Socioeconomic and Institutional Issues in Irrigation Management for Rice-Based Farming Systems in Bangladesh

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INTRODUCTION

ALTHOUGH IN BANGLADESH the share of agriculture in the Gross Domestic Product (GNP) has been declining over the years, it still remains the largest sector of the economy (Table 1). This sector produces nearly 38 percent of the country's output and provides direct employment to three-fifths of its labor force. In order to realize the economic and social goals of achieving self-sufficiency in food grains, ensuring the supply of raw materials for the growing industrial sector, and generating employment and income for the burgeoning rural production, the rate of growth of the agricultural sector must be accelerated.

Any acceleration of the growth of agriculture in Bangladesh, however, is critically dependent on irrigation development which has great potential in the country. Actual area irrigated by different methods in 1987-88 was found to be 2.35 M ha or about 26 percent of cultivable area and about 35 percent of potentially irrigable land (Table 2). Irrigated area can be increased by both investing in new projects and improving the efficiency of the existing imgation systems. Since investment in new irrigation projects has become more expensive as a result of increasing capital costs per hectare, the government as well as the donor agencies are now putting greater emphasis on enhancing the performance of existing systems through improved irrigation management.

Table 1. Sectoral shares of the GDP (percent) at constant (1984-85) prices

	1985-86	1986-87	1987-88	1988-89
Agriculture	41.4	39.9	38.5	37.6
Crops	32.9	31.6	30.2	29.4
Forestry	2.7	2.5	2.5	2.5
Livestock	2.9	2.9	2.9	2.9
Fisheries	2.9	2.9	2.9	2.8
Mining and quarrying	0.001	0.001	0.001	0.001
Manufacturing	9.7	10.1	9.8	9.9
Large scale	5.2	5.7	5.5	5.5
Small scale	4.5	4.4	4.3	4.3
Construction	5.4	5.5	6.1	6.3
Power, gas, water and sanitary services	0.6	0.7	0.8	1.0
Transport, storage and communication	11.1	11.9	12.0	12.3
Trade services	9.1	9.0	89	8.7
Housing services	7.9	7.8	7.9	7.9
Public administration and defense	3.8	39	4.1	4.0
Banking and insurance	2.1	2.1	2.0	2.1
Professional and miscellaneous services	8.9	9.1	9.9	10.2
GDP at market prices	100.0	100.0	100.00	100.0

Source; Statistical Pocket Bwk of Bangladesh. Bangladesh Bureau of Statistics (BBS) 1990.

Table 2. *Total area* irrigated *by different* methods in Bangladesh in *1987-88*.

Methods	Actual area ha ('00000)	Irrigated percent
A. Surface water irrigation		
i. Gravity flow	1.15	4.90
ii. LLP	5.27	22.44
iii. Traditional methods	238	10.13
Subtotal	8.80	37.47
B. Groundwater irrigation		
i. STW	8.70	37.03
ii. DTW	5.55	23.63
iii. HTW	0.44	1.87
Subtotal	14.69	62.53
Total	23.49	100.00

LLP = Law lift pump.
STW = Shallow tubewell.
DTW = Deep tubewell.
HTW = Hand tubewell.

Sources: Planning Commission, Government of Bangladesh, 1990 Draft, Fourth - Five Year Plan, Dhaka.

Irrigation management can be defined as "the process in which institutions or individuals set objectives for irrigation systems, establish appropriate conditions, and identify, mobilize and use resources to attain these objectives — while ensuring these activities are performed without adverse effects (IIMI 1989). Objectives often adopted in the irrigation management process include (Uphoff 1986):

1. Greater production or productivity in terms of crop yield, area cultivated and/or cropping intensity;

2. Improved water distribution in terms of greater reliability, predictability and equity;

3. Reductions in conflict among water users and with government agencies;

4. Greater resource mobilization — both material and human;

5. Sustained system performance.

The realization of the above objectives depends, in large part, on a number of socioeconomic factors and issues. This paper aims at identifying some of these factors as they relate to the performance of irrigation system management in Bangladesh. It is based primarily on the findings of studies (Hakim et al. 1990a, b, c, d, e and Islam 1990) conducted under the IIMI-IRRI Project on Irrigation Management for Rice-Based Farming Systems. These studies were conducted in the north and northwest of Bangladesh and covered both gravity and groundwater irrigation (deep tubewell) systems. The gravity irrigation system studied is the Ganges-Kobadak (G-K) System — the largest irrigation system in the country and located in Kushtia District. The deep tubewell (DTW) irrigation systems include the North Bangladesh Tubewell Project (NBTP) in Thakurgaon; Bangladesh Agricultural Development Corporation (BADC) DTWs under direct and rental management (in the Rajshahi area); and private DTWs located also in Rajshahi District (Table 3).

Table 3. Location, ownership and mangement patterns of irrigation systems included in the study.

System and location	Ownership	Management
BADC Rental DTWs *with* RAKUB participation. Rajshahi	Public, BADC	Private. Farmer group
BADC Rental DTWs *without* RAKUE participation, Rajshahi	Public, BADC	Private. Farmer group
BADC, BIADP DTWs, Rajshahi	Public, BADC	Public, BADC + Private, Farmer group
Private DTWs. Rajshahi	Private (Farmers)	Private (Farmers)
G-K, Kushtia	Public. BWBD	Public. BWBD
NBTP, Thakurgaon	Public, BWBD	Public, BWBD

BADC = Bangladesh Agricultural Development Corporation
DTWs = Deep Tubewells.
RAKUB = Rajshahi Krishi Unnayan (Agricultural Development) Bank.
BIADP = Barind Integrated Area Development Project.
G-K = The Ganges-Kobadak. It is the largest gravity irrigation system in the country.
BWBD = Bangladesh Water Development Board.
NBTP = North Bangladesh Tubewell Project.

In addition to a number of cross-site issues, the studies included the results of two experiments, one dealing with water rotation in the G-K Irrigation System and the other on a method to increase irrigation coverage in the North Bangladesh Tubewell Project. The data utilized in all of the studies were collected through personal interviews with farmers, fanner leaders and agency managers using structured questionnaires, informal discussions and participant observation methods.

