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Water Security and Farmer-Managed Irrigation Systems of Nepal

by

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INTRODUCTION

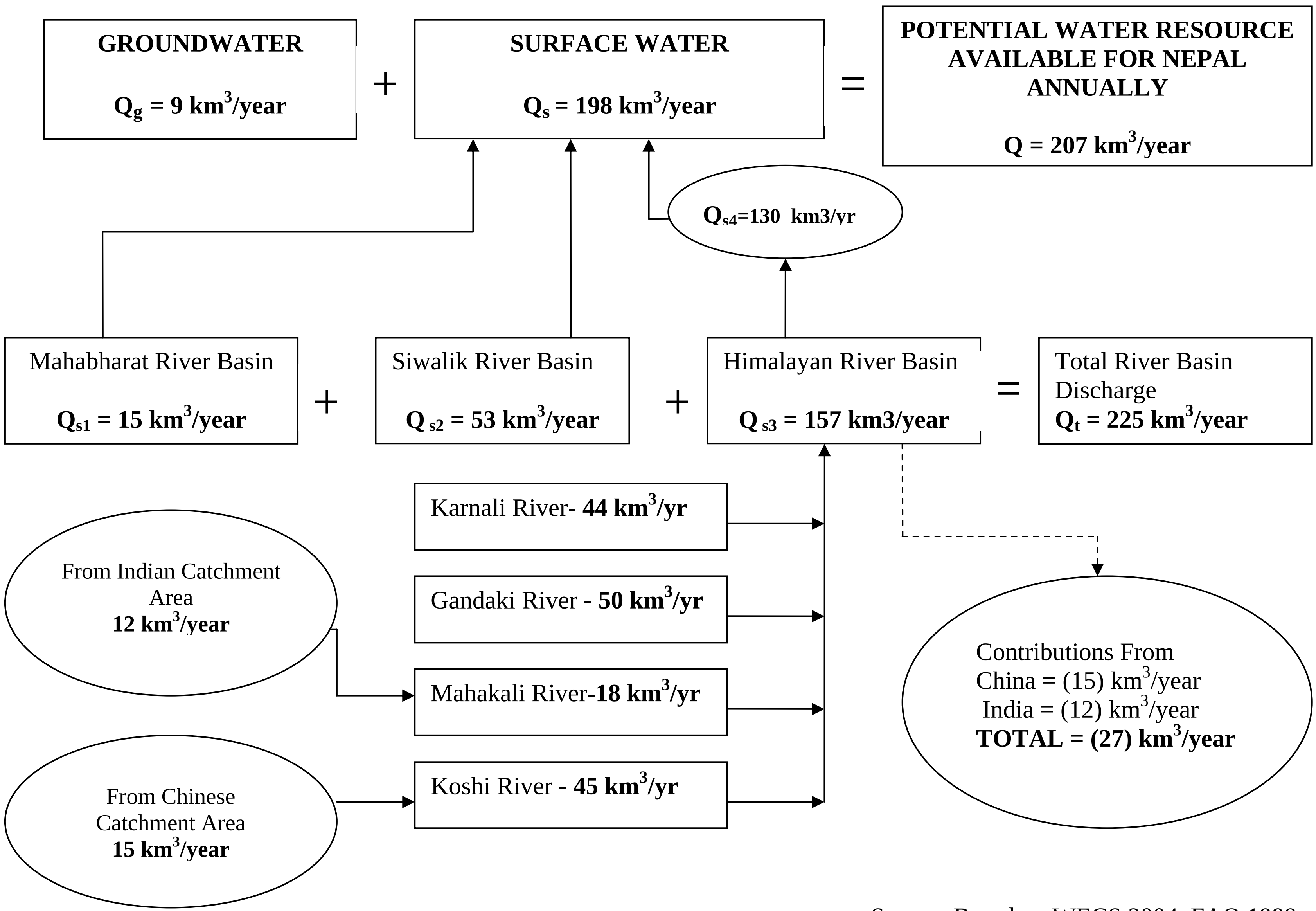
Hydrologists have estimated a figure of 1,700 m^3 per person per year as the national threshold that is required to meet water requirements for agriculture, industry, energy, and the environment. If availability is below 1000 m^3 then a region is considered to be in a state of "water scarcity" and if below 500 m^3, absolute scarcity (HDR, 2006). With an estimated availability of 7,600 m^3 per capita (4 x threshold) Nepal is relatively well endowed with water resources. Water availability, however, does not automatically translate into water security. The ability to use water and make it available at the right place, time, quantity and quality depends on a variety of additional factors such as institutional capabilities and economic environment. Nepal's water resource consumption, for instance, is less than 10% of an estimated 207 km^3 of water resource that is available annually (see figure 1-1). Projected national needs do not exceed 40%. From the resource availability perspective there is plenty of water yet there is severe supply crisis in various water sectors such as drinking water, power generation, and irrigation. Abundant water at the macro accounting level is of no use if it is not available at the local level. Institutional capability is, obviously, a more critical factor than resource availability in achieving water security in the case of Nepal.

Drinking water supply in Kathmandu valley is severely stressed. The national water supply corporation is able to meet about 70% and 38% of Kathmandu's 210 million liters per day demand during the wet and dry seasons respectively (Shangraula, 2007). The power sector too, with its installed capacity of 609 MW, is unable to meet existing demand supply gap which is estimated to be growing at 50MW per year (Dhakal, 2004). This has resulted in 6 hours of load shedding each day especially during the dry season. Performance in the irrigation sector is also disheartening. Year round irrigation is available to less than 20% of the 2.2 million hectares of land area that can potentially be irrigated (Shah and Singh, 2002). The outcomes of government efforts to develop these sectors have not at all been satisfactory. The failure of government agencies, who till recent times were the only actors in supplying these services, to deliver is in most cases a result of deficient skills in designing institutions[1] and not in designing physical infrastructures. Unless agencies are willing to recognize that local users under certain conditions are able to offer better institutional solutions and enforce rules at lower costs they run the risk of failing over and over again.

96% of water consumption is in the agricultural sector, followed by domestic use 3% and industrial use 1% (Environment Department, World Bank, 2004). As populations increase, industries expand, rates of urbanization accelerate, and the irrigation sector continues to expand one can expect competing claims and pressures to redistribute water. If water supplies are not allocated equitably among different users and uses conflicts may arise. Some believe that the

[1] The use of the word institution in this paper connotes rules-in-use.

Fig 1-1 ANNUAL AVAILABLE WATER RESOURCE/NEPAL



Source: Based on WECS 2004, FAO 1999

allocation problem can be tackled better by analyzing water use at the river basin level and by managing it on that scale. In this paper I emphasize that water availability per se is not the critical factor that leads to conflicts or enhances water security. It is the way water resources are governed and managed that causes conflicts. Therefore, to enhance water security or minimize water scarcity emphasis has to be placed on creating institutional environments that encourage and support the governing capacities of local resource users.

