Performance Evaluation of Selected Farmer-Managed Irrigation Systems in Nepal

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ABSTRACT

ABOUT TWO-THIRDS OF the total area irrigated in Nepal are presently under farmer management. While some farmer-managed irrigation systems (FMIS) are managed well with intensive cultivation, others are operating below the production level they could achieve with their available water and land resources. This study attempts to objectively measure and evaluate the performance of selected FMIS supported by the Agricultural Development Bank of Nepal using selective output and impact performance indicators. Both intensive and extensive methods of data collection were used to generate necessary information. Technical performance indicators such as relative water supply and water availability index (WAI) suggest that the farmer groups have learned to balance the total irrigated area in the wet season with overall water conditions, and that there is no discrimination between head- and tail-end parts of the system. However, there is a big difference in WAI between plots. This suggests some room for improvement in water distribution among neighbors. Economic analyses show that there is a great payoff to society in investing in FMIS and that they are financially attractive to farmers. Our analysis also shows a high inducement effect of public funds in local capital formation and farmers' participation in such projects.

INTRODUCTION

Farmers in Nepal have constructed and managed irrigation systems for centuries. It is estimated that about 67 percent of the total irrigated area in the country is presently under farmer management and at least 45 percent of the population's subsistence cereal requirement is being met by the increase in food production made possible by irrigation from farmer-managed systems (IIMI 1990). The FMIS in Nepal vary in size from less than 10 ha to as large as 15,000 ha. Most FMIS are simple run-of-the-river diversions with temporary headworks and are mainly used for supplementary irrigation of rice during the monsoon.

Some FMIS are well-managed with intensive cultivation of three crops a year giving an annual production in the range of 7.5 to 9 tons per ha (Yoder 1986). Others are operating far below the production level they could achieve with their available water and land resources (Pant 1985; Tiwari 1986; Hydro-Engineering Services 1987). This study attempts to measure objectively and

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to evaluate the performance of selected FMIS supported by the Agricultural Development Bank of Nepal (ADB/N) using selective output and impact performance indicators. Given the important role that FMIS can play in meeting national food production goals and the significant contribution made by ADB/N in assisting FMIS in recent years, it is important to evaluate the performance of ADB/N supported FMIS with a view to identifying the areas for further improvement.

METHODOLOGY

Intensive and extensive data collection methods were applied to attain the study objectives of obtaining in-depth data and wide coverage. The intensive and extensive methods, or rapid appraisal data collection techniques, were applied to generate the information necessary for technical and economic performance evaluation respectively. The selection of sample systems was made purposively considering representativeness in terms of region, degree of project success, accessibility to the systems and availability of secondary data.

Six surface schemes, three each from the hills and Terai (lowland plains) were selected for technical performance assessment. A set of measures of technical performance was given by the total water discharged to the system command area during the rice cultivation season, and water requirements.

The amount of water discharged was measured daily at the head of the command area using simple measuring devices. Using irrigation delivery information and data on rainfall, evapotranspiration (ET) and seepage and percolation (S&P), overall water adequacy for the irrigated area was assessed by computing relative water supply (RWS). If daily rainfall was less than 15 mm it was assumed that the irrigation was fully effective; for additional rainfall between 15 and 50 mm per day it was assumed 80 percent effective and with rainfall above 50 mm per day was only 50 percent effective. ET was assumed to be 5.5 mm per day for all schemes and average S&P was estimated for each scheme.

Another measure of technical performance was made through daily observation of the soil moisture status of geographically dispersed field plots in each system to determine the uniformity of water distribution. These plots were selected after the rice crop was transplanted. Instead of a random selection of sample plots several branches of the main canal that gave a reasonable distribution from head to tail were chosen. The number of sample plots selected varied from 30 to 58 among schemes. Four degrees of water availability were specified with regard to the adequacy of water at the individual plot level: standing water, water in footprints, moist but no visible water, and dry and cracking soil. On the basis of the condition observed, a water availability index was computed for each plot using a simple system of weighing to indicate the degree to which a plot had more or less water available during the period 20 and 70 days preceding the harvest as this period was considered to be the critical, water sensitive phase of the rice varieties grown in the scheme areas. To calculate the index, the number of days in the first category (standing water) were weighted quadruple and added to the number of days in the second category weighted triple plus the number of days in the third category weighted double plus the number of days in the last category (dry and cracking). An inter-quartile ratio was also computed to assess the equality of water distribution.

