ethics that specified he should not participate when a member of his family was involved already. Such norms may be predicated on the expectation of a family member receiving a favour in the future.

Another interesting facet of water user charges in Bharauli is the role of local-level processes in ensuring compliance with payment of irrigation service fees. Contrary to what most NGOs and donor agencies expect, compliance with water user charges is mediated by a complex web of exchange relations. Such inter-linked exchange relations also influence modes of payment of charges for use of water from earthen dams. For instance, Singh Ram, a marginal peasant

in Bharauli pays for use of water from the dam over a period of six months. Sometimes he even borrows money from the water contractor, Bant Ram. The contractor keeps an account of his dues. Sometimes he can make no cash payment to clear his debt with the contractor. At such times Singh Ram can be asked to work as hired labour on Bant Ram's land and his wages are adjusted in accordance with the debt he owes Bant Ram for a variety of services[37].

5.6 Can Livelihood Enhancement Be Sustained? Influence of Fiscal Regime and Declining Markets

An important principle followed by the forest department in determining the lease amount to be paid by the HRMS is that of the total forest area. For example, Bharauli with its larger forest area of approximately 700 ha pays a lease amount of Rs 8,100 to lease out fibre grass harvesting rights. In contrast, Thadion with its smaller forest area of some 350 ha pays Rs 725 as lease amount. But what is overlooked in this calculation is the net area under fibre grass within the forest area of a HRMS. For instance, although no studies have been done it is clear from discussions with field staff and fibre grass contractors that the net area under fibre grass in Bharauli is much smaller than that in Thadion.

The anomaly related to the fixing of fibre grass lease rates combined with the harsh taxation regime of the forest department makes ploughing back of profits by HRMS towards community development or resource conservation tasks difficult (CSE 1999)[38]. The high lease amount imposed on Bharauli, which is the highest in the Raipur Rani forest range combined with the system of taxation has serious implications for net profits of HRMS from sale of fibre grass (*Table 12*).

Table12: HRMS Net Profits from Leasing Fibre Grass from State Forests

HRMS	1997/98	1998/99	1999/2000	2000/01
Bharauli	18,033	12,390	Did not lease	8,335
Thadion	12,387	8,922	11,397	13,760

The table shows that between 1997/98 and 2000/01 net profits for Bharauli declined by Rs 9,698. By contrast, net profits for Thadion actually increased by Rs 1,373. Further, between 1997/98 and 1998/99 net profits for Bharauli declined by 31.2%. In Thadion the decline was 27.9%. Between 1999/2000 and 2000/01 net profits for Thadion increased by 20.7% while for Bharauli HRMS net profits declined by 32.7% between 1998/99 (when they last leased out) and 2000/01.

The point to be made here is that net fibre grass profits, which are an important source of funds to undertake repairs of dams, are being mopped up by the HFD. This seriously curtails the ability of local-level organizations to take decisions and implement them without being dependent on external agencies for support. It may be argued that since a very small percentage of households in the Bharauli micro-watershed actually benefit from water, public funds should not be channelled towards repair of dams. However, the issue of fund management is a matter to be resolved by the groups themselves. The basic principle is that funds generated by community-based organizations should be left with them in order to give such institutions a semblance of being self-sustaining.

The regressive fiscal regime of the HFD has been accompanied by declining markets for fibre grass. Since 1993 private paper mills, an important source of demand for fibre grass from forests managed by HRMS have declined. This was a consequence of the Central government's decision to liberalize import of raw materials[39]. This lead paper mills to import

cheaper raw materials from abroad. The decline in demand for fibre grass by paper mills lead to a decline in profits of HRMS from sale of fibre grass. Since fibre grass profits were an important source of funds for HRMS to undertake routine repairs of earthen dams the sustainability of earthen dam management has been threatened.