One of the key objectives of this paper is to underscore the idea that local user groups, under certain conditions[2], are able to self-organize and successfully govern their natural resources. Successful self-organized groups are not only able to craft optimal rules and enforce them at low costs but in many instances are also able to out-perform centrally governed resource systems. I draw on examples from the irrigation sector[3] to show that farmer managed irrigation systems (FMIS) are consistently better at delivering water to their tail ends, maintaining their infrastructures, and realizing greater agricultural productivities than agency managed irrigation systems (AMIS). Farmers in FMIS are, therefore, able to ensure better water security to their members than their counterparts in AMIS.

FMIS potential is substantial but not every FMIS is successful. There are some settings where appropriators are able to self-organize and other settings where they are not. Since there are many variables that can affect benefits and costs of organizing there are also many points of external intervention that can either enhance or reduce the chance of self-organization (Ostrom 2001). The paper, in some detail, examines how various variables affect irrigation performance, how resource settings influence cooperation and conflicts, which conditions are conducive to self-organization, and what conditions can threaten the abilities of communities to organize. An understanding of how different variables interact in different settings allows for designing policies that can strengthen institutional and governance capabilities of FMIS. Irrigation is important in Nepal. Agriculture contributes 38% to the GDP and provides employment to 75% of its labor force (MOF, 2006). If external assistance can help farmers self-organize and develop their own institutions there is great potential for improving irrigation performance, enhancing water security, and improving prospects for food security.

The paper is organized in the following manner. First, I provide a brief overview of the irrigation sector and its performance in Nepal. Second, I explore the incentive structures facing farmers in self-organized and in agency-managed systems to assess why farmers in the former system tend to be better motivated than those in the latter. Then, after reviewing the organization and governance structure of Farmer Managed Irrigation Systems (FMIS) I compare its performance with Agency Managed Irrigation Systems (AMIS). I then explore how resource settings may

[2] Though researchers are not able to definitely determine under what set of conditions appropriators will self-organize there is, however, consensus on the set of resource and resource user attributes that will enhance cooperation. The resource attributes are scope of feasible improvement, availability of reliable indicators of the resource condition, relative predictability of the flow of resource units, and the ability to learn and understand the dynamic patterns of the resource stock and flow. Resource user attributes conducive to self organization are salience, common understanding, low discount rate, trust and reciprocity, autonomy and prior organizational experience (Ostrom 1999).

[3] Quantitative analyses reported in this study are primarily based on the Nepal Irrigation Institutions and Systems (NIIS) database maintained at the Workshop in Political Theory and Policy Analysis, Indiana University. The NIIS database has information on 231 irrigation systems from Nepal.

affect cooperation and conflict in self-organized systems before making policy recommendations on how performance can be improved in irrigation systems

IRRIGATION DEVELOPMENT AND PLANNING IN NEPAL

The country has a total cultivated area of 2.6 million hectares. Though 85% of this area has potential for irrigated agriculture, only 1.1 million hectares is covered by irrigation infrastructure. Surface-water is used to irrigate 900,000 ha and ground-water[4] 200,000 ha of land area. Round the year irrigation is available to only 38% of the irrigated areas. Most (75%) of the irrigated areas are serviced by farmer managed irrigation systems and the remaining (25%) by agency managed irrigation systems (NENCID, 2007)

A vast majority of the irrigation infrastructure developed until the mid 1950s was constructed and managed by farmers. During this period there was some State involvement (Chandra Nahar and Juddha Nahar[5] and a few "Raj Kulos"[6]) but it was marginal (Shah and Singh, 2001). Even today farmer managed irrigation systems (FMIS) contribute three times more towards irrigated agriculture than agency managed irrigation systems (AMIS). It was only after 1956 that planned modes of irrigation development were initiated by the Government through its five year plans.

Irrigation infrastructure development from 1956-1980 initially focused on the construction of medium and large scale projects[7]. It then gradually moved towards the intensification of existing command areas through the expansion and rehabilitation of existing infrastructure. Program implementation during this period was very centralized. Irrigation officials assumed all planning, construction, operation & management, and maintenance responsibilities. Beneficiaries were not involved. Only after 1985 did the Government begin to take a more integrated approach to developing land and water resources and unlike earlier times more emphasis began to be placed on user involvement in the irrigation process (Angood et al 2002, Shah and Singh 2001).

The policy reforms undertaken by government to adopt a participatory approach to irrigation development are reflected in documents such as the Water Resources Act 1992, and the updated Irrigation Policy 2003. The policy sets out objectives and guidelines for irrigation interventions including FMIS development and management and transfer of DOI[8] systems to water user associations (WUA) (Water Aid Nepal, 2005). The irrigation policy which was initially adopted in 1992 has explicit provisions for supporting community efforts in irrigation development and encouraging more users' participation in Agency led irrigation development programs. The Water Resources Act 1992 also provides a legal basis for implementing participatory development programs as it recognizes the rights of WUAs. Another important document is the Government's 20-year Agricultural Perspective Plan (APP). Irrigation is identified as the

[4] Ground-water is used for irrigation mainly in the Terai
[5] Chandra Nahar was the first public sector irrigation project undertaken by the National Government in 1923. The Juddha Nahar was built in Rautahat district in the Terai in 1946.
[6] State budgets were allocated to construct and operate the "Raj Kulos" or royal canals. Regmi (1978) calls them state operated irrigation canals.
[7] A command area of approximately 500-2,000 hectares is defined as a medium scale irrigation system. Anything above 2,000 hectares is defined as large scale in the Nepali context.
[8] DOI – Department of Irrigation

primary input to increasing agriculture productivity and FMIS are recognized as key vehicles to deliver the inputs.

IRRIGATION PERFORMANCE

An estimated $1.2 billion has been spent in the irrigation sector from 1956-2000. Only 20% of this amount was funded through the Government's own resources. The remaining 80% in investments has been funded by external donors[9]. Nearly 60% of these funds have been spent on constructing new irrigation infrastructure. Despite a standing policy since the mid eighties to prioritize the rehabilitation and expansion of FMIS networks the DOI has invested only about 16% in this area (Shah and Singh 2002).

DOI investments in medium and large scale projects have been disappointing. Shah and Singh (2002) report that water volumes supplied by many large projects[10] are far below than originally planned and they consistently have capital cost over-runs. Some projects such as Bagmati and Babai are reported to have cost over $5000 per hectare to construct. The 1994 appraisal by the National Planning Commission's (NPC, 1994) regarding irrigation development performance in the country was also negative. It reported that "irrigation development and operation in Nepal is performing dismally relative to the amount of resources poured into the sector." There are many reasons for such poor performance but the ones that are more frequently reported are: a) weak governance framework and enforcement in attaining effective service delivery b) unrealistic productivity projections in assessing benefit-cost ratios, c) poor system management d) insufficient operation and management due to lack of user participation, and e) poor understanding of farmer priorities (ADB, 2001). The institutional arrangements to induce realistic project planning and effective system management are, obviously, weak.