SOCIOECONOMIC FACTORS AFFECTING IRRIGATION MANAGEMENT

Mobilization of Internal Resources — The Irrigation Service Fee

In Bangladesh, it is the stated government intention to recover the entire Operation and Management (O&M) costs and as much of the capital costs as possible from irrigation systems developed and owned by the government. The underlying objective is to ease budgetary pressures and release funds for investment to create additional irrigation facilities and to undertake other development projects. In pursuance of this policy, the government has not been providing enough money out of its general budget to meet the O&M costs and, wherever possible, to realize capital costs from the beneficiaries. The present irrigation fee of some of the public systems, however, is much too low to cover O&M costs. **As** can be seen from Table **4**, in the G-K and NBT systems, irrigation fees cover only **16** and **6.5** percent, respectively, of O&M costs. **As** a result, these systems have been suffering from operational and maintenance problems **(Ali** 1989 and Hakim et al. 1990a). If one 'looks at O&M costs as a proportion of incremental benefits due to irrigation there would appear to be little economic justification for fixing irrigation **fees** at the low levels used in these two projects (Table **5). As** users of rental and private tubewells (systems that cover most irrigators in Bangladesh) pay fees and charges at least covering their full O&M costs, there seem to be few equity or social justice reasons for keeping the fees so low on a few public systems.

In addition to low fee rates, the collection efficiency of the fees is very low in these two public systems. While the collection efficiency in private and rental systems under study varies from 79 to 98 percent, it is only **1.13** percent in G-K and **23.55** percent in the NBT System (Table 6). The relatively high collection efficiency in the other systems can be explained by three major factors. First, sanctions against non-payment are strong and effective. If a farmer does not pay his fee in a particular season, water supply to his field is stopped in that season and he is denied water in the following year. Second, the incentive for collection is very strong. If the fee is not collected, the tubewell managers lose their formal and informal pecuniary benefits. Formal benefit is their honorarium and informal benefit is the excess of irrigation fees over O&M costs. Furthermore, if fees are not collected they cannot continue irrigation because they are totally dependent on irrigation fees in order to operate the system. Discontinuation will deprive them of the direct benefits of irrigation. Third, in one system (private), the fee is collected partly in kind.

Table **4.** ***Irrigation fee and O&M costs in* irrigation *systems* under *study* (*average* per year per**

System and location	Year	Irrigation fees[a]	O&M costs[b]	Irrigation fees as % of O&M costs
BADC rental DTWs *with* RAKUB participation, Rajshahi	1989-90	2287[c]	2460[c]	93.66
BADC rental DTWs *without* RAKUB participation, Rajshahi	1989-90	3173[c]	2005[c]	163.24
BADC, BIADP DTWs, Rajshahi	1989-90	4810[c]	4442[c]	108.19
Private DTWs, Rajshahi	1989-90	3929[c]	1891[c]	207.77
G-K, Kushtia	1988-89	329[d]	2097[d]	16.06
NBTP, Thakurgaon	1988-89	289[d]	4426[d]	6.52

[a] [illegible]igation fees are defined as payments by the farmers to the farmer group management in the case *of all BADC DTWs systems, to the private owners in the case of Private* DTWs system, and to the government in the cases of G-K and NBTP systems for the [illegible] receive. In the c[illegible]ses o[illegible] DTWs systems irrigation fees include the rental / irrigation [illegible] d by BADC on farmer groups. Average per year per hectare irrigation fees as shown in the table have been calculated by [illegible] gross [illegible] area

[b] O&M costs include both direct and [illegible]

[c] For sample DTWs only.

[d] For entire project.

BADC	=	Bangladesh Agricultural Development Corporation
DTWs	=	Deep Tubewells.
RAKUB	=	Rajshahi Krishi Unnayan (Agricultural Development) Bank.
BIAD	=	Barind Integrated Area Development Project.
G-K	=	The Ganges-Kobadak. It is the largest gravity irrigation system in the country.
BWHD	=	Bangl[illegible] W[illegible] D[illegible] B[illegible]d.
NBTP	=	North Bangladesh Tubewell Project.

Table 5. Incremental benefit and *O&M* cost (*in* Taka) in **G K** *and NBTP* (*1989-90* **prices)**

Season	Crop	Per hectare net return w/ irrig.	Per hectare net return w/out irrig.	Per hectare incremental benefit	Per hectare G-K Kushtia	O & M costs NBTP Thakurgaon	O & M as percent of incremental benefit	
							G-K Kushtia	NBTP Thakurgaon
Kharif -I	Aus	14,426	2,063	17,363	1,489	1,903	12.00	15.4
Kharif-II	Aman	11,230	6,783	4,446	608	620	13.60	14.0
Rabi	Wheat	4,079	1,377	2,702	-	1,903	-	70.3

Sources: For O&M cost same as stated in Table 4.

For net return, average of several field survey findings,

Per ha net return = total variable costs minus grass return. Gross return has two components: value of main product and value of by-prcduct.

Per ha total yearly costs have been distributed among the crops in proportion to the present irrigation fees for the crops.

G-K = Ganges Kobadak.
NBTP = North Bangladesh Tubewell Project.
Kharif-I = Pre-monsoon dry crop season.
Kharif-2 = Monsoon crop season.
Rabi = Dry crop season.
w = with.
w/out = without.
irri. = irrigation.

In the Public G-K and NBT systems, low collection efficiency is explained by a number of factors over which local agency officials often do not have much control. These factors may be enumerated as follows:

Table 6. Irrigation service fee collection efficiency.

ystem and location	Period	Collectible irrigation fee ('00000 taka)	Collection ('00000 taka)	Collection efficiency (%)
BADC rental DTWs *with* RAKUB participation, Rajshahi	1984-85 to 1988-89	56.88[a]	45.45	79
BADC rental DTWs *without* RAKUB participation, Rajshahi	1989-90	2.12[b]	2.03	96
BADC, BIADP DTWs, Rajshahi	1989-90	3.29[b]	3.16	96
Private DTWs, Rajshahi	1989-90	2.79[b]	2.73	98
G-K Kushtia	1984-85 to 1988-89	1872.50[a]	21.20	1.13
NBTP, Thakurgaon	1984-85 to 1988-89	85.47[a]	20.13	*13.55*

Sources: For G-K, Thakurgaon and rental with RAKUB officialrecords and far the other three systems of the present field survey.

