

Full Length Research Paper

Sustainability and revitalization of irrigation systems: Searching for Innovative Approach

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Received 08 July, 2012; Accepted 19 October, 2012

Irrigated agriculture with innovative and revitalized irrigation systems hold future of food security. Revitalizing irrigation systems to meet the food demands of the future are to be considered in an integrated manner consisting infrastructure rehabilitation, investment to raise yield productivity from irrigated land and promotion of appropriate institutions and innovative management modes. A case study of an assistance program to farmer managed irrigation systems of Indrawati Watershed basin of Sindhupalchowk District of Nepal is presented here and the case study highlights the innovative measures and its results of longitudinal study over period of time. The systems which have assistance from Water and Energy Commission Secretariat (WECS) and International Irrigation Management Institute (IIMI) program have been the candidates for evaluation of impact of intervention in three time slices respectively in 1985, 1991 and 1999. The findings of the impact analysis of those systems indicated that intervention is not a one shot process of transferring resources to the farmers. It has an essential role to play in determining the relationship between input variables such as maintenance effort and agriculture potentiality and measurement of cropping intensity at the tail end. Intervention should enhance rather than replace the effort of the local farmers in irrigation management. One way to look at the sustainability effect is by looking at temporal dimension of farmers' adaptation of change and to observe how the intervention effect has affected the adaptation process. It was proposed to measure the effect of intervention in short term by the change in performance from time slice I to II and longer term effect by the change from time slice II to III. The summation of the two impacts gives the result of net effect of intervention. Features of innovative approach are listed.

Key words: Innovative, sustainability, revitalization, irrigation, food security, longitudinal study, impact evaluation.

INTRODUCTION

Population in general is increasing in Asian countries, so is the demand on food. Food supply has to come from agriculture. There is greater potentiality of increasing food supply to meet the demand of increasing population from irrigated agriculture than from rain-fed agriculture. Hence, sustainability and revitalization of irrigation systems play important role in ensuring the food security of the people. The irrigation sector must first be revitalized to unlock the potentials by introducing innovative practices and changing the ways that they are governed and managed. Hence, revitalizing irrigation systems to meet the food demands of the future are to be considered in an integrated manner consisting infrastructure rehabilitation, investment to raise yield productivity from irrigated land and promotion of appropriate institutions and innovative management modes (IWMI and FAO, 2009). It is

proposed here to present a case study of an assistance program to farmer managed irrigation systems of Indrawati Watershed basin of Sindhupalchowk District of Nepal and highlights the innovative measures and its results of longitudinal study over period of time (Ostrom et al., 2011).

In search of sustaining intervention

Oftentimes, government agencies and donors conclude that the best way to assist the irrigation systems of the farmers would be to build new systems. The approach will be guided by engineering works. However, it has proved in many places that such approach has brought only temporary improvement in the performance of the

irrigation systems (Chambers, 1988; Ostrom et al., 1993; Lam, 1996). Such approach tends to make the farmers dependent on the external resources. The search for sustaining intervention asks for the reconsideration of the existing practices of donors as well as government agencies assistance for the improvement of irrigation performance.

Two types of interventions both by the donor as well as by the government agency are in practice. They are: (a) employing external water engineers to construct modern irrigation infrastructure to replace the old ones used by the farmers and (b) introducing institutional templates for the organization of collective action for irrigation management. Both these approaches could not bring long term improved results. On many occasions, they generated further dependency of the farming community and institutional arrangement thus assisted in the irrigation system disappeared after the system construction period is over.

There are many examples of public interventions in irrigation systems in Asian and African countries (WECS and IIMI, 1987). The important result expected from intervention is the strengthened capacity of the farmers' organization to manage the system, increased agriculture production and less tendency of dependency of the farmers to external assistance.

A social-ecological system (SES): An irrigation system is a prototype

Recognition of the importance of the social-institutional aspect of irrigation management is important. In order to understand an irrigation system as a social-ecological system which involves complex interactions between human actions and physical-biological dynamics is quite another matter. There is deeper impression among the implementers of irrigation improvement program that the construction of engineering works and institutional development are two related yet separate domains. So, the implementing agency feels that infrastructure should take priority and then appropriate institution model be introduced in accordance with some best-practices templates for the operation and maintenance of the infrastructure later on.