Intervention by government agencies to improve farmer managed irrigation systems have also run into difficulties. Ostrom (2002) points out that these difficulties often arise because irrigation agencies fail to recognize the institutional aspect of irrigation systems and focus only on improving the physical capital. To emphasize her point she cites the experience of the USAID funded Chiregad Irrigation Project in Dang as reported by Hilton (2002). A new irrigation system with permanent headworks and cement lined canals was constructed in an area that was previously irrigated by a network of five farmer managed irrigation systems. Making no efforts to understand how the pre-existing water associations were organized DOI appointed a new water user committee. This committee, however, did not even include the water managers of the earlier five FMIS. The outcome of this intervention was that only three of the five "maujas" received water consistently. Prior to the intervention all five "maujas" used to receive adequate water. The effort to improve agricultural productivity through investments in physical capital alone thus resulted in reduction of the service area, unreliable water deliveries, nonfunctional WUA, and a weakened older WUA. Institutional structures stand on social capital developed over many years of learning through shared experiences and are as tangible as physical capital. Their neglect as we see in this example not only resulted in weakening of farmer organizations but also led to opposite outcomes.

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[9] The Asian Development Bank, World Bank and the Saudi Development Fund account for 60% of the investment and bilateral donors 20%.
[10] Large irrigation projects such as Sunsari-Morang, Bagmati, Bhairawa-Lumbini Groundwater, Narayani etc.

WHY FARMERS MAY BE MOTIVATED TO PERFORM BETTER IN SELF-ORGANIZED SYSTEMS THAN IN AGENCY MANAGED SYSTEMS.

A self-organized system can be structurally superior in generating positive incentives than externally organized systems. In a self-organized system such as the FMIS it is the farmers themselves who act collectively to construct and govern their systems. They make decisions on delineating service areas, determining water allocation rules and assigning maintenance responsibilities. However, in externally designed systems such as the AMIS it is someone other than the farmers who design the physical system and assume responsibility for making rules and enforcing them. Government officials who are tasked with managing these systems, however, have to govern on shoe string budgets and with limited manpower. Without much incentive to develop long term working relationships with the farmers and faced with resource constraints many try to develop simple uniform allocation rules across the board and often neglect to enforce rules. Given the farmers' diverse cropping schedules and needs such uniform rules are mostly inadequate and without enforcement the stage is set for breaking rules. When "official rules" do not match local needs then conflicts break out, canals are breached, and physical capital is destroyed (Lam, 1998; Shivakoti and Ostrom, 2002).

In more recent times irrigation policy does encourage "turnover" and "joint management" of AMIS to formal water user groups to overcome perverse incentives. However, very little attention tends to be paid in forming these groups and they are often seen as arrangements to obtain a community's cooperation. Little is done to either encourage or develop the governing function of these organizations. Officials (professional engineers) who oversee this process are not motivated[11] and often not skilled[12] to serve the needs of the farmers. The farmers too, since they are not sold on the turnover, are not motivated to invest their time in operating the system. Incentives to shirk on the part of the officials and incentives to free-ride on the part of the farmers often result in the poor performance of AMIS.

Farmers in successful self-organized systems tend to overcome their collective action problems by crafting their own rules. However, the conditions that are necessary to initiate collective action do not arise spontaneously. Unless farmers have a common shared understanding of the costs and benefits of engaging in collective action, unless a secure property regime makes it possible for them to reap the benefits of their efforts in the long run, and unless they are confident that external authorities will not interfere in their rule-making, rule following and rule-enforcement activities farmers will not invest their efforts in organizing for the long term. Simply turning over systems to the farmers and expecting viable organizations to take root is expecting too much. To craft rules that suit a particular environment there has to be an understanding of the interrelationships between the combination of rules with the physical, social, and cultural environment.

[11] Engineers do not regard the O&M operation highly. They are much more interested in the construction part of the process. Also promotions in the civil service are based on seniority which to a large extent discourages initiative and creativity. Promotions and transfers are strongly associated with political patronage and not to keeping an irrigation system in good condition.
[12] Institutional aspects of irrigation system design are often not a strong component of engineering training.

GOVERNING FARMER MANAGED IRRIGATION SYSTEMS (FMIS)

An irrigation system can be conceptualized as a common-pool-resource. Withdrawal of water from the system means that there is less water available for others to use and once a system is constructed farmers who own land adjacent to the watercourse can potentially access water even if they have not contributed towards its provision. Farmers sharing an irrigation system have to cope with the problems of provisioning and appropriation. Unless non-contributors can be excluded from enjoying the benefits of a common system no rational actor would be willing to contribute towards its development and upkeep. Also, unless there are rules constraining resource use each user would want to maximize consumption. We see, however, that many farmer managed irrigation systems are able to resolve such cooperation dilemmas by creating effective agreements amongst themselves. I draw on my own research (Regmi, 2007) and Shukla et al's (1993) work on irrigation resource inventory of Chitwan to describe the structure of a FMIS and how they operate.

Irrigation Infrastructure

The key FMIS irrigation infrastructures consist mainly of headworks, canals and structures for water distribution. The headwork of an FMIS typically consists of an intake structure to divert water and a gated structure to control water flow. The intake diverts water from the natural water course into a constructed canal. These intakes are mostly temporary structures constructed from stone and brushwood. Uses of semi-permanent gabion box structures have also been observed. The gated structures for flood control are usually observed in systems that have received external assistance. Systems that do not have gates are forced to breach their diversion structures when threatened by flood waters.

Systems consist of a main canal and a number of branch canals. The majority of systems in East Chitwan have fewer than six branch canals where mean canal lengths (sum of the main and branch canals) are less than 6200 meters. Most of the branch canals are unlined and the main canals partially cement-lined. The mean service area and households served by a typical FMIS is 124 hectares and 139 households respectively.

Quite a few systems have the cement concrete proportional weirs for dividing water shares. Most rely on piped outlets and other temporary structures. Systems without permanent water allocation structures use wooden stakes, bushes, stone and earthen materials across the main canal to ensure proportional allocation of water.

Water Sharing Arrangements

Allocation of water in a system reflects entitlements. Water is allocated only to those farmers or farmlands who have water rights and not to others. Allocation also means the quantitative division of water in the system among the entitled farmers or fields. The principle on which water is shared is decided by the irrigator community and can take a number of forms (Pradhan 1989). The most common allocation principle observed in Chitwan is the principle of dividing water in proportion to the land owned by the farmer. There are other principles too, for instance, apportioning of water based on the paddy cultivation task[13] and on water shares[14].

Distribution of water among farmers is the implementation of the allocation principle. It involves implementing a set of agreed upon rules with the help of some physical structures. Depending upon their system characteristics water users are known to use a variety of methods to distribute water e.g. free flow, timed rotation, time-area relationship, and time required to wet/saturate a given unit of land. The most popular method of distributing water during stressful periods is timed rotation[15]. Water user associations decide the time and duration each farmer is allowed to irrigate his/her field.