[a] For entire project.
[b] For sample DTWs only

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DTWs = Deep tubewells.
RAKUB = Rajshahi Krishi Unnayan (Agricultural Development) Bank.
BIADP = Barind Integrated Area Development Board.
G-K = "he Ganges-Kobadak which is the largest gravity irrigation system in the country.
BWBD = Bangladesh Water Development Board.
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Lack *of farmer participation/involvement.* Collection efficiency depends, to a large extent, on the ability and motivation of user-fanners to pay. As noted earlier, in terms of incremental benefits received from irrigation, farmers do have the ability to pay irrigation fees, yet they do not pay. One reason for this is their lack of motivation to pay which may be explained, partly, by their nonparticipation in any aspect of irrigation management — including the determination of irrigation fee rates. One hundred percent of the Kushtia and Thakurgaon sample fanners reported that they were not involved in the fixation of rates (Table7), 94 percent of Kushtia farmers and 40 percent of Thakurgaon farmers were ignorant of the criteria used for the determination of their present fees (Table8) and 93 percent of Kushtia farmers did not know who decided the fee rates (Table9). Farmers have not been convinced of why they should pay the fees. One hundred percent of the Kushtia sample farmers consider even the present low fee to be unreasonable (Table 10).

Table 7. *Sample* farmers' responses as to whether they participated in deciding *irrigation fees.*

System and location	Responses		
	Yes	No	Total
BADC rental DTWs *with* RAKUB participation, Rajshahi	19 (52.8)	17 (47.2)	36 (100)
BADC rental DTWs *without* RAKUB participation, Rajshahi	31 (96.9)	1 (3.1)	32 (100)
BADC, BIADP DTWs Rajshahi	53 (91.5)	5 (8.6)	58 (100)
Private DTWs Rajshahi	33 (84.6)	6 (15.4)	39 (100)
Total: Rajshahi	136 (82.4)	29 (17.6)	165 (100)
G-K Kushtia		89 (100)	89 (100)
NBTP Thakurgaon		160 (100)	160 (100)
Grand Total Rajshahi + Kushtia + Thakurgaon	136 (32.8)	278 (67.2)	414 (100)

Note: Figures in parentheses are row percentages.

BADC = Bangladesh Agricultural Development Corporation,
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Table 8. Sample farmers' awareness about the criteria for fixation of irrigation fees

System and location	Aware of criteria	Not aware of criteria	Total
BADC rental DTWs *with* RAKUB participation, Rajshahi	**34** **(94.5)**	2 (5.5)	36 (100)
BADC rental DTWs *without* RAKUB participation, Rajshahi	**31** **(96.8)**	I (3.2)	32 (100)
BADC, BIADP DTWs Rajshahi	**58** (100)		58 (100)
Private DTWs Rajshahi	**38** **(97.6)**	1 (2.4)	39 (100)
Total: Rajshahi	161 **(97.6)**	4 (2.4)	165 (100)
G-K Kushtia	5 (5.6)	**84** **(94.4)**	89 (100)
NBTP Thakurgaon	*80* (50)	*80* (50)	160 (100)
Grand Total: Rajshahi + Kushtia + Thakurgaon	**246** **(59.4)**	167 **(40.6)**	414 (100)

Note: Figures in parentheses are *row* percentages.

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Table 9. Samplefanners' *awareness* about who decides the *level of* irrigation *fees*.

System and location	Aware of who decides	Not aware of who deades	Total
BADC rental DTWs with RAKUB participation, Rajshahi	35 (97.2)	1 (2.8)	36 (100)
BADC rental DTWs without RAKUB participation, Rajshahi	32 (100)	-	32 (100)
BADC, BIADP DTWs Rajshahi	58 (100)	-	58 (100)
Private DTWs Rajshahi	39 (100)	-	39 (100)
Total Rajshahi	164 (99.4)	1 (0.6)	165 (100)
G-K Kushtia	6 (6.7)	83 (93.3)	89 (100)
NBTP Thakurgaon	151 (94.4)	9 (5.6)	160 (100)
Grand Total Rajshahi + Kushtia + Thakurgaon	321 (77.5)	93 (22.5)	414 (100)

Note: Figures in parentheses are row percentages.

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Table 10. Sample farmers' *opinion* on the reasonableness of the *size* of irrigation *fees*.

System and location	Responses		
	Yes	No	No opinion
BADC rental DTWs *with* RAKUB participation, Rajshahi	3 (97.2)	51 (2.8)	
BADC rental DTWs without RAKUB participation, Rajshahi	30 (93.75)	 (6.25)	2
BADC. BIADP DTWs Rajshahi	54 (93.1)	4 (6.9)	
Private DTWs Rajshahi	31 (79.5)	8 (20.5)	
Total: Rajshahi	150 (90.9)	13 (7.9)	2 (1.2)
G-K Kushtia		89 (100)	
NBTP Thakurgaon	148 (92.5)	12 (7.5)	
Grand Total: Rajshahi + Kushtia + Thakurgaon	298 (71.9)	114 (27.61)	2 (0.5)

Note: Figures in parentheses are row percentages.

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C-K = The Ganges-Kobadak which is the largest gravity irrigation system in the country
NBTP = North Bangladesh Tubewell Project.

KSS (cooperative) managers are involved in the collection of irrigation fees. These leaders, however, are not necessarily chosen representatively from the irrigators. In addition, cooperative discipline (as represented by the holding of regular member meetings) is low — resulting in reduced accountability of the **KSS** leaders. These leaders have little formal or informal authority to enforce any discipline. Under these circumstances, the involvement of KSS managers in fee collection cannot be considered as involving farmers.

Lack of financial autonomy. Financial autonomy here refers to "situations where an irrigation agency must rely on irrigation service fees for a significant portion of the resources needed for O&M, and where it has control over the expenditure of the funds collected from the fees" (ADB-IIMI 1986). In the G-K and NBT systems, whatever fees the agencies collect go to the government treasury. The agencies do not have any say on the **use** to which the irrigation fees are put and their annual (O&M) budget is independent of the amount of irrigation service fees collected. This lack of financial autonomy can be expected to affect collection efficiency in three ways. First, since collection does not affect their O&M budget directly, the agencies may not have a sufficiently strong material incentive to increase collection efficiency. Second, since the agencies do not have any say on the use of collected fees, they may feel unmotivated to increase fee collection efficiency. Third, without financial autonomy the quality of irrigation services may be adversely affected due to low accountability of the irrigation agencies. Farmers may resist paying fees if the quality of irrigation services is unsatisfactory.

Quality of services. Imgators in the G-K System, especially middle and tail users, express some dissatisfaction on the quality of services they receive in terms of the certainty, adequacy and timeliness of water deliveries. **Users** do not always know when the main pump will start and when they will get water. They are unable to predict pump starting time on the basis of past experiences because there is such a wide variation in the past start-up dates (Ghani 1987). **An** attempt is being made to regularize this start date.