The engineering-centered approach to irrigation assistance does not mean that engineering works are not important. Irrigation development requires the multi-sectoral knowledge of hydrology, hydraulics, civil engineering, soil, agronomy and social-institutional environment of the command area. But engineering works are one of many components that constitute a social-ecological system (SES) of which an irrigation system is a prototype. It is equally important to understand how the users are organized to get the benefit out of local natural resource management. Janssen et al (2007: 309) define a SES as: composed of

biophysical and social components where individuals have self-consciously invested time and effort in institutional infrastructure (and, in some cases, physical infrastructure) that of outcomes (for example, patterns of resource use and their distribution within the population) achieved over time in coping with diverse external disturbances and internal problems.

An irrigation system composed of a resource (sources of water), physical infrastructure (storage and canals), actors who manage and appropriate from the resource (farmers and irrigation managers), and a governance structure that regulates the action and interaction of the actors (irrigation institutions) is an example of a SES. An SES is a complex system. Its features emerge from the interactions of actors within the system. Its dynamics are activated by human and biophysical processes at multiple spatial and temporal scales and scopes that often generate complex positive feedback loops (Ostrom, 2009; Miller and Page, 2007; Mitchell, 2009).

An effective intervention process has to be designed in conjunction with the operation of the SES rather than being conducted as an external process of manufacturing changes to the system. In Nepal and many other Asian countries where the engineering-centered approach has been, and in fact is still very much, dominating the assistance community, an intervention project is often considered to be no more than a package of 'deliverables' to be provided by government or donor agencies. Officials in these organizations often look at an intervention project from a bureaucratic lens, focusing on how to manufacture the deliverables in accordance with some criteria and standards specified by their organizations. It is unlikely that the 'deliverables' would fit what is needed for improving the performance of the SES.

The construction of engineering works is based on technical knowledge. It is assumed by many policymakers that professional engineers have command of the technical knowledge. They are in the best position to tell the system users about the engineering works they need or should have. This situation results into an unequal power relationship in which the former see themselves as the 'help providers' and the latter the 'help recipients.' In such unequal relationship, one would not be surprised to find that the voice of the 'help recipients' is hardly taken seriously by the 'help providers'. The following case study presents an innovative intervention approach undertaken in assisting farmer managed irrigation systems (WECS/IIMI, 1990).

MATERIALS AND METHODS

This action –research project on intervention was jointly undertaken by Water and Energy Commission Secretariat, Nepal and International Irrigation Management Institute, Sri Lanka in 1986. The author is

one of the team members as social scientist in the action research project and involved in the follow up activities during those three times slices evaluation of the impact of the intervention. Several objectives were set in the action-research project in Indrawati River Basin. First objective of the action-research project was to build low-cost procedures for identifying the relative needs of all systems in the area. Secondly, the procedure would allow the selection of systems for assistance which can generate impact on increased food production. The third objective was to establish and test the methods for delivering assistance which would strengthen the farmers' management capability for the operation and maintenance of irrigation systems along with the physical infrastructure improvement.

During the process of intervention, they remain farmer-managed systems. It was considered that it is important to ensure the participation of the farmers in the identification of the available resources and their limitations. It was visualized that farmers' participation in the irrigation system improvement activities under the guidance of competent engineers would give opportunity to the farmers to learn about maintaining the physical system and allow them to learn the management skills essential for mobilizing local resources.

Project area

This is a hill area where the Indrawati River has cut deep into the valley, making the water from this large snow-fed river nearly inaccessible to farmers for irrigation. To develop irrigation, farmers have constructed diversions on the small high-gradient tributary streams to the Indrawati River. These streams have destructive floods in the monsoon and only a small spring-fed discharge in the dry season. Farmers have built contour canals, often across rock cliffs and through unstable slopes, to irrigate terrace fields. To allow systematic identification of existing systems, the river basin hydrologic boundaries were used to define the project area (WECS/IIMI, 1990).

The procedures used by the action-research project

The WECS/IIMI action-research project carried out the following procedures in the Sindhupalchowk District in order to provide assistance to FMIS. These procedures may provide references to other intervention programs to adapt as appropriate to their needs.

System identification and selection

In the first stage, the objective was to identify all irrigation systems in the 200 km² project area. In the second stage, a reconnaissance/inventory of the systems was prepared

to determine the location and resource base of each system within the project area. On the basis of the inventory, 119 potential candidates for assistance were identified. Criteria used for identification of potential candidate were the: potentiality of the system expansion of command area, crop intensification, or reducing maintenance cost. Twenty-two of these systems were identified as candidates for improvement on the basis of having the possibility of command area expansion and extra water resources available.