Maintenance and Resource Mobilization

WUAs are organized for regular as well as emergency repairs. The regular maintenance activities include de-silting of the major branch canals, repair of intake structures, and strengthening of canal dikes. These activities are undertaken prior to the rice planting season i.e. in March for the spring rice season and May for the monsoon rice season. Emergency maintenance typically involves repairs of the diversion structure and main canal embankments that get washed away by floods. In addition to the one off bi-annual maintenance activities farmers are also organized for continuous maintenance during the monsoon season. Either association members themselves or hired helpers regularly monitor the canals for early detection of canal breaches.

Cash as well as labor resources are mobilized internally to carry out repair of intake structures and de-silting of canals. While landholding is the basis for cash contributions households are the basis for mobilizing labor resources. In an emergency all members are mobilized regardless of benefits or entitlements.

Organization

All irrigation systems in Chitwan have WUAs. However, some may not be formally registered and may also not have written constitutions. Association memberships are mostly based on ownership of land in the service area. Executive officers headed by a chairperson are selected from among the members. Officials are tasked with mobilizing resources for maintenance, organizing and supervising system work, maintaining records and accounts, and resolving conflicts. Although WUA officials are permitted to take routine decisions the major ones need

[13] The task of paddy cultivation can be divided into two periods a) transplantation period and b) post transplantation period. During the first period water is required for preparing the seedbeds and preparing land for transplantation. During this period farmers can agree to meet the water needs of all the users irrespective of entitlements. In the post transplantation period, however, water distribution is based on entitlements.

[14] The total water supply in a system is divided into a fixed number of shares which is then apportioned to farmers based on their initial contributions towards system construction.

[15] Depending on the water availability and area entitled to be irrigated associations decide the time duration per branch canals before they rotate turns. For instance, there are four branch canals in the Baireni/Pakhdibas irrigation system which rotate turns after 24, 36, 17, and 51 hours respectively. All of the water in the system is supplied to the first branch for the first 24 hours before it is diverted to the second branch for 36 hours and so on. The fields in each branch then divide up the water among themselves based on a prior agreed allocation principle. There is quite a variation in waiting times. Farmers in some system may get their turn every 8 hours and in other systems every six days.

consensus from a general assembly. All members make compulsory contributions towards the upkeep of systems either through labor or cash contributions.

Rules are used extensively to structure irrigation activities. All systems have explicit and commonly understood rules and regulations relating to the allocation and distribution of water, contribution of resources for repair and maintenance, and sanctions for violating rules. Sanctions can take any of the following forms: a) verbal warning without monetary fines, b) monetary fines, c) cessation of water turn, and d) removal from the association. Sanctions are imposed by water user functionaries, guards, or fellow appropriators depending on the nature of the sanction imposed. About 60% of the systems in Chitwan have written rules and regulations. Many of the systems managed by the indigenous people (Tharu) do not have formally written rules yet rule following is reported to be higher in these systems than in others (Shukla et al, 1993).

COMPARING FMIS AND AMIS PERFORMANCE

There are many individual case study reports by authors who assert that FMIS in Nepal perform better than AMIS. Lam (1998) who undertook a systematic and comprehensive study of 127 Nepali irrigation systems also reaches the same conclusion. In the following sections I review his results and those of a few others to underscore Ostrom's (1990) idea that self-organized resource users may be better able to resolve cooperation dilemmas (or be a major part in the resolution) when resources are local in scale. In other words, external actors may face more difficulties than local resource users in designing optimal institutional solutions and enforcing rules at lower costs.

Lam uses three measures of irrigation performance - Agricultural Productivity[16], Water Delivery[17], and Physical Condition[18] - to compare performances between FMIS and AMIS. All of his measures are composite indices that consist of multiple variables. Agricultural productivity attempts to capture the productive potential of a group resulting from their collective action efforts. Water delivery measures the ability of a system to deliver water adequately, reliably, and equitably. And, physical condition measures how well an irrigation system is maintained. Comparing FMIS and AMIS along each of these three dimensions he finds that FMIS on average have higher levels of agricultural productivity, maintain their infrastructures better, and deliver water more effectively than AMIS. These differences are statistically significant at the .01 level (Table 1.1).

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[16] Agriculture Productivity consists of three variables viz. agricultural yield measured in metric tons per hectare per year, cropping intensity at head-end, and cropping intensity at tail-end. One crop per year on a plot of land equals a cropping intensity of 100%, two crops mean 200%, and three crops mean 300%.
[17] Water Delivery includes three variables i.e. water adequacy, equity and reliability. Water adequacy refers to whether a system is able to make enough water to meet farmer needs. Equity refers to fairness in distributing water between head and tail end. Reliability refers to the predictability and timeliness of water delivery.
[18] Physical condition reflects the collective maintenance efforts as well as the degree of social organization of the group. It comprises two variables viz. condition of infrastructure and the degree of perceived economic efficiency in maintaining the infrastructure.

Table 1.1[19]
Performance by type of governance arrangement

	FMIS (N=70)	AMIS (N=19)	F	p
Physical Condition	3.73	2.75	40.76	.00
Water Delivery	3.73	2.65	38.02	.00
Agricultural Productivity	4.36	3.40	17.25	.00

Source: Adapted from Lam (1998)

Two other relevant results that he reports in his study are that rule following among appropriators is significantly greater in FMIS than AMIS, and levels of mutual trust is higher in FMIS than in AMIS. More than 50% of the FMIS are characterized by high levels of rule following whereas this is only 20% in case of AMIS; rule infractions in 9 out of 10 FMIS systems are of a minor nature compared to 1 in 2 in AMIS; and farmers trust fellow farmers nearly twice in FMIS than AMIS. The reason why FMIS are able to perform better than AMIS is probably because the rules adopted by the former are better able to distribute the benefits and costs more equitably among the users than the latter. This is reflected in the higher levels of trust and greater rule following behavior observed in FMIS than in AMIS.

Water is generally most abundant in river courses during the monsoon season. In the spring and winter seasons, however, it tends to be scarcer. Water is the most critical agricultural input for Nepali farmlands and crop yields and cropping intensities are mostly a function of its availability. Therefore, the ability of irrigation systems to deliver water to their tail ends across the seasons is a strong indicator of irrigation performance. Comparing FMIS and AMIS on this measure Ostrom and Gardner (1993) find that FMIS consistently outperform AMIS across the seasons, more so in the scarcer seasons, in their ability to provide abundant water to their tail ends (see Table 1.2).

Table 1.2
Water abundance by type of governance arrangement and season

Season of Year	FMIS	AMIS	FMIS	AMIS
	Abundant Water at the Head End		Abundant Water at Tail end	
	% (N)	% (N)	% (N)	% (N)
Monsoon	97 (100)	91 (23)	88 (100)	44 (23)
Winter	47 (99)	43 (23)	38 (98)	13 (23)
Spring	34 (98)	26 (23)	24 (96)	9 (23)

Source: E. Ostrom and Gardener (1993:103)

Table 1.2 shows that twice the numbers of FMIS are able to deliver abundant waters to their tail ends than AMIS. During the scarcer seasons, in winter and spring, 3 times more FMIS than AMIS accomplish this task. There is abundant water at the head ends of more FMIS than AMIS even in the summer season; however, the differences are not as striking as in the water scarce seasons.

