Contribution of Irrigation to Sustaining Rural Livelihoods: Bangladesh case study

KAR Project R7879

C Angood
F Chancellor
J Morrison
L Smith

Report OD/TN 114
March 2003

Imperial College London

HR Wallingford

DFID Department For International Development

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Contract - Research

This report presents findings from survey work carried out under Knowledge and Research (KAR) contract R7879, "Contribution of irrigation to sustaining rural livelihoods" funded by the British Government's Department for International Development, (DFID) for the benefit of developing countries. The views expressed in the report are the responsibility of the research team members and are not necessarily those of DFID. The research team comprises the International Development Group, HR Wallingford; the Agricultural Economics and Business Management Research Group, Imperial College at Wye; the Local Development Training Academy (LDTA), Nepal; Bangladesh Agricultural University, Mymensingh, Bangladesh; Dr P. Pradhan from Nepal; and Professor S. Mandal from Bangladesh.

The HR job number under which this report was completed is MDS 0537.

The DFID KAR details are:

Theme:	W5. Improved availability of water for sustainable food production and rural development
Project title:	Contribution of irrigation to sustaining rural livelihoods
Project:	R 7389

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Summary

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The report describes work undertaken in Bangladesh under KAR project R7879, which is aimed at reducing poverty in rural areas. The project will provide information for policy makers, to help governments ensure that irrigated agriculture secures productive livelihoods for the poor. Previous report OD/TN 113 described similar work carried out in Nepal in the first part of the study. The project also aims to build the capacity of irrigators through the provision of targeted training and promotional material.

Many households in Bangladesh nowadays receive a substantial proportion of their total income in the form of remittances from family members working elsewhere, either within or outside the country. Since the purpose of the project was to assess the impact of irrigated agriculture on livelihoods, it was established at the outset that farming is still the main source of income for the majority of households in the study villages.

Of the selected study villages, Talki and Mohanpur, each counting some 80% of small farmers (<1ha) in their populations, are poor according to Bangladesh Government criteria. Borni appears slightly better-off according to the same measure, but in fact has a higher proportion of landless labour with limited prospects than either of the other two villages.

Large numbers of privately-owned shallow tube wells (STWs) began to be installed in the early 1990s, after costs fell. Some farmers who previously bought their water from a nearby STW have been able to buy their own well from the profits of irrigated production.

The primary impact of irrigation from STWs has been to allow farmers to grow HYV boro rice, supplemented by a (mainly) rainfed improved aman crop, in place of a relatively low-yielding, rain-fed, broadcast aus-aman cropping pattern. The mean boro crop yield for the study villages in 2002 was around 4.5 T/ha – which was substantially greater than pre-irrigation yields. It was very clear from the investigations in the three villages that people principally attribute improvements in their livelihoods to irrigation from STWs. The impact on incomes may be judged by the fact that the average yields for aus, prior to general use of STWs, was around 1.3 T/ha, and for aman was 1.7 T/ha.

Farmers now cultivate fewer traditional crops like jute, sugarcane, wheat, mustard and gram, and they keep fewer animals. However, with capital accumulated from greater rice production,.they are diversifying into enterprises like intensive poultry production and aquaculture. Farmers generally seem to obtain information on agricultural techniques from others. They lack a source of reliable information/training on irrigated cultivation, as Block Supervisors rarely visit.

Many houses have been improved since irrigation became widespread. Typically, galvanized sheet cladding replaces mud walls, whilst latrines and hand tube wells are installed.

Road improvements have made a large, complementary, contribution to the development of all three villages. Better access to markets has reduced the cost of inputs and expanded the market for produce. Local transport services have benefited. Many poor villagers now obtain a basic living from driving rickshaws or 'vans'.

Ordinary farmers and labourers have been able to acquire a range of household goods. Increased spending power has stimulated the off-farm economy. Many shops, providing both agricultural and general goods, have sprung up round the schemes. There are new rice mills in all three areas.

Many more children are now attending school. Farmers are willing to spend part of their increased income on their childrens' education, in support of the government's education policies.