Implementation of improvement of selected irrigation systems

Several dialogues between the agency personnel and the farmers groups were initiated. The first dialogue between the farmers and agency personnel took place in the selected system. The purpose of the first dialogue was to obtain information on the number of beneficiaries, role and strength of the beneficiary organization, and irrigation management practices. Critical areas that needed physical improvement were also identified. The first dialogue was important because it established a rapport between the farmers and technical and social groups from the project side.

In addition to collecting the basic information, the technical team with the participation of the farmers also collected relevant data for the design of the new irrigation structure. The farmers were then asked whether they wanted to participate in such an assistance program and what contributions they could make. After the farmers had agreed to the terms and conditions of assistance and once each system was notified, and the total amount of fund available for improvement determined, a second dialogue with the farmers took place.

In the second dialogue, the following activities occurred. First, a tentative list of irrigation improvements was prepared in consultation with the farmers. In establishing the priority of the various physical improvements, the farmers were asked to help rank all of the desired physical improvements into three groups according to priority:

1. The highest priority was placed on improvements necessary for expansion of the system but difficult for farmers without assistance.
2. The second priority was assigned to work that would improve system operation and maintenance.
3. The third-priority improvements included work that farmers could accomplish using their own skills, labor, and materials (Yoder, 1991).

The farmers, in consultation with the technicians, also needed to take into consideration the budget ceiling set by the government's financial contribution. This helps the farmers to decide what improvement work would be

undertaken using government assistance and what they would do on their own. Generally, the farmers would decide to undertake the earthworks on their own. They decide to spend the resources to secure the skill not available within the village.

Second, the farmers were informed of the amount of money allocated to be spent on their system based on the estimate of the first priority infrastructure. If they could save money on first-priority work, they would be able to use it for second-and even third-priority work. The intention was to create a positive incentive for the farmers to use the project funds with great care.

Third, water users' organization was either formed where it does not exist or strengthen the existing one which is to be responsible for several tasks. The water users organization thus formed undertakes (1) the identification of existing and future water users (from the expanded area) and the land area each irrigated; (2) preparation and acceptance by all water users of a plan for water allocation to the new area; (3) preparation of a plan, including rules, for supervising the improvements to be made and for future management of operation and maintenance; and (4) setting the requirements and rates for free and paid labor mobilization (WECS/IIMI, 1990: 20).

Fourth, the farmers and the engineers designed the structures for the improvement of the irrigation system. During this time, some shifting of priorities and changes in design took place. Fifth, assistance to FMIS involved both physical and managerial improvement of the system. For example, to help farmers strengthen their management capacity, a social organizer was presented to help them conduct regular meetings. In addition, members of an irrigators' executive committee, who were elected by the farmers, were trained in recording the minutes of meetings, keeping records on labor mobilization, and keeping financial accounts.

Furthermore, farmers could also strengthen their managerial and organizational capacity by visiting other similar systems to learn from their experiences. A farmer-to-farmer training program was organized for members of the irrigation organization so they could observe improved irrigation practices in another system and learn from the farmers in that system. Several farmers selected by the farmers themselves participate in the farmer-to-farmer training program. After their return from the visit to other systems, the participant farmers organized the meeting of the users of the system and explained what they had observed in other systems and what might be adopted, and what needed modification in the context of their own system. Thus, a larger number of farmers were exposed to new and improved irrigation management systems during the planning phase.

In summary, during the process of the first and second dialogues, and also during the physical and management improvement period, field supervision was carried out by teams that consisted of engineers, overseers,

agriculturists, social scientists, and persons with construction skills. The construction activities were to be a 'training exercise for the users' organizations in making decisions, establishing rules, managing conflicts, mobilizing labor, and keeping records' (WECS/IIMI, 1990: 20).

During the third dialogue, the farmers' contributions, the role and responsibilities of the technicians were defined. The implementation of physical improvement also began. During this third-dialogue phase, the farmers requested many additional changes in design as they better understood the actual dimensions and other characteristics of the structures that were to be built. Designs were modified to accommodate site-specific characteristics as excavation and construction work progressed. One out of the three consulting groups took charge of the improvement of 6 out of the 19 systems selected for assistance. It was reported that out of 47 structures that were initially designed for the 6 systems, 30 were modified to meet the farmers' requests or to better fit the site condition during construction. Eight of the 47 initial structures were dropped by the farmers during construction in favor of adding 42 others totaling the same cost but better fitting their priorities. In essence, the project's commitment to full farmer participation and farmer acceptance of the designs required that the technicians resolve the farmer's dissatisfaction over any aspect of the project (Bhattarai, 1990).