[19] The values reported for each of the dimensions are factor scores and do not have a unit of measure. These scores can, however, be used relatively to make comparisons.

Studies of 160 FMIS in Tanahu by Poudel et al (1994) and 88 FMIS in Chitwan by Shukla et al (1993) also indicate that FMIS are able to produce more spring paddy (4 mt/ha/yr and 4.6 mt/ha/yr) than the national average (2.28 mt/ha/yr).

The above results indicate that farmers in self-organized irrigation systems are capable of performing better than their counterparts in systems that are managed by external actors. This, however, does not mean that farmers are always successful at self organization. There is general agreement that appropriators who are dependent on a resource, intend to use their resources over a long period of time, have achieved certain levels of trust, and possess some level of autonomy to make their own rules are more likely to self-organize. Whether they are actually able to do so, however, depends on how attributes of the resource and attributes of the resource users interact in specific field settings to affect the perceived costs and benefits of organizing (Ostrom 1999). In the following sections I examine how some of the resource user attributes and resource attributes may influence performance of FMIS in specific resource settings.

FARMER MANAGED IRRIGATION SYSTEMS IN CHITWAN

In this section I draw heavily on my study (Regmi 2007) of 74 farmer managed irrigation systems from Chitwan, Nepal. In Chitwan, there are two distinct types of river systems; north-south flowing rivers and east-west flowing rivers. Rivers that flow north-south originate from the Mahabharat hills and pass through changing terrain from hills to plains. These rivers are characterized by steep gradients, seasonal flows, changing river course, low discharge volumes, and difficult terrain. Irrigation systems drawing water from these rivers tend to have longer canals, pass through landslide zones, and require frequent maintenance of diversion structures. East-west rivers on the other hand are characterized by flat terrain, mild gradients, perennial flows, and high discharge volumes. Irrigation systems on these rivers enjoy an advantage over the other systems in terms of ease with which appropriators can access resource units. The north-south and east-west groupings reflect distinct resource settings. Apart from this, system variations can also occur with respect to group size, ethnic compositions, exit options, in-group income differences and many other variables. It is within such a context that local resource users have to organize and craft rules that allow them to maintain their resources as well as ensure equitable resource distribution.

Factors that Influence FMIS Performance

One of the key results of my analysis indicates that performance of an FMIS in Chitwan is strongly associated with the orientation of the river system from which it draws its waters. As pointed out in the earlier paragraph, the characteristics of a river system have a direct bearing on the amount of efforts required to operate and maintain a system and the volume of resource units available to it. This is reflected in the ability of E-W irrigation systems to access water for more number of months in a year (Table 1-3), maintain their infrastructures better (Table 1-4) and enjoy higher cropping intensities (Table 1-5).

Table 1-3
Relationships between Average Access to Water and Orientation

	Systems on East–West Running Rivers	Systems on North–South running Rivers
Access to water less than 9 months/yr	0 (0%)	35 (76%)
Access to water greater than 9 months/yr	25 (100%)	11 (24%)
TOTAL	25	46
	100%	100%
Chi^2 = 37.52, p = 0.000		

Table 1-4
Relationships between Orientation and Performance Measures

	N	Systems on East - West running Rivers (N=22)	Systems on North-South Running Rivers (N=43)	F	P
Physical Condition	65	4.33	3.67	43.43	0.00
Productivity	65	5.38	4.29	44.57	0.00

Table 1-5
Orientation and Cropping Intensities

	East-West Systems	North-South Systems	F	p
Cropping Intensities at Head End	297 % (22)	245% (43)	39.9	0.000
Cropping Intensities at Tail End	275 % (22)	212 (42)	33.2	0.000

Whereas all E-W irrigation systems have access to water for more than 9 months this is true for only 1 out 4 N-S systems (Table 1-3). Not only is agricultural productivity significantly better in E-W systems than N-S systems (5.38 vs. 4.29; p=0.00) but so is the physical condition of irrigation infrastructure (4.33 vs. 3.67; p=0.00). This suggests that the average irrigation system located on E-W running rivers is more productive and also better maintained than an average system on N-S running rivers (Table1-4). Evidence of higher productivity can also be seen in Table 1-5. Cropping intensities at both the head as well as tail ends are significantly higher in E-W systems than in N-S systems. This implies that land area located at the head ends of irrigation systems tend to be more productive than those at the tail ends irrespective of the orientation of the system and E-W systems in general are more productive than N-S systems.

I find that irrigation systems located on N-S flowing rivers exhibit significantly higher levels of rule following behavior compared to their counterparts in the E-W Rivers (Table 1-6). However, I do not find significant differences in the monitoring and sanctioning activities (Table 1-7) and in the levels of rule infractions between the N-S and E-W groups (Table 1-8). The results suggest that less endowed resource systems (N-S) tend to be more conscious about following operational rules than the better endowed systems. But, in terms of monitoring and enforcing rules they tend to be more or less similar. The nature of rule infractions in both cases also tends to be mostly of a minor nature such as shirking "banwari"[20] duties or not showing up on time. It would be unusual to find irrigators stealing water or irrigating out of turn.

Table 1-6
Relationships between Rule Following Practices and Orientation

	Systems on East–West running Rivers	Systems on North–South running Rivers
Low/Moderate level of rule following	8 (42%)	8 (20%)
High level of rule following	11 (58%)	32 (80%)
TOTAL	19	40
	100%	100%
Chi^2 = 3.185, p = 0.074		

Table 1-7
Relationship between Monitoring/ Sanctioning and Orientation

	Systems on East–West running Rivers	Systems on North–South running Rivers
Low/Moderate Monitoring and Sanctioning Activities	5 (42%)	13 (37%)
High Monitoring and Sanctioning Activities	12 (58%)	22 (63%)
	17	35
TOTAL	100%	100%
Chi^2 = 0.057, p= 0.811		

Table 1-10
Relationship between Level of Infractions and Orientation

	Systems on East–West running Rivers	Systems on North–South running Rivers
Minor Infractions	15 (83%)	34 (97%)
Major infractions	3 (17%)	1 (3%)
TOTAL	18	35
	100%	100%
Yate's Chi^2 = 1.57, p = 0.21		

Rules are used extensively to structure irrigation activities. All of the surveyed systems have water users associations and rules govern the allocation and distribution of water, resource mobilization, and monitoring and sanctioning. There is also a common understanding among users regarding principles of water entitlements, resource contributions, and fines for rule violations. The rules in use, however, vary from system to system as they are designed to cope with their own situations.

[20] "Banwari" is a practice where each household has to contribute one able bodied person as loabor contribution towards irrigation system maintenance.