Economic performance of irrigation projects was assessed on the basis of two criteria: rates of return to the investments and effectiveness in mobilizing local resources for productive capital formation. Rates of return to the investment were estimated at two levels: to the society or economy and to the farmers. The first measure enables us to judge whether the bank-assisted projects are economically viable as compared to other public investment opportunities. The second estimate measures private rates of return to the farmer beneficiaries, which is a critical indicator to represent the farmers' loan repayment ability.

The bulk of data for most of the economic analyses was collected in the field through rapid appraisal surveys. Beneficiary farmers were the primary source of data. In each site, five to ten farmers were interviewed with the help of checklists and questionnaires. Farmers were selected randomly from various reaches of the command area.

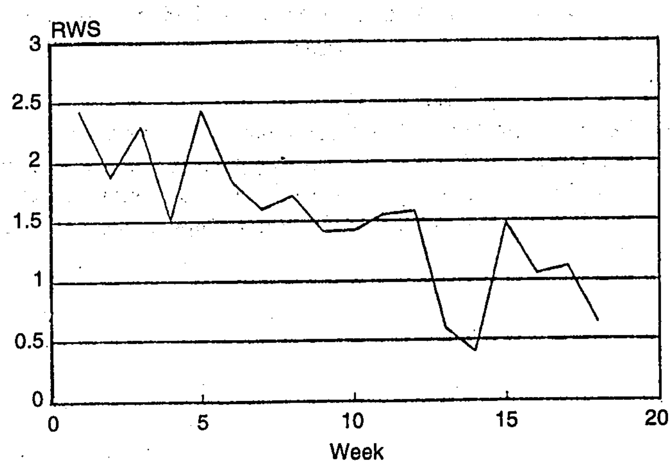
RESULTS AND ANALYSIS

Technical Performance Assessment

Overall water supply and response to rainfall. The six systems, three each in the hills and the Terai had different patterns of water supply in the main canal. This was due to different hydrological characteristics of the river source and due to the nature of diversion structures and the intake.

In the largest Terai System, Parwanipur (218 ha), the weekly Relative Water Supply (RWS) was more than 1.0 for the first half of the observation period suggesting that at system level there was no serious water shortage (Figure 1). While the RWS appeared to decline in the latter part, this was probably not critical to crop because some of the area had been harvested so that the actual demand for water was declining. In this system the river has a much larger discharge than required for the system itself, and due to the provision of head regulator gate, farmers only extract sufficient water to meet their requirements. This suggests that the farmers have adjusted their command area well to the total river water supplies, supplementing any deficits during periods of rainfall. Yet,

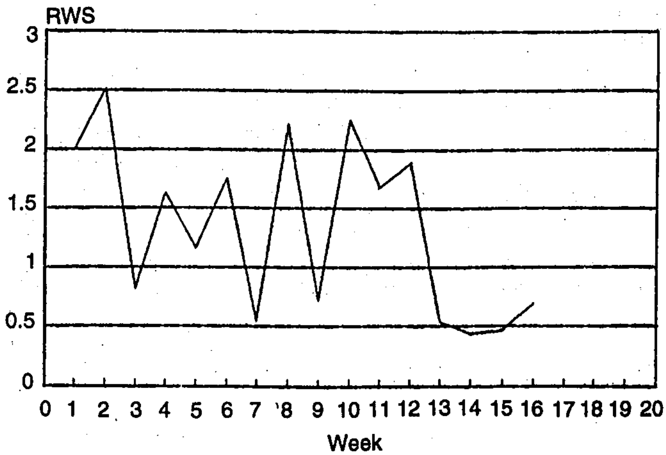
Figure 1. Weekly RWS of Parwanipur Irrigation Scheme.



the scheme does not irrigate the potential command area (266 ha) due to the absence of a canal network. Farmers are in the process of converting the remaining upland into a rice field. RWS results show that there will be a sufficient supply of water to irrigate the potential command area for monsoon rice.