RESULTS OF INTERVENTION

Hence, the intervention in Indrawati River Basin was like the three-legged table with the balanced approach of (1) the government, (2) the active participation of the beneficiary farmers, and (3) the consulting companies performing both technical and social mobilization. All contributed to the effectiveness of the program (Acharya, 1990).

Construction and cost

Table 1 show that assistance to the 19 systems allowed expansion of the irrigated area commanded by the canals by over 50%. The expenses incurred were recorded separately by each system and the record book was open for inspection by all users, the consultant, and WECS and IIMI staff. The cost based on the grant to each system was just under NRs 2,000 ha (about NRs 22/US\$ at the time the grant was received). With supervision included, the cost of physical and management improvements was about NRs 3,300 (US\$ 150) per hectare. This is in the same cost range as other agencies that have provided assistance to farmer systems in the hills using participatory methods such as the farm irrigation and water utilization division averaging

Table 1. Irrigable area and cost of improvements to 19 farmer-managed systems.

System	Existing command area (ha)	Command area expansion (ha)	Total irrigable area (ha)	Project grant (NRs)	Cost per irrigable hectare (NRs)
ChhahareKhola	126	37	163	126,615	777
SotiBagar	19	11	30	150,699	5,023
Dovaneswar	2	10	12	74,807	6,234
Magar	100	43	143	160,805	1,125
Siran, Ta	18	6	24	136,789	5,700
Majh, Tar	71	16	87	114,321	1,314
GhattaMuhan	23	10	33	124,321	3,767
Jhankri	18	13	31	91,707	2,958
Chholang	23	14	37	116,066	3,137
Siran, Baguwa	18	19	37	57,488	1,554
Majh, Baguwa	13	20	33	113,541	3,441
Chapleti	8	15	23	78,065	3,394
Baghmara	3	6	9	44,433	4,937
Chap Bot	12	5	17	71,630	4,214
Bhanjyang	21	14	35	65,178	1,862
Dhap and Subedar	30	35	65	85,000	1,308
NayaDhara	55	55	110	139,720	1,270
Besi	65	20	85	119,839	1,410
	625	349	974	1,871,024	
Average cost per irrigable hectare					1,921
Consultant and WECS supervision support				1,192,747	
Tools supplied				82,182	
Farmer training				55,000	
Average cost of supervision per irrigable hectare					1,365
Total cost of improvement per irrigable hectare					3,286

Source: WECs/IIMI (1990: 29).

NRs 3,400 ha, and the Agricultural Development Bank of Nepal, which cost about NRs 4,600 ha. Although the cost of supervision was high, the close participation enhanced the productivity of the money spent.

More important than the low capital cost per hectare of the grant was the effect of intensive supervision and farmer training tours in motivating farmers to use the grant resource productively and to augment it with their own labor. This resulted in nearly all of the improvements identified by the farmers and consultant (including second- and third-priority work) being completed even though the budget was expected to cover only the improvements of first priority. Table 2 shows that farmer involvement in the construction resulted in a 38% contribution from the farmers, about half of the systems managed substantial labor mobilization from their own resources.

a. Grant amount allocated to the systems to complete most first-priority work as estimated using national norms.

b. Grant money expenditure for completing first-priority work—money saved (a-b) was used for second- and third-priority work.

c. All unpaid labor (calculated as the number of person-days of labor multiplied by the district wage rate) plus the difference between the district rate and a lower wage rate as agreed to by farmers in some systems to reduce cost.

d. Value of work completed as computed using national norms. This is higher than (a+b) because: (1) estimates computed by norms are generally high and (2) work efficiency due to farmer participation was very high.

e. Effectiveness of the farmer participation in accomplishing more than estimated by the national norms.

f. NayaDhara and BesiKulo systems are not included because information on the actual cost is not available.

Averaged over all the systems, farmer participation can be credited with increasing the value of the grant by about 140%, where the volume of work completed is at

Table 2. Savings in cost of improvements due to farmer participation (amount in NRs '000).