Two other factors that significantly influence irrigation performance are the willingness of individuals in groups to assume leadership or entrepreneurial activities, and the group's history of prior organizational experiences. Whereas only 1 out 5 E-W systems lack leadership activities nearly 3 out 5 do so in N-S systems (Table 1-11). The differences in leadership activities also associate positively and significantly with performance variables (Table 1-12). This pattern is similar in the case of prior organizational experience (Tables 1-13, and 1-14). Whereas more than 8 out of 10 E-W systems have a history of cooperation in activities other than irrigation only 3 out of 10 N-S systems have such a history. Prior history of cooperation is also positively and significantly associated with performance (Table 1-14).

Table 1-11
Relationships between Leadership Activities and Orientation

	Systems on East–West running Rivers	Systems on North–South running Rivers
No leadership activities	3 (18%)	24 (60%)
Presence of some level of such activities	14 (72%)	16 (40%)
TOTAL	17	40
	100%	100%
$Chi^2 = 8.58$, $p = 0.003$		

Table 1-12[21]
Relationships between Leadership Activities and Performance

	No leadership activities (N=26)	Presence of some level of such activities (N=28)	F	P
Physical Condition	3.74	4.13	14.13	0.00
Productivity	4.37	5.06	14.85	0.00

[21] This note is valid for Tables 1-4, 1-12, and 1-14. The numbers in the tables are factor scores. They do not have dimensions but they can be used to make relative performance comparisons. The two factors that I use as my performance measures are Physical Condition and Productivity. The former attempts to capture how well an irrigation system is maintained and the latter the productive potential of a group (see Regmi, 2007 for details).

Table 1-13
Relationships between Cooperation in Other Activities besides Irrigation and Orientation

	Systems on East-West running Rivers	Systems on North–South running Rivers
No cooperation	3 (16%)	29 (69%)
Some cooperation	16 (84%)	13 (31%)
TOTAL	19	42
	100%	100%
Chi^2 = 14.87, p = 0.000		

Table 1-14
Relationships between Cooperation in Other Activities besides Irrigation and Performance

	No cooperation (N = 30)	Some cooperation (N = 26)	F	P
Physical Condition	3.76	4.05	5.72	0.02
Productivity	4.45	4.91	5.01	0.03

The results confirm that leadership abilities and prior organizational experience matter and that they significantly influence irrigation performance. Unless individuals are willing to invest substantial amounts of their personal time and energy to coordinate activities of the many users it may not be possible to craft workable institutions. Making, testing, fine tuning, interpreting, and monitoring and enforcing rules to structure irrigation activities is a continuous process and it requires substantial amounts time and energy. Ternstorm (2003) also finds a significant relationship between leadership abilities and performance in her study of irrigation systems. Prior organizational history also appears to be an important variable that influences performance. The reason why groups with a prior history of working together in other activities tend to also do well in governing their irrigation resources is because familiarity with various rules and strategies used to achieve various forms of regulations make the task of organization a bit easier as users are more likely to agree upon rules whose operation they understand from prior experience.

Heterogeneity and FMIS Performance

I find that the socio-cultural differences as reflected by a group's ethnic composition are not correlated negatively with irrigation performance. Performance, rather, is correlated negatively with income variation. The results suggest that variations in incomes within groups may be a greater impediment to collective action than the number of ethnicities that comprise a group (Regmi 2007). The result of this study in regards to the socio-cultural variable is in line with the studies of Fujita et al (2000), Gautam (2002) and Somanathan (2002). They too do not find any association between their measures of socio-cultural heterogeneity and collective action. Similarly, in regards to heterogeneity of assets my results corroborate the results of prior studies undertaken by Tang (1991), Lam (1998), and Ternstorm (2003). All these studies of irrigation systems find a negative correlation between income inequality and collective action. The size of the irrigation system as measured by its command area is also not correlated to performance. One might expect better coordination and collective action when system size is small but this is not the case. Again, this result is similar to the results that Tang (1991) and Lam (1998) report in their studies.

The effects of engineering infrastructure - type of headwork and canal lining - on irrigation performance appears not to be uniform. The presence of a sturdier and more permanent type of headwork on a system appears to be negatively correlated with performance. A sturdier cement lined canal, on the other hand, is positively correlated to system performance. Though the results are not statistically significant their implications very much are. A truly permanent headwork, ironically, generates negative incentives for head-enders not to want to cooperate with tail-enders in system maintenance (Lam 1998). Partial or complete cement lining on the other hand appears to improve performance by minimizing system water losses thereby enabling water to reach the tail ends. The policy implication of such results is that an improvement in engineering infrastructure alone may not necessarily translate into improved system performance. Unless users are able to craft and enforce rules to cope with the asymmetries generated by improvements in irrigation infrastructure the positive effects may well be cancelled out by the negative effects.

RESOURCE SETTING, COOPERATION AND CONFLICT

The general topography of a region can influence initial resource endowments. These conditions in turn determine the efforts that may be required to manage individual irrigation systems. Some systems may have to invest greater cooperative efforts than others to realize equivalent benefits but the fundamental cooperation dilemma for all systems is essentially similar. Intakes and canals have to be constructed and maintained on a periodic basis; rights and responsibilities have to be agreed upon; and appropriate rules have to be crafted, monitored and enforced. If multiple systems share waters from a common river course then intersystem arrangements also need to be worked out in addition to the intrasystem agreements. In the following sections I examine the response of individual irrigation systems to conditions of relative resource abundance and scarcity (Regmi, 2007).

Conditions of Relative Water Abundance

Rapti is a perennial, E-W flowing, river with a dry season mean monthly discharge greater than the estimated water requirements of 11 FMIS that draw its waters. Water in the river course is fairly abundant round the year. Systems on this river have to cope with flooding and maintaining washed out intakes, which requires considerable resource mobilization, instead of conditions of water stress arising from reduced flows. Resource abundance does away with the need to maintain inter-system water sharing agreements and opens up opportunities for cooperation. An example of cooperation between irrigation systems in Chitwan are those between Jana Kalyan “Kha’ and Amrit Kulo.

Amrit Kulo’s water source used to be the Kanteswori stream. It served 25 hectares of land in Kathar VDC Ward number 7. Farmers of ward number 5 in 1983 proposed to farmers in Ward number 7 to jointly construct a canal that would tap water from the Rapti River. Ward 7's cooperation was necessary because canals had to traverse their land before it could reach Ward 5. Farmers from these two Wards reached an agreement where both would jointly construct the main canal, ward 7 would grant passage by allowing ward 5 to use its existing infrastructure to transport water, and three parts of the water from the Rapti would go to Ward 5 and two parts to Ward 7. This canal named Janakalyan "Kha" was constructed in 1983. With its share of the water Amrit kulo was able to irrigate an additional 50 hectares of land raising their total irrigated area to 75 hectares. If adequate water was not available in the river course systems down stream would surely have objected to opening up a new intake.

Conditions of Relative Water Scarcity

If resource conditions are poor and there aren't too many suitable sites to locate intakes then conflicts can arise not only between systems but also within a system. In some cases systems are able to resolve these conflicts while in other cases these conflicts can render the system virtually useless. An example of an intersystem conflict that was ultimately resolved is that of Pumpa Kulo (PK) and Kyampa Kulo (KK). Another example of a system that has failed to function due to the inability of users to resolve their internal conflicts is that of Bahireni-Pakhadibas Kulo (BPK). All of these three systems draw water from the N-S flowing Pumpa River.