There is now greater employment in the study villages, providing benefits to many households including those of the marginal and landless. Farmers now report a shortage of labour at peak periods. More women are involved in rice cultivation, particularly in processing – parboiling and drying. Extended cropping, requiring labour for tasks such as transplanting and harvesting, has compensated for the reduction in land preparation and threshing tasks. Mechanised agricultural processing (and hand tube wells) have released labour, particularly female, to take up small rural enterprises, in a general expansion of economic activity in the villages. The combined effect of expansion in both the farm and non-farm sectors has led to a reduction in seasonal out-migration in search of work.

Increased demand for goods and services has led to diversified employment for landless and marginal households. Non-farm employment now rivals that in agriculture. In the study villages, there is regular employment for rural mechanics servicing irrigation and other farm equipment, for local blacksmiths and workshops manufacturing spare parts, for carpenters and masons working on house construction/ improvements, for maid servants in wealthier households, and for 'van' and rickshaw drivers transporting people, fuel, fertilisers, seeds and crops. Off-farm labour rates are reported to be better than those on the farm.

Food security has improved dramatically with irrigation, but vegetables are neither generally grown nor bought in. Despite the lack of balance in their diet, villagers are healthier. They are now able to buy necessary health care and medicines.

The study communities are relatively harmonious, but there are few social groupings carrying out joint activities. Most commercial activities are undertaken by small private enterprises.

Some negative impacts on the environment are apparent. Unlike Nepal, intensified production on existing land is accompanied by extended cropping on beels, forests and former grazing lands, which traditionally have helped support the poor. However, Bangladesh is very vulnerable to natural disasters. There is no doubt that irrigation provides a valuable safety net to farmers, allowing them to cultivate at a less risky time of year. Environmental concerns need to be set in this overall context.

Irrigation development will inevitably favour larger farmers where land is unequally distributed. However, the study demonstrates that small farmers will also benefit, provided they can obtain access to water. In Bangladesh, small farmers have been helped by effective systems of rural credit, by affordable irrigation equipment, and by the emergence of water markets. However, poverty still haunts landless and marginal farming households, for whom irrigation has been the means to prevent starvation and deterioration in living standards, as in former times, rather than to produce major improvement. However, the growing non-farm labour market provides them with opportunities. Landless households may rent or sharecrop small plots, most commonly during the boro season. Even where the output does not meet the full subsistence needs of a household, it makes an important contribution to poor livelihoods.

Overall, it can be concluded that irrigation development in Bangladesh has been an effective tool for poverty reduction, increasing cropping intensity, grain production, household incomes, waged labour employment and livelihood diversification. It has also provided a major stimulus to the off-farm economy in surrounding areas. The Bangladesh study confirms the conclusion of the Nepal case study (Angood *et al* 2003), that irrigation is most effective as part of a package of measures to support and vitalize the rural economy, of which agriculture is the backbone. Investment in irrigated agriculture provides strong support to the rural community. Investments in other developments, such as roads, schools and healthcare can strengthen impacts, but are complements to a flourishing agricultural sector.

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Annex

1. INTRODUCTION

Studies of three clusters of Shallow Tubewells (STWs) were made in Bangladesh between April and June 2002. The clusters of STWs were located in villages in the North of Bangladesh; Talki village is located in Sherpur district, Mohanpur village in Jamalpur district and Borni village in Netrakona district. Qualitative and quantitative data were collected to assess how irrigation has affected the lives of farmers and others whose livelihoods are linked to irrigated agriculture. The study adapted DFID's Sustainable Livelihoods methodologies to identify the impacts of irrigation on the five development capitals – physical, social, human, financial and natural - over the lifetimes of the three study areas. This report documents initial findings from fieldwork in Bangladesh.

This report is an interim output of the Project R7879, "Contribution of Irrigation to Sustaining Rural Livelihoods". The project has the purpose of seeking to help governments reduce poverty in rural areas in developing countries by providing information for policy makers to ensure that irrigated agriculture secures productive livelihoods for the poor.

The outputs of the project, as set out in the logical framework, are outlined below:

Output 1 Literature review.

Output 2 Information for policy makers to assist governments with planning strategies.

Output 3 Training and promotional material for irrigators.

Output 4 Dissemination activities.

Output 1 was completed as report number ODTN 109, "Contribution of irrigation to sustaining rural livelihoods: Literature review" in 2001. Primary research for the project was conducted on case-study irrigation systems in Bangladesh and Nepal. Three farmer-managed schemes (FMIS) in Nepal, and three villages in Bangladesh grouped around "clusters" of privately-owned shallow tubewells (STWs), have been investigated.