System	First-priority work		Saving	Farmers' contribution	completed Work	Effective increase d/a
	(a)	(b)		(c)	(d)	(e)
	Grant	Actual expenditure	(a-b)/a (%)	NRs '000	NRs '000	(%)
ChhahareKhola	127	62	51	3	168	132
SotiBagar	151	83	45	1	167	111
Dovaneswar	75	68	9	1	89	119
Magar	161	133	17	1	192	119
Siran, Tar	137	40	71	1	214	156
Majh, Tar	114	96	16	1	143	125
GhattaMuhan	124	82	34	0	170	137
Jhankri	92	28	70	1	108	117
Chholang	116	41	65	1	136	117
Siran, Baguwa	57	42	26	25	81	142
Majh, Baguwa	114	85	25	42	170	149
Chapleti	78	60	5	19	109	140
Baghmar	44	30	32	12	73	166
Chap Bot	72	60	17	16	86	119
Bhanjyang	65	50	23	15	102	157
Dhap and Subedar	85	35	59	4	154	181
NayaDhara	140	—	—	21	245	175
Besi	120	—	—	10	221	184
Total	1,872	995	38 ^f	174	2,628	140

Source: WECs/IIMI (1990: 30).

the rates given in the national norms for rate analysis. Most of the increases in value of the work done can be credited to the efficiency of work accomplished by farmer participation over what would have been required if contractors had been used.

Although a great deal of time and effort was required to bring about effective farmer participation, and the project got off to a slow start with delays for design modifications, ultimately it resulted in an extraordinary farmer response during construction. Once farmers were convinced that they were getting what they needed from the project, they worked hard to get the most out of it.

Management changes

In addition to effective construction output, the farmers gained confidence and pride in their own ability to organize and mobilize resources and gained skills in construction methods. This has improved their ability to continue management of operation and maintenance of the systems. While the savings in cost of physical improvements attributable to farmer participation is valuable, the real payoff is in the sustainability of those improvements and better water delivery from improved

management.

Management of operation and maintenance activities in all 19 systems assisted was on an ad hoc basis before improvements. There were few examples of cooperative efforts for maintenance and no evidence of rules, roles and sanctions that are common features in well-managed systems. The assistance project brought some level of management change in all 19 systems. In order to bring such management changes in those systems, a farmer consultancy program was also introduced. Farmers from better-organized systems were assigned to one of the project irrigation systems for a few days to work with the members of the management committee of WUA about the rules and regulations regarding resource mobilization, record keeping, water allocation and water distribution and punishment for noncompliance. The level of communication between the consultant farmers and system farmers became easy and they could appreciate each other's practical problem and possible solutions within the irrigated community.

Agricultural changes

Farmers who were interviewed in each system after the

first rice crop was harvested after assistance were asked how much more water was now available as compared to before the improvements were completed. The system with the lowest report indicated a 40% increase in water delivery. Another system reported a 50% increase. All the rest said that the water available at the command area had at least doubled. When the same farmers were asked what impact the increased water supply had, the most frequent response was that it allowed timely rice transplanting. In the past, they had to wait for rain. Several reported that head-end versus tail-end irrigator conflicts over water distribution no longer existed. In several systems, the increase in water delivery allowed for the installation of a water-powered grain processing mill.

The second perspective indicated that intervention is more likely to be effective when it enhances farmers' ability to manage their systems. Through intervention, farmers are enabled to mobilize themselves better to maintain the resources and to engage in self-governing activities concerning appropriation and maintenance.

Innovative intervention features

The WECS/IIMI project procedure identifies at least seven innovative features (Ostrom et al., 2011: 18). They are;

- (1) The farmers were allowed to choose whether they are to be involved or not.
- (2) Secondly, the project provided technical assistance. However, the project purposively did not provide full funding for engineering improvements and the farmers were expected to provide core labor and some materials.
- (3) The farmers were made to decide a full rank ordering of the improvements that they desired.
- (4) The farmers were allowed to understand the engineering plans and had to OK them before they were implemented (in other words, the farmers had a veto over engineering plans that were not consistent with their preferences).
- (5) The farmers were allowed to reduce the monetary expenditures for the highest-ranked projects by their own contributions, hence, the saving thus made was allowed to allocate to the next ranked project on the farmers' lists.
- (6) Participating farmers were given opportunity to participate in 'farmer-to-farmer' training in a more productive irrigation systems elsewhere in Nepal.
- (7) Each farmer group was expected to write its own internal set of working rules that covered how future decisions would be made for their system.

Examples of performance over period of time

The systems which have assistance from WECS/ IIMI

program have been the candidates for evaluation of impact of intervention in three time slices respectively in 1985, 1991 and 1999.

The first approach looks at the intervention as a one shot process of transferring resources to farmers. As long as the shot is strong enough and farmers are given adequate resources, irrigation will be improved. Second approach emphasizes the facilitative role of intervention. Intervention affects performance through enabling farmers to better utilize the physical, human and social resources that are accessible to them.