Due to maintenance problems, the G-K canals — particularly tertiary and field channels — are often not in proper condition. In some places it has become very difficult to identify the original alignments of canals and channels. In some places a number of the hydraulic structures of the secondary and the tertiary canals are either inoperable or missing. As a result, whatever water is available cannot be distributed in an effective and timely manner to users, especially to the fields of tail-end farmers. The head-end and middle farmers, being in an advantageous position, are often able to meet their water needs through unauthorized cuts in the canals — a form of water stealing at further cost to the tail enders. The lack of sufficient canal maintenance is explained partly by (i) an inadequate number of agency staff, especially those at the field level, (ii) the absence of an appropriate mechanism for farmer participation in the operation and maintenance of the system at the secondary, tertiary, and field levels, and (iii) the shortage of funds for operation and maintenance. A rehabilitation scheme is presently being implemented in the G-K System, after the completion of which the quality of services is expected to improve.

In the NBT System, while farmers can generally be certain of their tubewell's start-up time, the irregular supply of water has been a major problem at times in the recent past. Due to electricity failures, the regularity and sufficiency of water supply cannot always be maintained. Electricity failures are caused mainly by the theft of electric wires. Further, for the same reasons as in the G-K System, the maintenance of channels in many DTWs is inadequate.

Problems with the collection system. The collection efficiency of irrigation service fees in the BWBD projects is partly inherent in the system of collection itself. The system suffers from a number of weaknesses which may be enumerated as follows:

i. **Length of** assessment procedures. Under the present systems, the agencies have to go to through a lengthy five-stage process in order to give the final bill to the users. The first stage involves the identification and recording or booking of the irrigated plots for every farmer under the command area. The second stage involves hearing objections from farmers against the recording of their irrigated land. After booking is completed, the Patwari (the booking staff) sends the booking register to the Sub-Divisional Engineer (SDE), who sends it to the Executive Engineer (X-EN). The X-EN then circulates this booking information to water users and gives them one months' time to place their objections (if any). In the third stage the X-EN's office makes a preliminary assessment of irrigation fee for which two months' time is allowed. Water users are informed of this preliminary assessment and asked to file their objections, if any, against the assessed amount. The time allowed for informing the farmers and receiving objections from them is one month. The fourth stage involves the hearing of objections and finalizing assessments which require two months. In the final stage, which takes a further two months, demand notices are prepared for every farmer. After the demand notices are finalized they are sent to individual farmers through KSS managers. From irrigation booking to finalization of demand notices, therefore, it takes (officially) nine months. The distribution of demand notices among the individual farmers also takes additional time. A water user normally gets his demand notice three to four months after the harvest of his crops, a time by which he must have either disposed of or consumed the crop leaving him with insufficient funds to pay irrigation fees.

ii. Level of expense. The collection system is expensive in two ways — its implementation requires a great deal of manpower and a great quantity of stationary is needed for various forms, notices and registers (in the G-K System alone more than half a million taka is required to pay for stationary). BWDB has only a limited number of staff (Patwaris and Zilladars) to implement the system. The G-K System has only 23 Zilladars and 170 Patwaris to do assessment work for more than 120,000 farm families. In the NBTB System, there are only **59** Patwaris and no Zilladars to serve more than 14,000 water users. The assessment efficiency, like collection efficiency, is very low in these BWDB systems. Official data from 1984-85 to 1988-89 showed that G-K was able to assess 52.8 percent of the total irrigated area. For the NBT System it is 49.8 percent (Table 11).

iii. Lack of financial autonomy. Under their present system, the BWDB agencies assess and collect fees but do not have any control over the use of these funds. The entire sum of fees is deposited in the government treasury. Financial autonomy, as noted, can be closely related to collection efficiency.

iv. Lack of effective incentives for fee collectors and agency officials. The system provides incentives to collectors of fees. It has been reported, however, that the collectors do not always get their incentive money in full or on time. As a result, collectors often do not take much interest in their work. Further, there is no incentive provision for agency officials who are involved in the assessment and collection of fees.

v. Lack of provision for farmer participation. This point has been discussed above.

Table 11. Irrigation fee assessment efficiency in BWDB systems.

System and location	Year	Area irrigated (ha)	Area assessed (ha)	Assessment efficiency (%)
G-K Kushtia	1984-85 to 1988-89	94	713,872	52.8
NBTP	1984-85 to 1988-89	74,945	37,311	49.8

Source. Compiled from official records.

G-K = The Ganges-Kobadak which is the largest gravity irrigation system in the country
NBTP = North Bangladesh Tubewell Project.

Nonenforcement of sanctions. Enforcement of sanctions against willful nonpayment of irrigation fees is very important for a system aiming at a high rate of collection efficiency. The rules provide that if a user does not pay his fee for a particular season, he may not be given water in the following season. This strong official sanction has not, however, been implemented in either the G-K or the NBT systems. This nonenforcement may be explained by such factors as (i) lack of financial autonomy, (ii) lack of sufficient manpower, (iii) less than satisfactory water supply, and (iv) fear of popular resentment and agitation, etc.

Communication and Interaction among Farmers and Project Officials

Irrigation system management involves the partnership of irrigation managers (often agency officials) and farmers. For efficient system performance regular and effective communication between these partners is necessary. To be effective, such communication must involve farmer leader representatives of the general irrigators and managers/officials who have the authority to attend to the problems faced by the farmers. In many parts of the study areas involved in the IIMI-IRRI research, these conditions were not met. As a result, effective and regular interaction and communication between officials and farmers did not occur.

Farmer Organization and Participation

Evidence from a variety of systems supports the proposition that irrigation management objectives can be furthered by the participation of farmers in system management (Uphoff 1986; FAO 1989; Pradhan 1989; Pant and Verma 1983). Especially where landholding is typified, by small and fragmented farms, it can be expected that farmer participation becomes more predictable, productive and sustainable if they participate in groups through some form of organization rather than on an individual basis.

The nature and dimensions of the irrigation activities which a farmer organization might perform depend on the type of irrigation system, the method of irrigation, the ownership of the system, and on many socioeconomic, institutional and cultural factors. To create a framework for the analysis of the role of farmer organizations in irrigation management one can identify some activities of a general nature. Uphoff (1986), for example, provides a list of such activities as follows:

Activities related to water use:

a) Acquisition of water from surface or subsurface sources;
b) Allocation of water by assigning rights to users;
c) Distribution of water among users; and
d) Drainage of excess water.