6. CONCLUSIONS

Most evaluations of externally funded watershed projects conclude on the basis of improved cost recovery rates that far reaching institutional change has been brought about. But based on a study of two watershed management groups in Haryana- one that has succeeded in ensuring compliance with rules relating to water allocation, user fee collection and routine maintenance and another that has failed we argue that we need a more elaborate understanding of what constitutes institutional success. We argue that institutional success may be judged by how much rule compliance has succeeded in ensuring sustainable rural livelihoods- farmer incomes, gender equity, environmental regeneration or investment in routine maintenance. Our analysis of the watershed group that succeeded in rule compliance indicates that rule compliance is a necessary though insufficient guarantee of sustainable rural livelihoods.

Rule compliance is necessary to ensure conflict free water allocation, collection of water user fees and to ensure routine maintenance of physical infrastructure like earthen dams. Further, we observed how success with rule compliance in earthen dam management in Bharauli HRMS had lead to favourable land use changes and replenishment of social capital assets. However, success with ensuring rule compliance is crucially dependent on external conditions. We highlighted how favourable agricultural terms of trade for wheat had made dam assisted production of the crop a viable enterprise. Similarly, we pointed out how changes in import policies of the Central government made it cheaper for paper mills to import raw materials from other countries. The resultant reduction in demand by paper mills for fibre grass supplied by HRMS affected the gross profits of community organizations. As a result proceeds of fibre grass sales that constituted an important source of funds to undertake repair of earthen dams were no longer forthcoming.

Our analysis also pointed out that institutional success needs to be judged by how much equity concerns are addressed. For instance, we demonstrated that distribution of water from earthen dam in Bharuali was more equitable when compared to Thadion because water supply was more predictable for both head end and tail end water users. On the other hand we observed that although households with larger land area under dam assisted irrigation achieved relatively higher cropping intensity rates and farm incomes, women as a sub-group were burdened with increased workload. Despite the relatively greater costs that women were bearing when compared to men as a result of an increase in access to irrigation there were few avenues for them to re-negotiate a distribution of costs and benefits arising from watershed management. This was because they were effectively excluded from decision making forums related to management of watershed resources.

Our study has highlighted certain policy implications. First, we argue that the focus of institutional analysis of watershed projects must shift from "project" to "post-project phase". Second, we need to move away from focusing simply on variables like household income and cropping intensity. Instead we need to focus on the external conditions that made such improvements in well being possible in the first place. In particular, we need to focus on factors like trends in State policies, transparency in natural resource management strategies of State parastatals or changes in the stock of physical, natural, produced, social and cultural

capitals both at the community and household level. Finally, we need to examine how access of traditionally marginalized groups like women and landless to decision making forums is guaranteed. Guaranteeing access of such groups to decision making forums offers them an avenue to seek redress in case anomalies in benefit distribution persist. From a methodological standpoint therefore we are in favour of approaches that would highlight power dynamics both within households and community groups that leads to appropriation of benefits arising from rule compliance by a privileged few.

Notes

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1. A watershed refers to a geo-hydrological unit that drains at a common point. For an elaboration see Kenneth Brooks Peter Folliott and Hans Gregersen. (1992). Watershed Management- A Key to Sustainability, in: M.N. Sharma (Ed), Managing the World's Forests- Looking for Balance between Conservation and Development, Washington DC, The World Bank.

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9. Earthen dams are made of compacted soil from the Shiwalik foothills. Shiwalik hill forests serve as catchment of earthen dams. The catchment areas are usually bowl shaped; water from the hills collects in them during the monsoon period. Water collected during the monsoon period is used during the winter period for supplementary irrigation primarily for wheat cultivation. Institutional arrangements that regulate opening and closing the sluice valves are critical; if the sluice valve is left open beyond a certain point the dead storage of the dam silts up. Water is transported to agricultural fields on the basis of gravity flow. The dams are also fitted with spillways to ensure that excess water flows away without damaging the main body of the dam.

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15. *Purdah* includes the practice of veiling a woman's face in public (Agarwal 1994). It is important to note that veiling is only aspect of purdah ideology. Further, veiling practices may differ depending on context. For instance, although veiling is high in north-west India compared to other areas it may vary by caste status. Religion may also influence veiling practices; Muslim veiling is before all men defined as outsiders and women do not usually veil before close relatives and close family friends. Hindu women veil only from older male in-laws and village elders in the husband's village. Hindu women may never veil before anyone in their native villages. For a discussion see Agarwal B. (1994). A Field of One's Own: Gender and Land Rights in South Asia, South Asian Studies No. 58. Cambridge: Cambridge University Press.