This report complements the research carried out in Nepal, documented in report number ODTN 113, "Contribution of irrigation to sustaining rural livelihoods: Nepal case study". For comparison with surface irrigation systems studied in Nepal, only groundwater irrigation was studied in Bangladesh. Irrigation is primarily from privately installed and owned shallow tubewells (STWs), although a small number of still operating government owned deep tubewells (DTWs) were observed in the study areas. The findings from the literature review and the lessons learnt from both country studies are intended to provide the basis for Output 2, identifying relevant information and recommendations for Policy Makers.

Chapter 2 of this report sets the study in the context of the current irrigation development and policy environment of Bangladesh. A brief methodology of research is then followed by a description of the location of the study areas. Chapter 3 provides a summary of the village/cluster sample characteristics. Chapters 4 to 8 describe the findings of the survey, each chapter titled according to the framework of the five capitals: financial, physical, human, social and natural. Chapter 9 summarises the findings and presents general conclusions of the study.

2. BACKGROUND

2.1 Irrigation development in Bangladesh and policy environment

Bangladesh is a country of 135 million people living in a land area of 0.15 million sq. km. It has a high population density of about 880 persons per sq. km. About 84 percent of the total population live in rural areas and are directly or indirectly engaged in a wide range of agricultural and non-agricultural activities for employment, income and livelihoods. The Gross Domestic Product (GDP) was estimated to have grown by over 6 percent in 2000/2001, while the average rate of growth of GDP during the 1990s stood at nearly 5 percent per annum. Per capita GDP grew at about 7 percent annually during the 1990s.

The structural composition of the economy has also changed significantly in the last decade with the relative contribution of agriculture as the primary sector decreasing and the share of modern sectors such as manufacturing, construction and service sectors increasing (Planning Commission 2001). Agriculture still contributes about a quarter of the country's GDP, one-third of export earnings and provides employment to two-thirds of the civilian labour force (MOA 1999; Planning Commission 2000). The crop sector alone contributes 20 percent of total GDP and 56 percent of agricultural GDP. Although very sluggish, a growth of 0.43 percent was observed in the crop sub-sector during the early 1990s. This growth picked up sharply and registered as high as 4.27 percent during the latter half of the 1990s.

In Bangladesh there is hardly any scope for bringing new land under cultivation. The country lost about 1 million ha of arable land during the period between the last two censuses of agriculture (1983/84 and 1996). This was due to excessive pressure on land for housing and settlement, building physical infrastructures, river erosion and various other non-agricultural uses. In 1996 the country had about 7 million ha of land cultivated by about 12 million farm holdings. This has meant a rapid decline of average farm size from about 0.81 ha in 1983/84 to 0.7 ha in 1996, with a simultaneous increase in land sub-division and fragmentation (Bangladesh Bureau of Statistics 1999). While there has not been any apparent adverse impact of declining farm size on productivity or equity, such change in the land resource base warrants appropriate technological innovations, as well as new forms of production organisation. Development of irrigation water markets, power tiller hire services, contract growing of vegetables and poultry are some of the recent examples of changing production organisation in Bangladesh.

About 80 percent of farm holdings are small farms, cultivating on average only 0.3 ha. Marginal farmers comprise 34 percent of holdings, with an average farm size of only 0.08 ha, while about 18 percent of farm holdings are medium farmers cultivating 1-3 ha, and the remaining 2 percent are large farmers cultivating above 3 ha (Bangladesh Bureau of Statistics 1999). The majority of the expanding non-farm population (34 percent of rural households) sustain their livelihoods through work in diverse, rural, non-farm activities such as petty business, grain and input trading, shopkeeping, rural transport, construction work and carpentry. There has been a slow growth in the farm labour force, whereas nominal and real wage rates of farm labourers have risen. This has not, however, affected crop sector output growth because significant parts of farming operations are now performed by increasing farm mechanisation, e.g. use of power tillers/tractors, irrigation pumps, hand weeders and paddle threshers.

During the 1990s, agriculture and horticulture (excluding fisheries) grew, on average, at about 2 percent per annum, which has been above the population growth rate. The average growth rate of the sector in the second half of the 1990s has risen sharply to over 4 percent. The major source of agricultural growth was the accelerated production of foodgrains, i.e. rice and wheat, which has grown over 4.5 percent annually since 1995/96. Total foodgrain production in the country rose to 26.5 million tons in 2000/01, a surge in food production in recent years that has been above the long-term trend. This has resulted in a cereal food surplus of about 1.5 million tons above the country's total food intake requirements (World Food Programme 2001).