Activities related to the physical system:

a) Design of structures;
b) Construction of **structures;**
c) Operation of structures; and
d) Maintenance of structures.

Activities which include organization and management functions:

a) Decision making;
b) Resource mobilization;
c) Communication; and
d) Conflict management.

All these activities are highly interrelated. Ways in which farmers' groups might become involved in these functions are included among the recommendations of a workshop on "Irrigation Policy and the Management of Irrigation Systems in Southeast Asia" (Taylor and Wickham 1976). These recommendations included:

1. Taking more responsibility to pay for irrigation;
2. Assuming more responsibility to organize and perform O&M tasks;
3. Giving more feedback to irrigation officers on the field performance of systems; and
4. Exerting greater influence on decisions involving water allocation and scheduling.

The findings of the IIMI-IRRI project show that farmers' organizations of the G-K and NBT systems have not played much of a role in irrigation management. In the Rajshahi tubewell systems, the groups have performed a number of irrigation management functions, but again there is scope for broadening the involvement of farmers. The following are several constraints that these farmer groups' attempts at irrigation management participation are beset with

Inadequate irrigation management orientation. The formal fanners' organizations often have an inadequate orientation toward irrigation management. Frequently, they are societies more oriented toward credit — following the principles **of** the early credit cooperative societies which were later restructured along the lines of the two-tier cooperatives developed by the Comilla Academy. Their bylaws do not adequately deal with inigation management functions nor do they outline agency/ farmer relations.

Water availability. One of the major conditions encouraging farmer participation in irrigation management is the availability of adequate water in a timely and certain manner. Often, too much or too little water is available which discourage farmers from participating in irrigation management. The relationship between water availability and incentives for participation might be represented by an inverted U curve, farmers' willingness to participate being low at either extremes of water abundance or scarcity (Uphoff 1986). In the IIMI-IRRI study, poor fanner participation can largely be explained by water availability. In the G-K System, it was observed that the tail-end farmers do not get water in a sufficient and timely manner. They do not have enough water to manage — making participation irrelevant. Head-end fanners, on the other hand, often get (or manage to get) so much water that they have little need for organized efforts to conserve and manage the resource. In the NBT System the situation is similar to that in G-K while in the Rajshahi area the problem is not severe.

Ownership. **A** sense of ownership of the system is an important prerequisite for farmer participation in management. In almost all of the systems under the farmer organization study, the irrigation facilities are owned by the government. In Rajshahi, however, the de facto ownership of DTWs, to a great extent, lies with farmer groups. Farmers' sense of ownership of the system is relatively greater in the Rajshahi area resulting in more **participation by the farmers.** In the G-K and NBT systems, scope for farmer participation is limited by project design. In both systems BWDB is supposed to perform almost all irrigation management activities. There is no talk of turning over any significant degree of ownership of these systems to the farmers.

Factionalism. Farmers' organizations for irrigation management are not free from **the problems of factional conflicts.** Problems of family or lineage-based factions are reflected in their management. Factions that dominate the management often eliminate the participation of other factions to the detriment of widespread participation of a broad spectrum of farmers.

Training. The training of farmer group leaders in irrigation management has been found to be either absent or inadequate. Training of agency personnel to motivate them to accept farmer participation as an essential component of improved system performance is also generally absent.

***Lack** of participation of all* irrigators. It has been noted that only irrigators in the Rajshahi DTWs and a portion in the NBT System and the BIADP of Rajshahi have no legal barrier to become members of the organizations because the organizations are irrigation community- **or** command area-based — precluding nonresident irrigators from becoming members.

Disadvantaged farmers' interests are not safeguarded. Since there is no legal provision to safeguard their interest and ensure their representation, the disadvantaged farmers (especially the tail-end and small farmers) do not have any incentive to join the organizations. Without their participation, the organizations cannot be expected to perform equitably. It has been noted in the literature on the subject (Parker 1979) that if farmers' organizations are allowed to become the tools of the most powerful people, the groups will not fulfill the purposes for which they were created.

Interagency Cooperation

To get increases in production, fanners must have access to increased amounts of their non-water inputs. For this to happen, there is a need for interagency cooperation — cooperation between the irrigation agencies, the extension department and the credit agencies. Such cooperation needs to be enhanced in all the systems studied. While some form of institutional infrastructure for such coordination does exist in all the study areas, there is still a need to energize and activate the system with appropriate management innovations evolved through applied research.

Training

The level of training of farmers, fanner leaders and agency managers on irrigation management was noted to be inadequate. Training courses on irrigation management generally cover (with varying levels of effectiveness) technical aspects of water management and crop production. Modules on communication, coordination, cooperation, leadership development, human relations and other related aspects of management are not given much emphasis. Further training on sustaining the institutional infrastructure for management is generally not included in the overall project O&M budget.

Ownership and Management Patterns

The study indicates that under similar agro-ecological conditions (i.e., excluding the BIADP tubewells which are located in the Barind area), there is somewhat better performance of DTWs under private (versus BADC rental group) ownership and management in terms of area irrigated, yield per hectare, irrigation fee collection efficiency, O&M costs per hectare, etc. (Table 12). This private management, however, has charged higher irrigation fees per hectare. Because the sample size was small, statistical tests of the differences in performance were not possible, so no strong judgements can be made on the relatively better performance of DTWs under private ownership and management.

Choice of Crop

Under the G-K Gravity Irrigation System, the option for growing rabi crops under irrigated conditions is unavailable at present because the system is kept inoperative during winter when such crops might be grown in order to overhaul machines and pumps. Under the DTWs irrigation systems, farmers can use irrigation water to grow rabi crops as a substitute for boro rice or in addition to growing a late (braus) rice crop. It has been observed that farmers do not generally grow rabi crops as

Table 12. Average irrigated area, yield, O&M cost, irrigation fee and irrigation fee collection efficiency of DTWs irrigation under alternate management under similar agro-ecological conditions in the Mohanpur area of Rajshahi District.