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25. A study conducted by N.C. Saxena (1996). "Farm Forestry in North-West India", Ford Foundation, New Delhi found that cattle dung is used extensively as a cooking fuel in the Shiwalik region. Increased production of cattle dung it is assumed would reduce pressure on State forests for supply of fuelwood for cooking purposes.

26. The eight functioning dams were under the management of 8 HRMS

27. We used three criteria for selection of HRMS for a comparative case study. First, both HRMS must be functional, dams in both HRMS must be functional and finally HRMS must be situated next to each other to overcome major differences in contextual factors like soil or forest type, distance from markets and cropping patterns.

28. National Remote Sensing Agency. (1999). IRS-1B LISS-II Geo-coded Satellite Imagery, 6 April. Hyderabad: NRSA.

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30. We may recall from earlier in the discussion that a system of tradable water shares was introduced by the JFM project. This meant that landless households in particular who did not have a need for irrigation water could sell their share of water to other households. But our study indicates that the system of tradablewater shares was not being implemented in Bharauli.

31. In defining efficiency we adopt a multi-layered approach. We argue that efficiency would be enhanced due to presence of robust operational rules that minimize conflicts, elicit payment of irrigation service fees that facilitate routine maintenance of watershed resources. Presence of such robust operational rules we argue would greatly facilitate organizational sustainability of community-based natural resource management. In discussing equity we highlight three issues: 1. Those who use water pay for its use, 2. Those who use more water pay more and 3. Those who bear a cost in facilitating provision of the collective good are compensated for the risks they bear. For a Discussion see Amartya Sen. (1999). Development as Freedom New Delhi: Oxford University Press.

32. We allotted weights to qualitative assessments of how predictable farmer's access to water from earthen dams was in Bharauli and Thadion. By predictable we refer to how confident a farmer was that the dam water user with a plot adjacent to his would release water to him for his use. Accordingly, we allocated weights depending on whether a farmer's access to water was high (2), medium (1) or low (0). For an elaboration see Elinor Ostrom. (1994).

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33. 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 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. This leads us to conclude: 1. that per-capita use of water from the dam in Thadion was greater largely due to greater demand for irrigation to compliment supply from private tubewells for paddy cultivation in the dry season and 2. That a larger number of farmers in Thadion could potentially benefit from dam assisted irrigation for wheat cultivation in the dry season if use of the dam for complimentary paddy irrigation were curbed during the same period.

34. Two households with fields in the head end of the irrigation system removed distribution pipes on the pretext of leveling their fields. Despite repeated requests from households with fields in the tail end of the system the pipes were never replaced. One of the large landholders offered to circumvent the problem by installing a siphoning system. But his uncle, another large landholder refuted the idea of siphoning as it would silt up the dam. He instead offered to desilt the dam and charge water users for water use to recover his investment. However, he did not carry out desilting work but continued to charge users for water use. His nephew objected to this practice and began a parallel scheme of siphoning water and distributing it to peasants and insisting that his uncle should keep his promise of undertaking de-silting work on the dam. Continuing conflict between these two households resulted in the dam falling into complete disrepair in March 2001.

35. We ran a regression based on sapling data collected from plots laid in the forest catchments of Bharauli and Thadion micro-watersheds. We found the difference between the basal area of saplings in forests in Bharuali and Thadion to be statistically significant.

36. Each family or *gotra* is allocated water from the *kuhl* by rotation for a twelve-hour period. One water user has been given the responsibility of monitoring the rotation. For his services he is allocated six hours of water from the *kuhl* in excess of his designated share of twenty minutes of water. The number of hours a household receives water is determined by the size of their landholding. For example, among the Poswal *gotra* there are seven households with a total water availability of twelve hours per rotation. One among the seven households with land size of 20 acres is allocated six hours of water while the remaining six households with land size of three acres each are allocated water for one hour only. In case of sub-divided land within a household the number of hours of water allocated is likewise reduced. The water users of Kambala and Bharauli meet twice annually to decide on minor repairs to be undertaken to the *kuhl*.

