Farmer Managed Irrigation Systems of Nepal: Balancing Water Uses and Environment Conservation for Sustaining Livelihood

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Abstract

In Nepal Farmer Managed Irrigation Systems (FMISs) dominate the number and the irrigated area. They were built and managed by farmers themselves for centuries. The main objective of this paper was to analyze the factors that made these FMISs function well for so long. FMIS communities have indigenous but ultra-modern knowledge of layout, construction, management, ecology and hydrology. They have built irrigation structures in exceptionally difficult and varying geophysical environment without the aid of modern equipment. FMISs were constructed, operated and maintained for centuries with least damage and threat to environment and humanity. This study has found that perpetuation of accumulated experience, skill and the knowledge have enabled them balance water use, conserve natural ecosystem, generate employment and feed rapidly growing population, build social capital for collective action and maintain communal integrity, make best use of local resources and indigenous technology, and keep several FMISs alive. Centuries old live FMISs testify it. An in-depth study on FMISs doctrine and fine-tuning them to respond to the current challenges will benefit not only the FMISs but also the entire humanity.

Keywords: Farmer managed irrigation systems (FMISs), livelihoods, upstream, downstream.

1. Introduction

Nepal falls between the monsoon-region stretching from Japan to India (MOWR and JICA, 2000). Hence, irrigation system has

been developed to grow rice since ancient time. FMISs in Terai (plain land) of Nepal were developed even before the sixth century (Shah and Singh, 2001). FMIS covers about 70 percent of total irrigated area in the country (Shukla, et al., 1997, Pradhan, 2003) and over 89 percent of the irrigated area in hills and mountains (Parajuli, et al., 2001). There are more than 18 thousand FMISs in the country (Pradhan, 2003). They have been developed and managed by farmers themselves. Historically their explicit goal has mainly been to ensure food supply for household consumption through supplement irrigation to monsoon paddy. But rapid population growth and increased demand for cash to meet other livelihood needs has induced FMISs to adopt various measures to grow more food and earn cash. It has sustained livelihood for so long. However, the process is slow to address growing complexities and challenges. On the other hand modernization has brought several negative impacts on environment. Therefore, the concern now is to look into possibilities of marriage between modernization and traditional FMIS technology to effectively address current challenges of food and cash requirement with least or no damage to the environment.

The main objective of this paper was to analyze factors that kept thousands of FMISs function well and address challenges ahead. Hence, this study has focused on the analysis of complex relationships that sustained FMISs so long and made their environment friendly.

2. Materials and Methods

Although indigenous irrigation development technologies look simple but they were the result of trials done for centuries. The indigenous technologies that we see today are the outcome of accumulated experiences, knowledge and skills. These were carried over generations without any written documents. This paper focuses on the technologies adopted in FMISs and the factors that kept them moving for centuries with least damage to the environment and at the same time coping with challenges ahead.

This study has analyzed five livelihood assets in relation to various equities, food production, employment generation, environment conservation and water use balance among various uses and users. Five livelihood assets or capitals selected were human, natural, physical, financial and social. Economically active family members with different age and gender constituted the human capital. Similarly, water and land resources constituted the natural capital, irrigation infrastructure, road and agro-processing units constituted the physical capital, on-, off- and non-farm incomes constituted the financial capital, and socioeconomic and water allocation equities, literacy rate, access to credit and innovations constituted the social capital. Livelihood as defined by Chambers and Conway (1997) comprises capabilities, assets and activities required for means of living.

The information for this paper was mainly derived from the census survey of downstream and upstream FMIS households of Chitwan, Nepal conducted from May-December 2002. Surtani FMIS was selected to represent downstream or lowland system whereas Pampa to represent the upstream or upland system.

The frequencies, means, proportions and indices of different livelihood capitals and their variables were computed to analyse factors that kept FMISs functioning for so long and at the same time balanced water use for various uses and users and conserved ecosystem with least damage to environment. Lowland and upland systems were compared to analyze upstream-downstream relationships.