System and location	Average irrigated area per well (ha)	Average yield per hectare (in tons)		Average O&M cost per hectare (in taka)	Average irrigation fee per hectare (in taka)	Irrigation fee collection efficiency (percentage)
		Crop cut	Farmers reported			
BALX rental DTWs *with* RAKUB participation Rajshahi	22.76	3.94	3.85	2,460	2,287	79
BALX rental DTWs *without* RAKUB participation Rajshahi	21.59	3.41	3.82	2,005	3,273	96
Private DTWs Rajshahi	23.66	4.75	4.12	1.891	3,929	98

substitutes for rice. Islam, (1990) identifies the following factors that discourage NBT System farmers from growing wheat:

a) problems of seed storage due to insect attack;

b) uncertain irrigation water supply resulting from electricity failures;

c) problems of threshing because of wet weather at the time of harvesting and lack of threshing services;

d) problems of turn-around period; and

e) declining yield and low output prices.

The declining yield and low output price were the main reasons for fanners' unwillingness to grow wheat. In terms of cost-benefit ratios, rice (Purbachi variety) is superior to wheat and other upland crops such as millet and sesame. This is supported by a comprehensive agriculture sector review conducted recently (UNDP 1989). The review points out that, given the present configuration of input and output prices, Boro (rice) remains a relatively profitable winter crop. Pulses, oil seeds, mustard and other boro-competing crops are at a competitive disadvantage which is not likely to be removed by any foreseeable increase in prices or improvement of yields.

CANAL ROTATION AND MINIMUM IRRIGATED CROP ACREAGE EXPERIMENTS

Rotation

As the Ganges-Kobadak System does not have adequate water to meet the water in relation to the total needs of its command area, a nine-day rotation (with three days of flow followed by six days off) among secondaries has been followed for some years.

However, this rotation system had faced a number of problems which included: (i) nonobservance of rotation among tertiaries; (ii) deteriorated condition of canals and field channels; (iii) unauthorized cuts in canals; (iv) poor condition of hydraulic structures as well as of some bridges and culverts; (v) absence of farmers' organizations and participation; and (vi) a general lack of communication and interaction between farmers and project officials.

In 1990, the ten-day rotation (five days *with* water followed by five days *without* water) was introduced. The secondary canal chosen (denoted as S8K) was one of the more problem-ridden parts of the G-K System. Project officials arranged for repairs of this canal and its control structures and devised a system to ensure that the ten-day rotation could be strictly observed. Along with research team members, they made special efforts to keep the farmers along the secondary canal informed and to encourage their participation. In addition to numerous field visits, these efforts included a field workshop held in a centrally located village along S8K. At this workshop farmers were able to voice their concerns as well as participate in decisions regarding their (and the Project's) responsibilities in the rotation scheme. A good deal of cooperation between farmers and officials and among farmers of different tertiaries (notably absent in previous years, with head-end tertiaries taking all of the water) followed this workshop.

The impact of the rotation experiment on S8K has been highly positive in terms of area irrigated, yield and equity. Of course, the sustainability of this improvement in future seasons remains to be seen.

Area irrigated. Area imgated under S8K in the 1990 Kharif-I season increased to 528 hectares from 54 hectares in 1989 Kharif-I (Table 13) — an increase of 877 percent. This record of achievement at the macro level is supported by data collected from the sample fanners (Table 14). It is noted that the farmers included in the sample cultivated a total of only 1.6 ha in the Kharif-I season of 1989, as against 20.8 ha in 1990 — an increase of 1,170 percent. Seventy-five percent of the 1990 target of the Water Board on this secondary has been achieved as against an achievement of 61 percent in 1989.

Table 13. Area irrigated in S8K in 1990 (in hectares).

	1989 Kharif-I			1990 Kharif-I		
Tertiary (= T)	Target area	Area imgated		Target area	Area irrigated	
		Area	Percent of target area		Area	Percent of target area
TI	132.38	21.56	16.3	121.45	120.40	99.1
T2	236.84	27.97	11.8	238.46	179.49	75.3
T3	178.13	3.31	1.8	174.08	130.93	75.2
T4	90.28	1.33	I.5	103.64	97.14	93.7
Total	637.63	54.00	8.5	637.63	527.96	82.8

Table 14. Area irrigated by sample farmers fin hectares),

Tertiary	Head		Middle		Tail		All sample farmers	
(= T)	1989	1990	1989	1990	1989	1990	1989	1990
TI	0.47	1.68	0.50	1.94	-	0.85	0.97	4.47
T2	0.27	1.40		1.74		1.67	0.27	4.81
T3	0.40	2.30		2.03		1.20	0.40	5.53
T4		3.49		1.61		0.90		6.00
Total	1.14	8.87	*0.50*	7.32		4.62	1.64	20.81

Equity. The distribution of water among different tertiaries and among head, middle, and tail farmers along the various field channels has also become much moreequitable. Table 15 shows that in 1989, farmers of T4 irrigated only 2.5 percent of all land actually irrigated along S8K. In 1990, their share of total land irrigated increased to 18.4percent. The T4 target had been 16.3percent of the total S8K target. While this tail tertiary did not quite fulfill its own absolute target it did well in relation to its upstream tertiary neighbors. The position of T3 farmers also improved dramatically but not as much as that of the T4 farmers (an improvement from 3.1 percent of total S8K irrigated area in 1989 to 24.8 percent in 1990—the T3 1990 targeted share, however, was 27.3 percent). In addition, the share of tail-end farmers within each tertiary has improved substantially where it is shown; while they did not cultivate any land under irrigated crops in Kharif-I in 1989, they irrigated 4.6 ha of land in 1990 (22.2 percent of land imgated by the full sample of head, middle and tail farmers). Furthermore, all of the sample tail-end farmers reported that they received sufficient water during the Kharif-I season.

Table 15. Distribution of irrigated land among different tertiaries (in hectares) in 1989 *and 1990.*

Tertiary (= T)	1989 Kharif-I		1990 Kharif-I	
	Area irrigated (ha)	(%)	Area irrigated (ha)	(%)
TI	21.56	39.93	120.45	22.81
T2	27.97	51.81	179.49	33.99
T3	3.13	5.80	130.93	24.80
T4	1.33	2.46	97.14	18.40
Total	54.00	100.00	527.96	100.00

Minimum Irrigated Cropped Acreage

The results of the other experiment to increase irrigation coverage, the minimum irrigated cropped acreage (MICA) and the trial conducted in the North Bangladesh Tubewell Project (NBTP), are not as positive as those of rotation in the G-K System. However, it also shows potential for improving system performance through management changes and farmer involvement.

A great number of deep tubewells (DTWs) in Bangladesh, including the wells of the NBTP tend to imgate much less than their technically practical command areas. Among the reasons for this tubewell underutilization are: (a) disruptions in DTW operation due to faulty power supplies, inadequate maintenance, etc., and (b) farmer organizational problems that create severe inequities in access to reliable supplies of water.