Pumpa is a seasonal river that flows through changing terrain from hills to plains. During the dry season the flow in the river course is drastically reduced and the lower reaches dry out completely. Pumpa Kulo is upstream from Kyampa Kulo but their intakes are less than 300 meters from each other. The characteristics of both these systems are similar in terms of households and area served. Pumpa has a smaller service area than Kyampa (70 vs. 100 hectares) but serves more households (140 vs. 120 hh). Both of these systems have exerted tremendous efforts to construct their systems and their infrastructures are in top condition suggesting very high levels of cooperation within the system. However, the two systems have been involved in extensive physical and legal battles over water rights. What sparked the battle was the construction of a semi-permanent structure by Pumpa at its intake (see Shukla et al, 1996 for details). Kyampa's claim was that this construction drastically reduced their water shares. After years of conflicts an agreement has been reached which requires Pumpa to release sufficient water during winter to irrigate Kyampa's wheat crops[22]. Relative water scarcity is the source of conflict between these systems; however, they have been able to resolve their conflicts.

The intake of Baireni–Pakhadibas Kulo is located about 2 Km downstream from the intake of Kyampa Kulo. Naturally, less water is available in the river where its intake is located. Further, scouring of the river bed has lowered its elevation at the intake. Since the differences in elevation between intake and canals are becoming smaller this is reducing the natural flow of water into the canal. During the dry season when water volumes in the river are low flow in the canals is reduced to a trickle. Relocating the intake to higher elevations is possible but requires serious investments in time and labor. Also, a significant length of the main canal passes through difficult mountain terrain prone to landslides. Given these conditions user groups are facing difficulties in operating the system. Serious conflicts have arisen among the Tharus and the Tamangs, the two major ethnic groups sharing this system, on labor contribution and water

[22] Water stressed systems grow two crops, rice in the summer and wheat in the winter.

sharing issues. This has led to a decline in the condition of the infrastructure and the system in average is able to access water only for two months in a year.

Conditions That Enhance Self-Organization

Attributes of a resource that are considered important for self-organization are chances of feasible improvement, predictability of resource units and moderate size boundaries (Ostrom 2000). Also, unless modest levels of scarcity are apparent to users little efforts will be exerted to organize. Scholars also agree that appropriators who are dependent on a resource, intend to use their resource over a long period of time, have achieved certain levels of trust, and possess some level of autonomy to make their own rules are most likely to organize. Many of the aforementioned variables are in turn influenced by the larger political regime in which users are embedded. Whether users are actually able to organize, however, depends on the benefits and costs of changing institutional rules as perceived by those who can change them.
From the examples presented in the previous section we note that group efforts required to self-organize for irrigation are not trivial. Farmers under varying resource conditions have to define command areas, negotiate canal alignments, construct and maintain infrastructure, and coordinate efforts to design institutions that all agree to abide by. Despite the costs involved there are also benefits to be realized from cooperation. Year-around irrigation not only ensures higher crop yields but also increased cropping intensities. The ability to produce two rice crops annually instead of one is strong motivation for farmers to cooperate. Since the benefits of organizing are valued and commonly understood most user groups are able to create and sustain agreements to avoid serious problems of appropriation and provision. Under certain conditions we also see that groups can fail. For the most part, however, FMIS in Chitwan are able to overcome the basic cooperation dilemma.

Each successful self-governed common-pool resource system copes with its own settings by designing institutions that are most relevant to its own conditions. The particular rules that successful systems use may vary substantially from one another but there are common principles underlying their success. Ostrom (1990) calls them the design principles and has identified them to be a) presence of boundary rules, b) congruence, c) ability to monitor and sanction, d) right to modify rules, e) minimal recognition of rights to organize and f) mechanisms for conflict resolution. Most of these design principles can be observed in the farmer managed irrigation systems of Chitwan. Users maintain written records and know exactly which households have the rights to withdraw resource units and which don't; there are clear commonly understood rules defining who can appropriate how much resource units and when; all are aware of what constitutes an infraction; a simple, effective and low cost monitoring[23] mechanism is in place; rule infractions attract graduated sanctions; WUAs have the power to change operational rules via the general assembly; WUAs are registered with department of irrigation and have legal standing; and informal conflict resolution mechanisms exist to resolve potential problems.

[23] In irrigation systems the cost of monitoring is relatively low. The irrigator who is about to complete his turn would like to extend his time, but the next irrigator in line is waiting for him to finish his job and would like to start early. The presence of one deters the other and additional resources do not have to be invested to monitor, one is simply waiting his turn.

There are conditions that are conducive to self-organization and there are also conditions that can threaten the abilities of communities to manage their institutions. Ostrom (2005) cites the inability to cope with rapid exogenous changes as one of the factors that can threaten the robust governance of common-pool resources. Example of an exogenous shock that led to the breakdown of a system in Chitwan is that of Jyamire Kulo, a system on the Kair River. Incessant floods washed away its intakes and flooded not only its farmlands but also those of neighboring systems. There was tremendous pressure on Jyamire Kulo to close its intake. A permanent gabion wall over hundred meters in length had to be constructed to contain the floods. Since Jyamire Kulo was a small irrigation system (55 hectares, 100 households) it was unable to generate sufficient resources to develop a diversion structure at an alternate site. Farmers now rely on the drainage waters of neighboring systems and some on private pumps fro their water needs. A well-functioning system instantly went out of commission due to its inability to cope with an exogenous shock. Such shocks can also be induced by rapid out-migration or in-migration from or into an area. Out migration can change the economic viability of a regime due to loss of those who contributed resources. In-migration can bring in new participants who do not trust others and share extant social norms that have been established over a long period of time (Ostrom 2005). Since collective action is based on mutual trust and reciprocity self-organized resource regimes can quickly disintegrate if population changes occur rapidly. Threats to self-organized small scale resource governance systems can also come from transmission failures from one generation to the next of the operational principles, corruption and opportunistic behavior, lack of large-scale institutional structures to support governance at the local level; and easy access to external funds (see Ostrom 2005 for details).

FMIS face a variety of challenges. Under some set of conditions they are able to perform well and not so well in other sets of conditions. There are certain attributes that are conducive to self-organization and others that are not. They are also continuously subject to external threats some of which they are able to cope with and others that can quickly unravel long established systems. Particular examples associated with each of the above scenarios can be observed across the FMIS of Chitwan. However, in general, most perform pretty well given their particular conditions. They have effective water users' organizations with well-defined rules for water allocation, distribution, resource mobilization, and conflict resolution; they are low cost and based on local resources; and leaders of these systems are accountable to the users. Their technical deficiencies are well compensated by the managerial inputs (Shukla 2001). FMIS can be suitable vehicles for improving agricultural performance. Policies to improve irrigation performance have to be geared towards supporting these self-organized local resource management systems.