37. For a discussion on inter-locking factor markets see Bardhan 1984:61.

38. Centre for Science and Environment. (1999).The Citizen's Fifth Report, Part-I-National Overview, Anil Agarwal, Sunita Narain and Sribani Sen (eds), New Delhi, Cosmo Publication.

39. For a discussion of trends in raw material procurement strategies of newsprint and paper mills in India and implications for supply of raw materials from Forest Departments see Kurian M. (1998). Issues in Newsprint Sector Reform, *Public Enterprise*, 16 (1-2): 127-34, (Slovenia: International Centre for Public Enterprises in Developing Countries.

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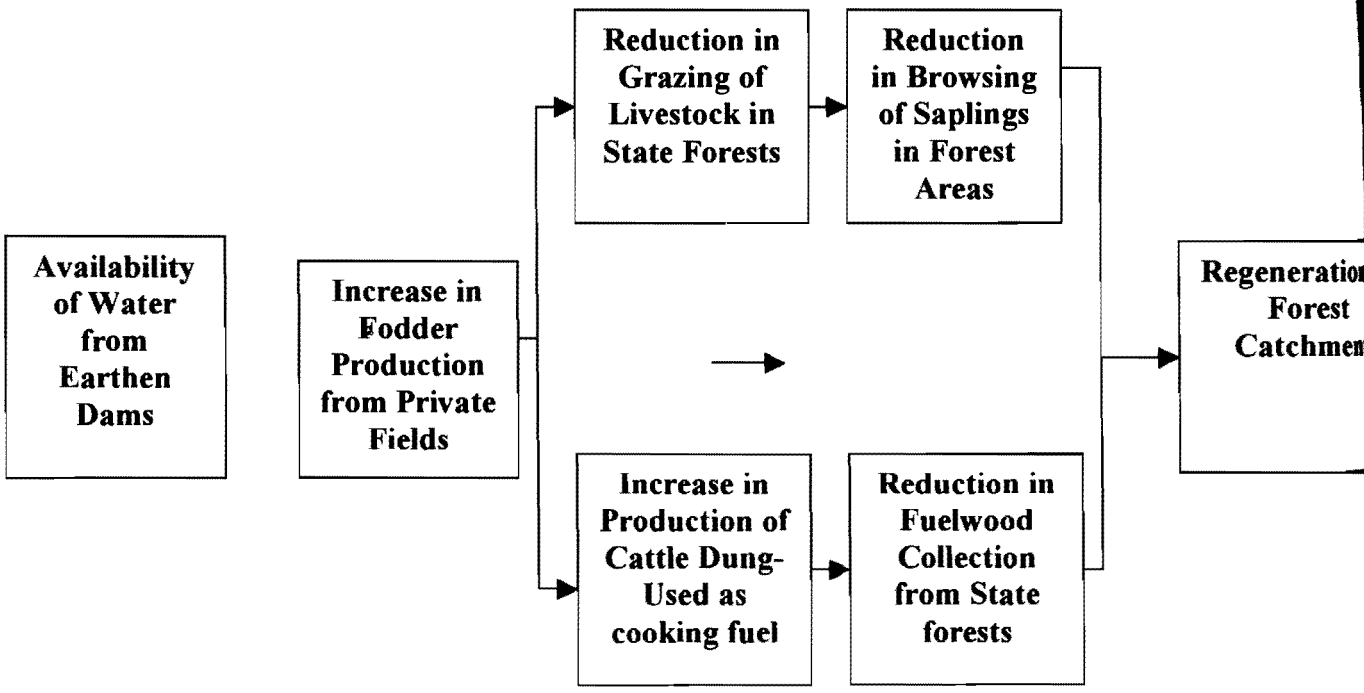
Appendix 1

The Sukhomajiri Watershed Model



Appendix 2

Method for Computation of Household Endowment Scores

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.

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

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. 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.

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, Ca = no. of camels, G = no. of goats, $H.H.\ Size$ = no. of members in a household.