To encourage farmers at these tubewells to work together and promote more interaction between farmer groups and agency officials, the research project made a policy suggestion that BWDB adopt a minimum imgated cropped acreage system. Under this system the farmer groups would indent for irrigated water before a given season but the agency would only operate the well if some pre-determined minimum acreage was to be serviced. The rationale was that it would put pressure on each farmer group to solve at least some of its organizational problems that may have constrained the spread of irrigation in the past. Those few farmers who were normally using tubewell water, would have to accommodate other farmers' demands if anyone at all were to receive water. The agency, at the same time, would have to make strong efforts to improve the reliability of the operation of those tubewells where a minimum number of cropped acres are enlisted for an irrigation season.

Serious implementation of the MICA policy did not begin until the Aus season of **1990.** At that time the project officials and the research team made efforts to communicate the new system to the irrigators. Project officials and extension personnel spread word about MICA, primarily through the KSS leaders. Agency officers and members of the research team also held a series of field workshops aimed at explaining the program and getting a feedback from the farmers.

While participation did increase to some extent with the spread of MICA, the water demand indent system was easily abused as fanner groups only had to *claim* that they would be irrigating the minimum number of acres for the water to be turned on for the season. No system was devised for stopping the operation of the well during the season if the number of irrigation acres claimed did not materialize. In addition, the Project's ability or will to enforce sanctions against noncomplying tubewell groups was under some doubt though a formal test of that ability was avoided due to the manner in which the indent system operated.

Some of the impacts of the minimum irrigated cropped acreage experiment are as follows:

i. Area irrigated. Information on area irrigated is available from the **16** sample DTWs and from 80 others — all of the latter are located in Thakurgaon Upazila. **Four** of the sample **DTWs** are also from Thakurgaon. It has been found that of 80 DTWs of Thakurgaon, **3** were out of operation, **21** were able to achieve their minimum irrigated area targets, **15** were reported (as of May **15,1990)** to be expected to fulfill their MICA targets and **41 (53** percent) did not achieve MICA targets (Table 16). Of the **16** DTWs examined by the IIMI-IRRI research team, **5** could not achieve MICA targets while 11 fulfilled their minimum targets (Table **16).** Major reasons cited for nonfulfillment of MICA targets are:

a) Poor canal conditions;
b) Sandy soils;
c) Weak farmers' organization; and
d) Cultivation of wheat in some command areas.

Table 16. Utilization status of Thakurgaon Upazila DTWs and sample DTWs (of NBTP) in relation to MICA implementation in the Kharif-I season of 1990.

DTW category	Total number of DTWs	Number out of operation	Number in operation	Number under BADC farm	Number meeting MICA target	Number expected not meeting MICA target	Number not meeting MICA target
Thakurgaon [a] Upazila DTWs	80	5	75	2	19	14	40
Sample DTWs	16	-	16	-	11	-	4

[a] In Thakurgaon, there were 84 DTWs of which 4 were included in the sample

Table 17. Per DTW average MICA target, average actual area irrigated under MICA and average actual area irrigated before MICA (average for three years - 1987,1988 and 1989) of research DTWs and outside research (Thakurgaon) DTWs.

DTWs Category	Average MICA target (ha)	Average actual irrigated area under MICA(ha)	Average irrigated area before MICA (ha)	Difference between MICA and Pre-MICA acreage (ha)
A. Research DTWs				
i. Those met MICA	15.61 (N=11)	19.83 (N=11)	16.90 (N=11)	2.93[a]
ii. Those did not meet MICA	15.61 (N=5)	7.20 (N=5)	3.67 (N=4)	3.53[a] (N=4)
Average	15.61 (N=16)	15.88 (N=16)	13.37 (N=15)	2.51’
B. Outside research (Thakurgaon) DTWs				
i. Those met MICA	17.00 (N=19)	22.00 (N=19)	14.25 (N=19)	7.73’
.i. Those did not meet MICA	15.10 (N=37)	7.30 (N=39)	6.66 (N=33)	0.67’
Average	15.74 (N=56)	12.12 (N=58)	934 (N=51)	2.78”
C. A + B				
i. Those met MICA	16.49 (N=30)	21.20 (N=30)	15.26 (N=29)	5.67***
i. Those did not meet MICA	15.16 (N=42)	7.28 (N=44)	6.33 (N=37)	1.17*
Average	15.72	12.93	10.26 (N=72)	2.67’ (N=74) (N=66)

Source: **From outside research (Thakurgaon) DTWs, compiled from official record. For research DTWs, field survey data.**

DTW = Deep tubewell.

MICA = **Minimum irrigated crop acreage. ‘No statistical test was done.**

*****Significant at 1 percent level.**

***Significant at 10 percent level.**

Table 17 shows average area irrigated by the DTWs. It shows that those research DTWs which achieved MICA targets irrigated more area than that in the Kharif-I seasons of the past three years. Although the unsuccessful research DTWs covered only about 50 percent of their MICA targets they also irrigated more land than they did in the previous years. Likewise, the successful non-research DTWs of Thakurgaon, performed better than in the previous three years. Even those non-research DTWs which failed to achieve MICA targets by even 50 percent have, in general, irrigated more land than in the past. Two general pictures emerge from Table 16 and Table **17.**

a) The research DTWs have performed relatively better than those non-research wells indicating that the action-research component (involving the field workshops and the frequent presence of the research team at the sample tubewells) of the study achieved some success. If the component had been started on time (aspects of action research were started rather late) its success could have been more prominent.

b) As an approach to ensure optimal utilization of DTWs, MICA indicates the potential for increasing command area in the NBTP.

ii. **Yield.** Almost all farmers under the study grew the Purbachi variety of rice. Yield records obtained through crop-cuts showed that yield in the research DTWs varied from 4.3 to 7.9 t/ha (from the data that went into the averages shown in Table 18). In general, DTWs which were not able to achieve their MICA targets achieved lower yields than those DTWs which either reached or exceeded their minimum irrigated area targets. Comparable data are not available for non-research DTWs for the same season, i.e., Kharif-I of 1990. However, some area data collected for several past seasons by the BRRI-BWDB-IRRI research project showed a yield per hectare of **3.6** to 4.2 tons.

iii. Equity. In the sample DTWs, the equity situation has neither deteriorated nor improved over the years (Tables 19 and 20). The distribution patterns of irrigated land among head, middle and tail farmers and among small, medium and large farmers in 1989-90 are not, in general, different from what they were in the past years. In term of average yield per hectare, the head farmers of both groups of DTWs (those fulfilling MICA targets and those failing to fulfill their targets) have achieved the most, followed by the middle farmers. The tail farmers have achieved the lowest yield (Table 18).