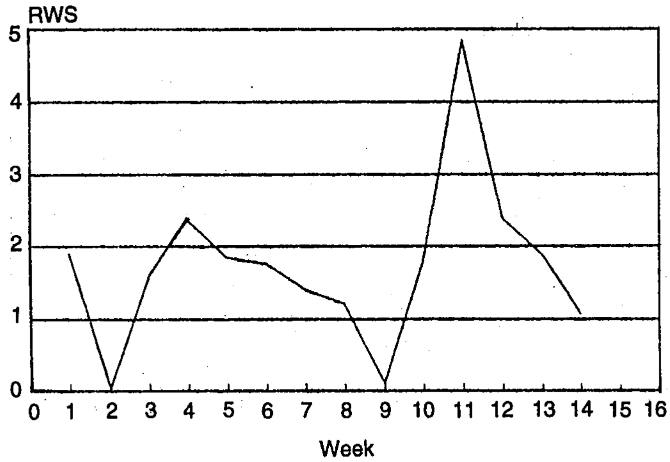
In the Laxmipur System, (134 ha), RWS results showed that water supplies in the main canal were not stable (Figure 2). Rainfall data show that when there is little rainfall, the river level drops quickly and farmers may face shortages of both canal water and rainfall. As a result of this hydrological pattern, there was considerable daily variation in RWS but when averaged on a weekly basis the RWS was normally greater than 1.0. However, because there were weeks in which RWS was less than 1.0 there may have been periods when there was an overall water shortage. It is therefore likely that farmers in this system will need to be a bit conservative in determining the area to be irrigated because if rainfall is less than average, there may be an overall shortage of water supplies which will affect crop production badly.

Figure 2. Weekly RWS of Laxmipur Irrigation Scheme.



In the smallest Terai system, Tulsi (70 ha), the situation was more complex. RWS was not very stable: with rainfall, weekly RWS was extremely variable (Figure 3). Except for two weeks (2nd and 9th) weekly RWS was always higher than 1.2. The fluctuation in water discharge was due to variations in river discharge by localized rainfall in the upper catchment of the river.

Figure 3. Weekly RWS of Tulsi Irrigation Scheme.



In the hill systems of Bandarpa and Jamune, the weekly RWS including rainfall was less than 1.0 throughout the season (Figures 4 and 5). This was mainly because of high seepage losses from the main canal and poor intake conditions. Furthermore, in these systems farmers do not feel the need to tap water from the main river source to irrigate their fields because springs which originate in different locations of the schemes supply the necessary water.

Figure 4. Weekly RWS of Bandarpa Irrigation Scheme.

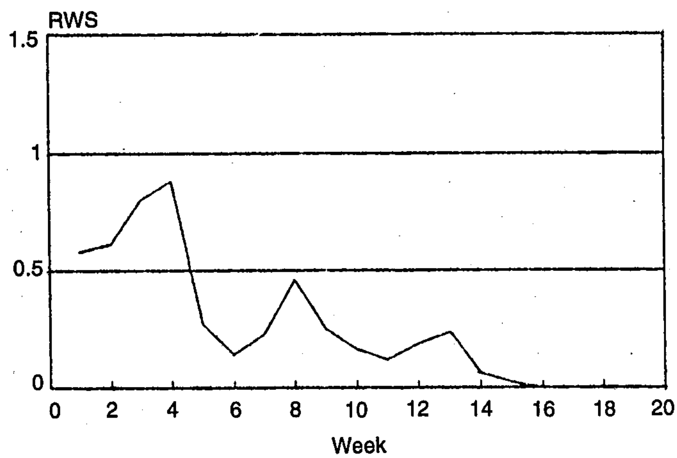
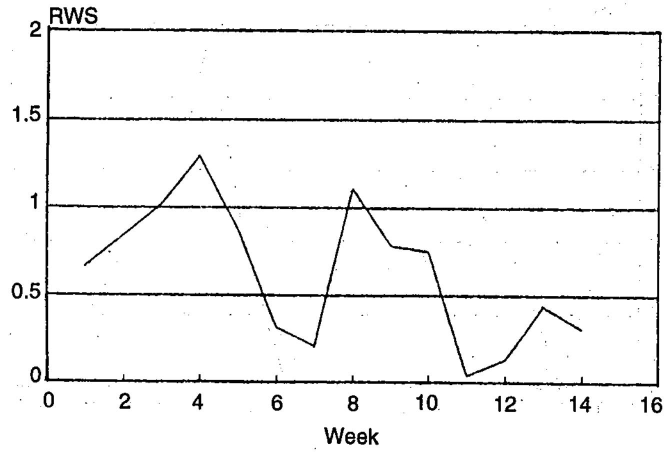
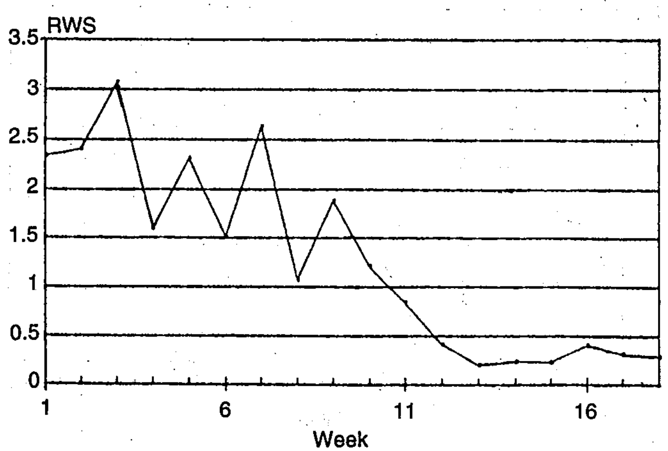