3. Results and discussion

There are as many as nine FMISs within a stretch of about 15 km in Pampa stream. All FMISs opted for indigenous weirs despite frequent damage by flash floods. Huge man, money, material and time resources are invested on the maintenance of such weirs. The upstream Pampa FMIS alone mobilized 530 labor days in 2001 and 1440 in 2002 just to rehabilitate indigenous headwork

damaged by 3-4 flash floods within two months of monsoon season in both years. Close network and trusts among users and an exceptionally high man-irrigated land ratio of 13 in both systems have made such labor intensive and arduous task continue for centuries through community participation. In addition Water Users' Association (WUA) had to use its Rs. 67,000 (1 USD = Rs. 78) cash saving and about Rs. 100,000 equivalent gabion wire grant provided by Department of Irrigation, Nepal in the later year.

Despite this all FMISs preferred for temporary diversion to keep downstream systems alive. Generally WUA appoints person/s as messenger to communicate about meeting, decision and labor mobilization among community members. Communications during natural disasters are exceptionally quick and effective. Remuneration for messenger comes from the contribution from all members of the irrigation community.

The community people have several years' accumulated knowledge and experiences about bed flow and downstream recharge through seepage and percolation from farm fields. Hence, there is at least the same or increased volume of stream flow after a few meters of diversion structure. These indigenous weirs are simple run-of-the-stream type made of locally available stone and brushwood. The species used for diversion are Baddhairo (*Legestroemia parviflora*), Banmara (*Eupatorium odoratum*), Dhursillo (*Solanum erianthum*) Lampate (*Aesculus indica*) and Sindoore (*Melotus philipinsis*). In due course few systems have replaced local materials by gabion wire but never with concrete structures. The goal of traditional weir has always been an optimization of social benefit but not the maximization of water acquisition at source.

Development and adoption of such indigenous weirs have enabled nine FMISs survive and irrigate more than 750 ha of their land at various locations. The accumulated knowledge and experiences and adoption of indigenous technology have been functional in balancing water use among communities and creating harmony and integrity within and between them. It is an excellent example of social capital formation being perpetuated for years. Local communities themselves have crafted and maintained such virtues. Paddy fields that have been mainly irrigated through FMISs were in fact water reservoirs to control flood and stabilize downstream flow. FMISs irrigation water was also been used for washing, bathing, livestock feeding, construction and in some instances drinking too.

Over the time FMISs have developed strong communal ownership on water resources and it has been strengthened by usufruct right as has been defined in Water Resource Act and Regulation of Nepal (MOLJPA/HMGN, 2001). Litigation on water acquisition at source between Pampa and Chipletee FMISs reached upto the Supreme Court. This is a measure for the degree of community ownership on water resource.

In spite of these FMISs are often criticized for overuse of irrigation water especially for paddy that is 6.3 lps (liters per second) per ha against the standard 1.5-3.0 lps/ha (Halcrow, et al., 1997, Parajuli et al., 2001). But it has been useful in recharging downstream flow and controlling floods as described above. Use of shrubs and branches in headwork construction has also been perceived damaging the environment. PRA with the community people revealed the fact that such use enhances coppicing as being pruned. Hence, such use is not necessarily damaging and is least harmful as compared to free grazing of livestock, forest clearing for cultivation and gathering wood, fuelwood and herbs from the forest. Downstream flow resulting from the adoption of indigenous headwork has preserved aquatic species particularly the fish. Hence, some households were able to continue fishing in downstream Pampa.

Crop diversification was high in both systems and both were growing as many as 14 different types of crops in one crop year. Their choice of particular crop was dictated by water adequacy and

farm households' access to support services specially the market and market information. Hence, upstream farm households were found growing water-economizing crops during dry seasons and none grew paddy in spring season. On the other hand, more than 93 percent downstream (a water adequate system) farm households were growing spring paddy. It is the reflection of higher natural capital index (0.91) particularly higher water index (0.95) as indicated in livelihood asset pentagon (Figure 1).