Table 18. **Yield per hectare *of land* under research *DTWs* (in tons).**

Categories	Head farmers	Middle farmers	Tail fanners	Total average of head, middle and tail'	Difference between yields of head and middle farmers
Those met MICA target	6.54	5.78	4.86	5.54	1.68***
Those did not meet MICA target	5.43	5.09	4.24	4.86	1.19***

DTWs = Deep tubewells.
MICA = Minimum irrigated crop acreage.
*** Significant at 1 percent level.
Test conducted between the total averages shows that the difference is significant at 1 percent level.

Table 19. *Distribution of irrigated* land **of** *sample farmers by* **their** *location* **in** *different* **years (in** *percentages).*

Year	Head	Middle	Tail	Total
1989-90	40.4	31.8	27.8	100.00
1988-89	40.2	32.2	27.6	100.00
1987-88	41.5	33.9	24.6	100.00
1986-87	44.1	31.8	24.8	100.00

Table 20. Distribution of irrigated land *of sample* farmers *by their farm sizes in* different years (in percentages).

Year	SF	MF	LF	Total
1989-90	12.1	59.6	28.3	100.00
1988-89	12.5	59.9	27.6	100.00
1987-88	11.0	57.6	31.3	100.00
1986-87	8.6	61.3	30.1	100.00

SF = Small farmers, having operated land from 0.02 to 1.01 hectares.
MF = Middle fanners, having operated land from 1.02 to 3.03 hectares
LF = Large farmers, having operated land of 3.04 hectares and above.
Operated land = Owned land + rented in land -rented out land.

CONCLUSIONS AND RECOMMENDATIONS

The research findings of the IIMI-IRRI project strongly suggest that there is great scope for substantial improvement of Bangladesh's rice-based imgation systems through improved management. The improved management should involve willing and active participation of irrigator farmers and irrigation managers — the two major partners in the systems.

The farmers can meaningfully participate in (a) taking more responsibility to pay more for imgation; (b) assuming more responsibility to organize and perform O&M tasks; (c) giving more feedback to irrigation officers on the field performance of systems; and (d) exerting greater influence on decisions involving water allocation and scheduling (Taylor and Wickham **1976).** Since farmers' participation can become more predictable, productive and sustainable if they participate in groups through some form of organizations than on an individual basis, (particularly in the Bangladesh context of small and fragmented landholdings), farmers' organizations should be developed, nurtured and sustained. While developing farmers' organizations care should be taken so that their irrigation emphasis is clear; principles of equity (Bromley, Taylor and Parker 1980) are followed so as to give representation to a cross section of farmers; they are organized on the basis of hydraulic characteristics of irrigation systems; some **sort** of quasi-ownership of the systems is given to the organizations (pending, in some cases, real and total ownership eventually); farmers, especially the farmer leaders, are provided with some training on socio-technical aspects of management, etc.

It would be useful if irrigation managers could participate in the improved management process not as administrators of the bureaucratic tradition but as managers with a participatory style. If farmer participation is to be effective, managers must first accept the idea that improved system management is dependent on that farmer participation. ***As*** demonstrated in the rotation and MICA experiments, managers can help initiate effective agency-farmer interaction, communication and cooperation. Farmer participation can be enhanced if imgation agencies or managers can ensure an adequate supply of water to the system delivered in a timely and certain manner. Irrigation managers need also to appreciate **the usefulness of cooperation with other line agencies and** take initiatives in that direction. To do all these, many irrigation managers could use training on various socio-institutional aspects of irrigation management.

Research, specifically action research with real participation by irrigation agencies and farmers, is needed to evolve and implement management innovations for the improvement of system performance of rice-based irrigation systems in Bangladesh. Some basis for such research has already been created in the IIMI-IRRI collaborative research. Action research on rotation in the G-K System and in minimum irrigated crop acreage (MICA) in the NBTP could usefully be continued and command area development (CAD) research could be started in the Rajshahi DTW irrigation systems. BWDB, BADC and Rajshahi Krishi Unnayan Bank (Rajshahi Agricultural Development Bank RAKUB) can meaningfully participate in this research. Eventually, other line agencies such as the Bangladesh Rural

Development Board (BRDB) and the Directorate of Agricultural Extension (DAE) might be included in the research network.

In regard to system finances, it is increasingly becoming clear that the Government of Bangladesh will be totally withdrawing its current subsidies on O&M costs. Both agency managers and imgators must adapt to these changing conditions. Needed changes include the development of a system of fee assessment and collection so that collection efficiencies can be raised. At the same time there is a need to increase the efficiency of the systems so as to reduce O&M costs. Farmer participation in system management can reduce O&M costs and financial autonomy of irrigation agencies can lead to better collection efficiency. Full or partial financial autonomy of the irrigation agencies could usefully be explored — along with ways to increase farmer involvement in irrigation management.

Growing rice under irrigated agriculture is still profitable but the declining trend in this profitability is likely to continue given the govemment policy of withdrawing subsidies on agricultural inputs and raising the price of fuel. The productivity of land and other inputs must be increased to face this situation and for irrigated agriculture to be sustained because output prices may not keep pace with the rise in input prices due to the influence of various macro-economic and political factors. Increasing the productivity of inputs is going to be an important task of imgation management.

Increasing the adoption of nonrice imgated crops in the dry season as a substitute for boro rice, however, faces some obstacles at present because of domestic demand patterns that are highly rice-oriented. In this situation, using price policy to encourage farmers to grow rabi crops might not be very effective. According to a UNDP document (1989) "..... using price policy to encourage diversification is likely to be a self-defeating enterprise, since at the price level required, demand is likely to vanish. For example, it would take a price increase of nearly 60 percent to make mustard competitive with HYV Boro; kheshari would require a 300 percent price increase for the same purpose." Crop diversification however, is likely, to become more important in the future as Bangladesh approaches self-sufficiency in rice production and as demand grows for vegetables, etc. This expected growth of nonrice crops is likely to raise various socio-institutional issues as regards the management of irrigation water as system managers struggle with providing for the diverse water needs of different crops.

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