Figure 5. Weekly RWS of Jamune Irrigation Scheme.



In the third hill system of Baretar, the weekly RWS was quite high in the initial phase, with more variation in the early days of observation (Figure 6). After the 11th week RWS declines, but farmers do not need much water during this period because rice is in the harvesting phase. The RWS is high in this scheme because the river has a high discharge and the intake of the scheme, though not permanent, draws water naturally without much effort on the part of the farmers. The presence of essential structures and lined canals in most of the critical parts also allows for a reliable supply.

Figure 6. Weekly RWS of Baretar Irrigation Scheme.



For all six systems, it is clear that active management is applied by the farmer groups, and there is no evidence of excess water use at system level. In most cases the RWS was normally within the range of 1.0 to 2.0, or a system-level efficiency of between 50 and 100 percent. This is quite high for the wet season when there is normally plenty of rainfall in addition to the river supplies, and shows that the total area planted has been well-adjusted to the likely overall water pattern received in each system.

Water distribution within each system. The second measure used to assess the performance of the farmer groups in managing the available water supply is the extent to which water is equally distributed throughout the system.

In all six systems there was very little evidence of a marked difference in Water Availability Index (WAI) between the head and the tail of the system. Using the Interquartile Ratio (IQR, or the ratio between the 25% of fields nearest the head of the system and the 25% furthest from the head), the data show almost no such differences. In the case of Terai schemes, the IQR are 1.14 at Parwanipur, 1.15 at Laximpur and 1.03 at Tulsi, while IQR of the Hill schemes are 1.06 at Baretar, 0.87 at Bandarpa and 1.19 at Jamune (Table 1). These values are so close to 1.0 that there is no significant difference in water availability between the head and the tail parts of the system.

Table 1. Inter-quartile Ratio of Water Availability Index between head and tail portions of the schemes

	Terai			Hill		
	Parwanipur	Laxmipur	Tulsi	Bandarpa	Jamune	Baretar
Average	144	179	146	146	144	161
WAI Top 25% (at head)	154	186	153	134	168	160
WAI Lowest 25% (at tail)	135	162	149	154	141	151
IQR	1.14	1.15	1.03	0.87	1.19	1.06
Equality	Good	Good	Good	Fair	Fair	Very high

However, in all six systems there was considerable variability in the individual values of the WAI, with quite large differences between neighboring plots. The variation does not appear to be related to the values of seepage and percolation measured in the field. The IQR based on the highest and lowest 25 percent of sample plots independent of distance shows much larger values than those based on distance: 1.4 for Parwanipur, 1.26 for Laxmipur and 1.17 for Tulsi (Terai schemes), and in case of hill schemes 1.57 for Baretar and 1.36 at both Bandarpa and Jamune (Table 2). In comparison to other systems these values are not excessively large, except for Parwanipur and Baretar, but it is not uncommon to find such variations in larger systems (Parwanipur) because the cohesion of farmer groups is somewhat less when there are many members. No doubt, WAI may vary widely by soil type, land preparation and management practices of the individual plots even though an equal amount of water is delivered. In case of Baretar, equality in WAI may be because there are two distinct types of land: upland rice terraces and lowlying rice fields.

Table 2. Inter-quartile Ratio (IQR) of Water Availability Index (WAI) in schemes selected for intensive study (without considering distance).

	Terai			Hill		
	Parwanipur	Laxmipur	Tulsi	Bandarpa	Jamune	Baretar
WAI Top 25%	170	199	162	173	177	195
WAI Lowest 25%	120	158	138	127	130	124
IQR	1.40	1.26	1.17	1.36	1.36	1.57
Equality	Fair	High	V.high	Fair	Fair	Poor

Overall, it is clear that water distribution within each system is above average. Based on the present data it is difficult to determine the real cause of local variations in WAI. There are certain other factors which may influence the WAI such as soil depth and its type, land preparation and management practice, seepage and percolation, maintenance of bunds and the presence of rat holes in particular fields and water-sharing practices between farmers in adjacent plots.