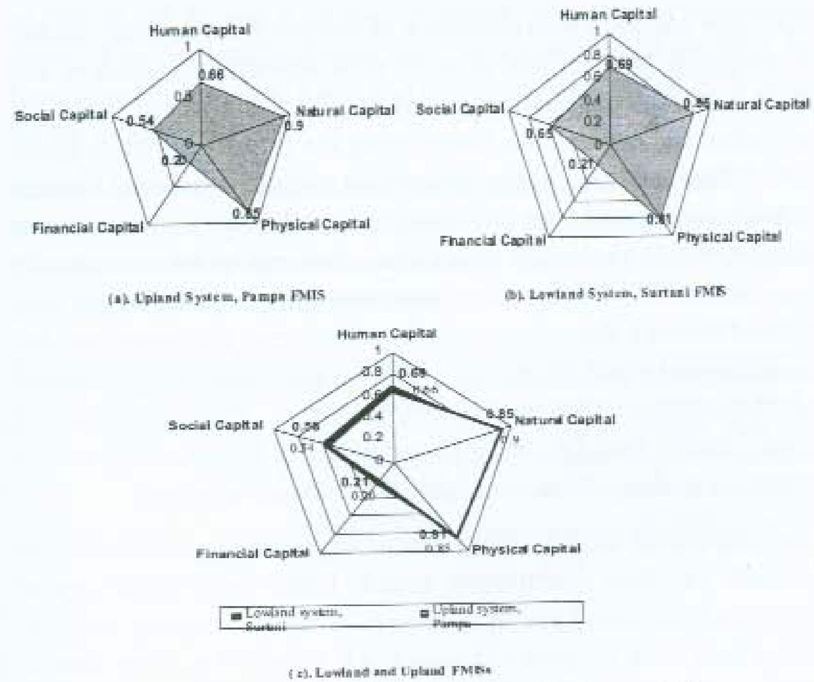

Figure 1. Livelihood capitals and their variable.

Cropping intensities in head, middle and tail portions were computed at 288, 284 and 284 percent for downstream and 265, 274 and 264 percent for upstream FMISs. The differences in CIs in head, middle and tail locations of irrigation systems were not significant in both FMISs (p=0.05). It implies that irrigation water was equitably distributed in all the locations of irrigation systems. Relatively upstream irrigation system faces water scarcity during winter and spring seasons mainly due to temporary diversion constructed from gabion wire and brushwood and observably higher seepage and percolation losses from cultivated lands owing to its location in an elevated peninsula. Some portions of cultivated lands have sandy soil as well. Hence, Water Users' Association (WUA) in upstream FMIS has made an additional day of irrigation arrangement for the third group farms located in the middle part of the system.

Equitable and judicious allocation of irrigation water in all reaches of irrigation system has created trust towards the system and among users. This has integrated people and ensured their participation to keep system functioning for centuries. Non-significant difference in cropping intensities and yields in head, middle and tail portions of both FMISs as obtained from analysis of variance (ANOVA) indicates water allocation equity. Democratically constituted WUA dynamism has made this possible. WUAs are formed through democratic process. Problems and issues are discussed openly and decisions are generally made by consensus. All decisions and accounts are transparent. This has enhanced trusts, mutual benefits and a strong network between and among members making all accountable for collective action.

Fairly equitable land distribution among farm households in both systems has kept community intact. Land distribution among large, medium, small and land-less (cultivating on rented-in lands) in lowland farm households was 3, 43, 50 and 4 percent with an average farm size of 3.75, 1.04, 0.25 and 0.11 ha respectively. Such distribution was 1, 47, 52 and 0 percent with an average farm size of 2.00, 0.82 and 0.28 in lowland system. The proportion of large and land-less was very low as compared to small and medium. Difference between small and medium was also very less.