POLICIES TO IMPROVE IRRIGATION PERFORMANCE

Emphasize Institution Building

Cooperation among villagers cannot be explained by the "benefits of engaging in cooperation" argument alone. Even in instances where cooperation could have benefited all parties, there are examples from Chitwan of sophisticated agency-managed irrigation infrastructure falling in disrepair due to collective inaction in assuming responsibilities for system operation and maintenance. There are many dimensions to the basis for cooperation among individuals.

Individual common-pool resource users are likely to contribute and cooperate only if they perceive that they will be able to reap the long-term benefits of engaging in collective action. They are also more likely to cooperate if they are aware of their interdependence and see mutual benefits resulting from working together. The presence of a set of credible, commonly understood, well-enforced and agreed-upon rules further helps in generating a positive incentive system for villagers to engage in collective action. Without creating the right environment, bureaucracies cannot assume that cooperation among resource users will develop naturally once an irrigation system has been handed over to the users.

The relationships between Nepali government officials, who are charged with oversight of natural resource systems, and resource users are generally based on the dominance-dependence relationship. Villagers are discouraged or disallowed from taking initiatives. The villager, therefore, sees no incentive in taking responsibility and assumes that it is the government's role to take responsibility for the operation and maintenance of the resource system. Given the non-incentives for villagers to participate, system performance hinges on the capabilities of the government officials. With inadequate resources, weak incentives to perform, and inadequate understanding of resource systems, these officials very often fail to perform. It, therefore, comes as no surprise to see agency-managed irrigation systems turning dysfunctional. Common-pool resource systems are co-production processes that perform best when both the oversight agencies and resource users cooperate in making the system work. Non-cooperation by either party results in poor performance.

Developing sustainable common-pool resource systems involves not only the application of technical skills but institutional design skills as well. Failures in most instances occur not because of deficiencies in technical skills but due to lack of knowledge in designing institutions (Ostrom, 1992). Since the most important consideration in institutional design is the process of developing a set of rules that participants in a process understand, agree upon, and are willing to follow, valuable insights can be gained by understanding them and their interrelationships. Agencies charged with oversight responsibilities need to recognize this.

Recognize Local Institutions

Policy actions that aim at facilitating the development of local institutions might have greater chances of success if existing local institutions are recognized and encouraged. Institutions are built on common understandings that take years to build (Ostrom 1992). If such an understanding already exists in a local community, this is a source of great strength. Institutional development is a slow process based on the principles of trial and error. One cannot expect new institutions to take root merely by introducing them, that too, without the support of the community who are affected by them.

The Department of Irrigation has frequently imposed their institutional designs and organization structures on irrigation communities. Imposing these structures adversely affect the functioning of local organizations if they exist. When legitimacy of local institutions is challenged, farmers' faiths in local institutions vanish quickly. When agencies intervene to develop irrigation infrastructure in potential areas, they need to recognize the presence of existing systems.

Officials often see local organizations merely as arrangements through which to obtain a community's contributions and cooperation. Very little attention is paid either to encourage or develop the governing function of these organizations. Participation is thus frequently equated to getting the villagers to fit their efforts in the operation and management plan suggested by the officials. Policy actions, therefore, need to be strongly linked with an institutional environment where villagers are provided positive incentives to participate in crafting rules and engage in productive working relationships. Farmers have to be recognized as being intelligent with capabilities to make informed decisions and engage in collective action.

Engage Local Resource Users

Farmers are very knowledgeable about stream flows, crop preferences, stability of land, and a host of other time and space information. Such types of information are extremely valuable in operating irrigation systems under considerable amounts of uncertainty. The weather, topography, and changing needs of appropriators introduce uncertainties in assessing the volume of resource units that will be available to an irrigation system. During monsoons, the intakes and embankments are regularly breached requiring emergency action. Discharge from the rivers during winters also decreases drastically, requiring major adjustments in the appropriation rules. Unless users are able to quickly adapt to changing conditions, system operation can drastically suffer. A quick response is not possible, however, without user participation and cooperation. If local knowledge and participation can be incorporated into designing rules governing resource use, then it is more likely the systems will function successfully. Without a clear understanding of the local time and space information that users possess, designing rules to regulate forest resource use may not, again, be effective.

Efforts at helping communities to develop institutions, therefore, have to be directed towards enhancing their capabilities and willingness to relate to and work with one another rather than handing down rules or organizations to govern resources. Institutions, no matter how well designed they are in the beginning, will subsequently require adjustments to changing conditions. Unless these changes can be incorporated, institutions quickly become ineffective. It is, therefore, important that resource users who are affected by the operational rules are permitted to participate in modifying the operational rules. Since the lifestyles of resource users are closely linked to their resource systems, they are the ones who are most knowledgeable about the resource conditions. Unless they are involved resource management can be expected to be both ineffective and inefficient.

Secure Legal Standing

Historically, farmer-managed irrigation systems (FMIS) were never recognized as a legal entity. Not only did they not have legal standing but even their contribution towards irrigated agriculture was not recognized by the Irrigation Department despite their significant contributions (even today, nearly 75% of irrigated agriculture in Nepal is a result of FMIS). Developing irrigation infrastructure for the Department meant the construction of medium and large-scale systems, especially in the Terai. Planning, construction, implementation, operation and management, and maintenance were all considered to be responsibilities of the Irrigation Department. The beneficiaries (resource users) did not have a role to play in any of these processes. In more recent times, however, with the adoption of the irrigation policy of 1992, provisions have been made for users' participation in the agency-led irrigation development programs. The Water Resources Act of 1992 also, for the first time, acknowledged the legal rights of duly registered water users associations with their own *bidhans* (charters). This is a significant step forward in ensuring secure property rights.

The enactment of key legislations does not instantly alter the power relationships between the bureaucracy and the users nor does it ensure ready cooperation by the users (Seymour and Rutherford, 1990). Regardless of legislations, National government and its agencies quite often fail to translate their policies into action. This inability, or rather the unwillingness, of the agencies to recognize diverse local rules governing rights and responsibilities is often a major impediment to successful self-organization. Legislations alone may not change the situation overnight but it does provide a legal base and legitimacy to user groups to assert their rights.

Practice Nuanced Interventions

It sounds counterintuitive to assert that irrigation system efficiencies may actually decline if temporary irrigation structures are replaced by permanent ones. However, Lam's (1998) results from the study of Nepali irrigation systems point in that direction. He finds that provision of permanent headworks is not a sufficient condition to improve irrigation performance, implying that technological fixes alone may not be the solution to improve system efficiencies. The amount of labor required for operation and management activities are significantly reduced by permanent structures, therefore, labor contribution by tail-end farmers becomes unimportant to farmers at the head end. Negative incentives are thus generated for headenders to ignore the demands of the tailenders, resulting in low levels of cooperation and hence lower productivity. An important policy implication is that there must be as much emphasis on developing social capital as there is on developing physical capital when undertaking projects to assist irrigation systems. Care needs to be taken to ensure that assistance does not negatively affect cooperation.

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