Economic Performance Assessment

Cropping intensity and yields. On average, cropping intensity increased by 35 percentage points in the hills and by 41 percentage points in the Terai following irrigation development. In most cases, this increase in cropping intensity was realized due to an increase in acreage under winter crops, particularly wheat. In addition, significant changes have taken place in cropping patterns. In the hills, rice-based cropping patterns have replaced maize-based ones. In the Terai, mustard has been substituted by wheat in most schemes. Another important change in cropping patterns has been the introduction of high value crops such as vegetables.

Irrigation development has also led to significant gains in yields of major crops. Average rice yields have increased by about 56 percent in hill schemes and by about 37 percent in Terai schemes. As expected, yield gains have been higher in wheat than in rice both in the hills and the Terai. In hill schemes, average wheat yields increased by about 84 percent after irrigation development whereas the increase in the Terai was about 71 percent.

Economic and financial rates of return. Discounted measures of project returns, i.e., the benefit-cost ratio (BCR) and internal rate of return (IRR) were computed for 13 surface schemes. The estimated indicators of economic and financial returns are summarized in Table 3. Only one hill scheme had a BCR of less than one and ten schemes had economic internal rates of return (EIRR) in excess of 25 percent. These results show that most sample projects generated positive returns to the economy well in excess of the opportunity cost of capital.

Table 3 also shows two sets of results on financial rates of return. The first set presents results assuming that there is no subsidy and farmers incur 100 percent of the construction costs and the second set shows results when only farmers' costs are included in the construction cost, i.e., when subsidy is excluded from costs since this is not a cost to the farmers. Even when we assume that the farmers have to bear the entire costs of construction, on average both hill and Terai surface schemes are financially attractive to farmers. An average hill scheme was found to have a BCR of 1.33 whereas an average Terai scheme had a BCR of 2.24. However, two hill schemes out of a total of eight had a BCR of less than one and three had financial rates of return (FIRR) lower than 25 percent (the prevailing interest rate in the informal sector). All five Terai schemes had a BCR of more than one and four had FIRR of more than 25 percent. The results improve when only the farmers' costs are included in the construction cost. In this case, only one hill scheme had a BCR of less than one. In the computation of financial rates of returns the opportunity cost of labor was assumed to be 50 percent of the market wage rate. This estimate of the opportunity cost of labor approximates the average of estimates made by earlier studies, which reported the lean season wage rates to vary between 48 and 62 percent of the peak season wage rates (IDS 1989; MacDonald and East Consult 1990).

Rates of return to the government. The rates of returns to society from the investment of scarce government capital funds (direct subsidies plus subsidies in the form of concessions on interest rates for loan) are shown in Table 4 in terms of BCR and IRR. The average IRR both for hill and Terai schemes are well over 100 percent indicating very high rates of return to government investment (in the form of subsidies) in ADB/N supported irrigation schemes. The BCR is also equally encouraging. These results confirm the cost-effectiveness of investments made by the government in these types of irrigation projects.

Table 3. Economic and Financial Rates of Return to Investment in farmer-managed surface schemes.

Irrigation schemes	Economic rates of return		Financial rates of return			
			Assuming no subsidy		Assuming subsidy	
	BCR	IRR (%)	BCR	IRR (%)	BCR	IRR (%)
Hill schemes						
Bhalutar	0.83	5.7	0.53	-2.3	0.75	4.8
Baretar	1.21	18.9	0.95	13.5	1.30	24.7
Bepariraha	1.51	32.7	1.40	26.4	1.66	38.2
Thulochaur	1.78	84.7	1.68	43.3	2.06	79.0
Bandarpa	1.68	45.5	1.63	35.2	1.92	50.4
Jamune	1.22	24.8	1.09	18.4	1.41	33.2
Balthali	2.36	83.3	1.96	50.4	2.11	59.7
Barhakol	2.17	69.8	1.43	29.1	1.82	46.3
	1.60	45.7	1.33	26.8	1.63	42.0
Terai schemes						
Parwanipur	2.15	77.8	2.98	97.7	3.50	187.2
Laxmipur	2.19	171.4	3.55	148.9	4.03	279.0
Kumroj-2	1.58	30.9	1.50	24.6	1.98	34.2
Balimkhola	1.89	50.0	1.95	43.7	2.50	70.5
Kanjawar	1.38	27.4	1.23	22.9	1.69	45.2
Average: Terai	1.84	71.5	2.24	67.6	2.74	123.2
Overall Average	1.69	55.6	1.79	47.2	2.19	82.6