The growth of the economy has been predominantly led by agriculture, characterised by smallholder farming, but has diversified considerably in both crop and non-crop enterprises. This, coupled with the

growth of rural non-farm activities, as well as expansion of government income transfer programmes, has had a significant impact on poverty reduction. The head count ratio of rural poverty dropped from 47.9 percent in 1995/96 to 44.9 percent in 1998/99 (Planning Commission 2001). The rapid growth in the foodgrains, fishery and livestock sub-sectors, linked with service sectors, has generated additional employment opportunities. The real wage of agricultural labourers, in terms of rice, has improved significantly and has led to an increase in average per capita calorie intake from 2206 kcal in 1995/96 to 2268 kcal in 1999/2000 (Mandal and Palmer-Jones 2000).

Since the early 1980s, the main impetus to foodgrain output growth in Bangladesh has come from the rapid development of minor irrigation technologies, especially groundwater irrigation by tubewells. The earlier development of minor irrigation depended heavily on the actions and support of the government through the Bangladesh Agricultural Development Corporation (BADC). Irrigation engines and pumps were heavily subsidised to supplement the high capital costs of equipment and also to popularise green revolution technologies for augmenting the production of rice. However, growth of irrigation in the public sector domain turned out to be very slow and rice production suffered (Palmer-Jones 1988).

Step-by-step liberalisation of markets for modern inputs in agriculture was carried out in the 1980s and 1990s in Bangladesh under pressure from foreign donors. It was realised that various direct interventions were fiscally unsustainable and unproductive. Prior to liberalisation, the Bangladesh Agricultural Development Corporation (BADC) had a virtual monopoly over fertiliser and agricultural equipment markets, while conforming to government pricing and related policies. Most of BADC's equipment was imported using foreign aid because domestic capacity for producing diesel engines and pumps and other irrigation equipment was small. Thus liberalising the import trade became the key element for agricultural equipment markets. Prior to the mid 1970s, there was hardly any private initiative in the development of modern irrigation. Publicly initiated programmes implemented by BADC had evolved from expensive large-scale projects to low-cost, small-scale ones using low-lift pumps and then deep and shallow tubewells. Initially, BADC owned, maintained and operated these pump sets, supplying water to farmers for a flat charge per hectare. By the end of the 1960s there were increasing efforts to transfer operational responsibilities to farmer groups and co-operative societies.

In the first major reforms, from 1980 to 1982, BADC sold all its low-lift pumps to private parties. From 1983 to 1985, all irrigation tubewells were transferred to farmers and co-operatives. In both cases, sales were supported by special credit arrangements for purchasers and elicited a good response from farmers. In 1988, restrictions on the import of engines and pumps, and standardisation restrictions limiting the makes and models available, were both withdrawn, resulting in a drastic fall in the price of equipment. By early 1989, the cost of a STW to irrigate 4 to 5 hectares of land had fallen below taka 20,000 (US$600). This was about 60 percent of the subsidised price for such equipment through BADC. This was one of the most significant aspects of agricultural input market liberalisation, as irrigation is the leading factor for growth based on seed-fertiliser technology (Ahmed 2000). Between 1988 and 1996, irrigated area expanded at roughly twice the rate that had been achieved between 1978 and 1986. Agricultural growth resulted from increased irrigated rice area and higher yields from this land, whilst irrigated rice area was the dominant factor influencing fertiliser consumption, and hence again yields (Ahmed 2000).

Thus from the late 1970s the major important policy reforms affecting irrigation included:

(i) liberalisation of imports and distribution of irrigation engines and spare parts;
(ii) rationalisation of duties and taxes on irrigation equipment import;
(iii) removal of engine standardisation restrictions;
(iv) withdrawal of tubewell spacing and siting regulations; and
(v) withdrawal of subsidies on irrigation equipment prices (Mandal and Parker 1995).

Recently, financial and technical support has also been extended to promote supplemental irrigation for *aman* rice in the drought prone areas.