The findings of the impact analysis of those systems indicated that intervention is not a one shot process of transferring resources to the farmers. Intervention has an essential role to play in determining the relationship between input variables such as maintenance effort and agriculture potentiality and measurement of cropping intensity at the tail end. Intervention should enhance rather than replace the effort of the local farmers in irrigation management. It is necessary to understand the sustainability effect of intervention. One way to look at the sustainability effect is by looking at temporal dimension of farmers' adaptation of change and to observe how the intervention effect has affected the adaptation process. It was proposed to measure the effect of intervention in short term by the change in performance from time slice I to II and longer term effect by the change from time slice II to III. The summation of the two impacts gives the result of net effect of intervention (Ostrom et al., 2011: 67-75). Factors that considered measuring the effect of intervention are:

- a) Size of the irrigated area
- b) Technical efficiency of irrigation infrastructure
- c) Water adequacy
- d) Tail end cropping intensity
- e) Level of deprivation in a system.

Size of the irrigated area

The intervention has become successful in expanding the size of the irrigated area in many systems. Farmers' efforts to expand the irrigated area continued for some time. However, the magnitude of expansion of the irrigated area leveled off in the long run. From time slice I to II, it is observed noticeable expansion of the irrigated area but the same intensity is not noticed between time slice II to III.

Technical effectiveness of irrigation infrastructure

The technical efficiency is generally measured by the effectiveness of the physical infrastructure to deliver water so that the farmers are able to obtain high crop yields to the greater extent. In this case also, time slice I

and II showed great improvement. But time slice II to III remained stagnated and in some systems, the yields decreased in the long run.

Water delivery

Adequate water delivery is reported in those three time slices. However, it is reported that the tail end farmers experienced a little bit shortage of water delivery. Positive effect of intervention on water adequacy has continued in most of those systems. One of the lessons learnt in water delivery is that collective action of the farmers can ensure the adequate water delivery in the irrigation systems.

Tail end cropping intensity

It is noticed that there is tendency of tail end cropping increase. This is one of the indicators for better performance of the irrigation system. However, other factors also play in determining the tail end cropping intensity. Time factor also plays important role in it. The other important factor is that the agriculture productivity tends to be affected by a complex array of conditions. Whether an intervention can bring an improvement in the tail end cropping intensity depends on how it configures with other factors.

Level of deprivation

It is important from the perspective of equitable resource distribution among the members of the community. Deprivation in the irrigation system is concerned whether irrigators in the system are consistently disadvantaged in the allocation of water. In the time slice I, it was reported that half of the system had problem of deprivation. In time slice II, the number has dropped. One fourth of the systems had problem of deprivation. In time slice III, none of the systems had the problem of deprivation.

Reflections on the issues of intervention

Intervention has to cope with complexity and change of the irrigation systems. As was discussed earlier regarding the “best practices” of irrigation improvement by hiring external water engineers to design and construct up to date infrastructure to replace what the farmers have built for many years and secondly, by developing an institutional template for how the government and farmers should be organized. Both these approaches have not been proved effective. The WECS/ IIMI action research in Indrawati Watershed Basin for irrigation intervention has tried to be different from “best practices” of intervention and the irrigation intervention was designed putting the

farmers in the driving seat. This approach helps achieve the question of sustainability and revitalization of the irrigation systems. However, there is need of continuation of institutional and technical support to such intervened irrigation systems.

It was shown that the systems which could mobilize internal or external resources to upgrade the infrastructure performed better than others which remain dormant in resource mobilization for infrastructure improvement. Existence of written rule of operation of WUA has contributed for the better performance of irrigation systems. However, these rules are to be formulated by the farmers themselves keeping in view their local need. In order to maintain equity and accountability, the system of fine for defaulters and punishment to non-complying members was important. The study of those 19 irrigation systems has indicated the importance of the fine and punishment for effective functioning of the water users associations. The prominent feature indicated from the study of those systems over period of time is the key role of the leadership. The strong leadership in the community has made the system perform better. Even the better performed system with effective leadership has become ineffective after the death of the existing leader. Finally, the system of collective action guided by the “social capital” accumulated in the community would affect the sustainability of the intervention and irrigation performance. In the post- Maoist revolution visit to these systems, it is found that there has not been noticeable disruption of the irrigation systems and their management. The systems and irrigation organizations developed resilience to survive through the political changes.

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