Investment and participation inducement coefficients. Table 4 also shows investment and participation inducement coefficients for selected surface schemes. The average estimated investment inducement coefficients (IIC) was 2.54 in the hills and 1.98 in the Terai. This implies that one rupee of public funds (capital subsidy, interest subsidy and technical assistance) generated Rs.2.54 worth of capital in the hills and Rs.1.98 in the Terai. These results, on the whole, indicate a fairly high inducement effect of public funds in local capital formation. These estimates are comparable to those reported for community irrigation projects in the Philippines (Kikuchi et al. 1977).

The participation inducement coefficient (PIC), on the other hand, measures the total contribution of the farmers in erecting the project per rupee of public funds. The average PICs for the hill and Terai schemes were 1.27 and 0.76, respectively, indicating that one rupee of public funds induced farmers to contribute Rs. 1.27 and Rs. 0.76 in the hills and Terai, respectively. On an average, farmers' contribution per unit of public funds is higher in the hills. On the whole, these results show encouraging inducement effects of public assistance towards farmers' participation in the project.

Table 4. Rates of Return to the government and Investment and Participation Inducement Coefficients in farmer-managed surface schemes.

Irrigation scheme	Rates of return to the government		Investment Coefficient	Participation Inducement Coefficient
	BCR	IRR (%)		
Hill schemes				
Bhalutar	2.57	33.8	1.77	0.52
Baretar	4.54	51.9	2.28	1.06
Bepariraha	11.54	122.5	3.70	2.27
Thulochaur	17.03	252.0	1.55	0.47
Bandarpa	16.19	168.2	3.72	2.41
Jamune	7.71	110.2	1.98	0.78
Balthali	26.67	201.6	3.76	2.55
Barhakol	13.08	138.7	1.58	0.11
Average: Hills	12.42	134.9	2.54	1.27
Terai schemes				
Parwanipur	27.48	18.18	2.91	1.77
Laxmipur	40.07	458.1	1.63	0.39
Kumroj-2	10.12	61.2	1.69	0.40
Balimkhola	10.76	110.1	1.80	0.48
Kanjawar	6.90	78.9	1.89	0.77
Average: Terai	19.07	178.0	1.98	0.76
Overall average	15.75	156.5	2.3	1.07

CONCLUDING REMARKS

The overall impression from these analyses is that, in terms of water distribution, farmers do a generally good job. There is little or no difference in average water conditions between head and tail. All of these indicators suggest that the farmer groups have indeed learned to balance the total irrigated area in the wet season with overall water conditions, and that there is no discrimination between head- and tail-end parts of the system.

This does not mean that there is not some room for improvement in water distribution between farmers of adjacent plots. In all six systems there are big differences in WAI between plots. In terms of overall equality, Tulsi is the best, because the average WAI is about 146, with no farmer recording above 175 or below 125. At Parwanipur the range is a little greater, but still there are no farmers with the maximum score of 200. At Laxmipur, however, several fields had standing water for the entire observation period, while other farmers got WAI values as low as 130. In case of hill schemes, Bandarpa and Jamune equality was fair with average WAI of 146 and 144, respectively. At Baretar, water distribution was not equitable as WAI varied between 101 and 200. This suggests some room for improvement in water distribution among neighbors.

Although performance is not as high as it could be, the data suggest that performance is probably better than would be found in larger systems in the Terai both in terms of the system-level management and in terms of sharing water among farmers. This is probably because the farmers are fully in control of their own water supply. If this is true, then it is likely that moves towards joint management which also guarantee more reliable water supplies at the head of each subsection of larger systems will result in more opportunities for farmer groups to develop equitable ways of distributing water among themselves.

The economic analysis shows that there is a great payoff to society from investing in surface schemes. The EIRR is substantially greater than the assumed cost of funds. This result makes a strong case for further expansion of investment in FMIS. At the current level of subsidy, these schemes are financially attractive to farmers. In fact, results of financial analyses show that the current rate of subsidy is essential for the hills, whereas a lower rate may suffice for the Terai schemes. Our analysis also shows a high inducement effect of public funds in local capital formation and farmers' participation in such projects.

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