Despite traditional irrigation infrastructure development technology both systems produced surplus cereal, which is their staple

food. Average annual household cash earning from the trading of such surplus was Rs. 47,841 in downstream and Rs. 34,592 in upstream systems. Downstream system produced net consumable (after deducting seed, post harvest losses and recovery percentage) 157.65, 16.10 and 8.85 tons of cereal, pulse, and oilseed against annual requirement of 84.32, 9.29 and 3.37 ton respectively (Table 1). Similarly upstream system produced net consumable 213.9, 5.74 and 17.05 tons against annual requirement of 107.32, 11.82 and 4.29 tons of above crop categories respectively. The food requirement was computed based on PRA on farm households' food habit and daily requirement of 2550 calorie for average people.

Table 1. Average annual food production, market and energy value of productions from one ha of land and food production from the entire system of downstream (Surtani) and upstream (Pampa) systems.

Food items	Downstream system (n = 76)				Upstream system (n =110)			
	Food production, ton	Market value of production, Rs.	Energy value of production, 10^6 Kcal	System food producion (35.3 ha), ton*	Food production, ton	Market value of production, Rs.	Energy value of production, 10^6 Kcal	System food production (52.5), ton*
Cereal	7.95	62378	2740	279.93	6.30	50376	2163	300.46
Pulse	0.54	12062	186	18.96	0.11	4235	36	8.03
Vegetable & potato	0.24	883	11	11.42	0.55	3256	50	22.60
Oilseed	0.01	28	6	15.08	0.01	105	2	2.06
Total	8.74	75351	2943	325.39	7.97	57973	2251	333.15

* Based on average yield rate and corresponding cropped area.

Both systems were employing large number of human and animal labors (Table 2). Family labor contributed more than 70 percent of total human labor employed in both systems for all categories of labor disaggregated by gender and age viz. adult male and female and child labor. The rest was contributed by hired labor. Female, male and child labors stand in their hierarchical order of employment in both systems. Only downstream system used contract labor for sowing/transplanting and harvesting. Good road network in downstream system facilitated seasonal flow of contract labors from neighboring districts. Tractors and threshers were for land preparation and threshing. Use of machine has substituted as much as 103 (27%) labor in downstream and 88 (21%) in upstream systems. This has provided very good opportunity for off- and non-farm employment to farm family members. Overall labor employment (including labor equivalent of contract work and machine costs) per year in one ha of land was 388 in downstream and 395 in upstream system. It meant upstream generated more employment than downstream system.

Table 2. Employment in one hectare of land in downstream (Surtani) and upstream (Pampa) systems.

Labor types	Downstream system (n = 76), No./ha/year	Upstream system (n = 110), No./ha/year
1. Male:		
Total	56	86
Hired	13 (23)	26 (30)
Family	43 (77)	60 (70)
2. Female:		
Total	175	219
Hired	44 (25)	43 (20)
Family	131 (75)	176 (80)
3. Child:		
Total	13	2
Hired	1 (8)	0.7 (35)
Family	12 (92)	1.3 (65)
4. Total human	244	307
5. Animal*:		
Total	1	8
Hired	0.8 (80)	4 (50)
Family	0.2 (20)	4 (50)
6. LE	144	88
7. LS	103	88
8. Overall LE	388	395

** Bullock pair with a human labor.*

Figures in parentheses are percent of total.
LE = Labor equivalent of contract work and machinery costs,
LS = Labor substitution by machine.

Both irrigation systems are vulnerable to financial, social and human capital shocks owing to lower access to or endowments of these capitals in the study FMISs. Higher food security was associated with higher natural and physical resource endowments as indicated in asset pentagon. Similarly, moderate to slightly high human capital index in asset pentagon was related to higher level of employment.

4. Conclusion

The study shows that several FMISs virtues have made them sustainable since time immemorial with minimum damage to natural environment and at the same time meeting growing demand for food and employment. Some important virtues were accumulated experiences, knowledge and skills on ecology, hydrology and layout, construction, operation and maintenance of irrigation system. In addition, democratic and transparent decision making, socioeconomic and water allocation equities and strong communication mechanism were some of the foundations for social capital building. These have enhanced the development of trusts, mutual benefits and networking among uses and users. These virtues have enabled FMISs to amass collective action at all time and levels and sustain for centuries.

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