The most significant impact of the market liberalisation and privatisation policy was a marked reduction in prices of engines and other irrigation equipment. This means that irrigation equipment was more widely available at the local level and affordable to the farmers. Farmers now have a wide range of choices of brand and size of engines. Local workshops have grown rapidly to manufacture spare parts and provide fast repair services (IIMI and BSERT 1995; Mandal 2000). Minor irrigation is currently the most dynamic private sector, involving about 1.7 million full or part owners/managers of mechanised irrigation pumps, with another 0.76 million owners and operators of unmechanised and traditional irrigation devices. In addition to this are about 0.16 million rural mechanics who are engaged in the installation, repair and servicing of irrigation pumps and engines (Mandal 2000).

This has led to a rapid growth in irrigated area of about 8 percent per annum since 1991/92. Shallow tubewells (STWs), whose number increased from 235,900 in 1988/89 to 757,044 in 1999/00, have propelled the growth of irrigation. The STW area grew from 0.94 million hectares in 1988/89 to 2.64 million hectares in 1999/00. This meant an average annual growth of around 14 percent in STW irrigation, which covered 81 percent of groundwater irrigation, 64 percent of minor irrigation and 59 percent of total irrigation in 1999/00. Growth of low-lift pump (LLP) and major canal irrigation was moderate, while there has been virtually no growth in deep tubewell (DTW) irrigation. In 1999/2000, total irrigated area stood at 4.48 million hectares, which accounted for around 64 percent of approximately 7 million hectares of cultivated land. Groundwater irrigation technologies as a whole (i.e. STWs, DTWs, and Farmer Managed Tubewells (FMTWs)) covered about 73 percent of the total irrigated area (NMIDP 2000).

The increased access of small farmers to irrigation was facilitated by the significant reduction in the costs of engines and pumps which broke up the monopolistic control by the landed rich or 'water lords' (Boyce 1987; Quasem 1985). The spatial inequity of DTWs that had existed was the result of a misdirected policy which encouraged the installation of subsidised DTWs in areas suitable for STWs. The latter are more appropriate and affordable to small and medium farmers (Gisselquist 1991).

There are inter and intra-regional variations in the extent of irrigation development. For example, the National Minor Irrigation Development Project (NMIDP) census of minor irrigation shows that the Districts of Bogra, Jaipurhat, Naogaon, Dinajpur, Rangpur, Gaibandha, Chuadanga and Tangail have experienced a relatively higher growth of minor irrigation, compared to a slower growth in other areas with equally good groundwater potential. The variations are attributed to socio-economic conditions such as farm size and land tenure systems, as well as physical conditions including agro-ecological characteristics, aquifer characteristics, development of an equipment market at the local level, growth of physical infrastructure, availability of institutional credit and provision of electricity (Murshid 1985; NMIDP 1999). Access to formal credit appears to have been a leading factor influencing the extent of irrigation development. In some areas with poor access to formal credit, but with competition for irrigable plots, new forms of partnership have emerged for investment in irrigation as a business enterprise[1].

Generally, policy has supported a high level of profitability for irrigated rice production, mainly due to the subsidised cost of irrigation, fertilisers, pesticides and credit (Biswas and Mandal 1982; Hamid *et al.* 1982; Jaim and Rahman 1978). However, gradual reduction of direct and indirect subsidies has led to a rise in production costs relative to rice prices and returns from irrigated rice production have decreased (Quasem 1985; Mandal 1989). For example, Mandal and Parker (1995) showed that very low paddy prices in the 1993 *boro* season in Faridpur District, discouraged many farmers from growing irrigated *boro* rice in 1994.

A recent NMIDP census of minor irrigation also revealed that a high price for *aman* rice in the previous season encouraged potential investors to respond quickly to foodgrain shortages by installing a considerable number of new irrigation units (NMIDP 2000). More importantly, diversification of

[1] Such partnerships are not just the result of credit market failure but offer opportunities for: mobilisation of capital for purchase and operation of irrigation equipment; meeting of kinship or social obligations; enlargement and protection of a combined plot area; and acquisition of adequate financial security and influence to be able to sell irrigation water without threat of encroachment from competing pump owners (Mandal 2000b).

irrigation from dry season rice irrigation to year round irrigation of rice, vegetables and fruit has increased returns to both irrigators and pump owners (Biswas and Mandal 1993; Mandal and Dutta 1995). Therefore, it is important to maintain a favourable price regime for foodgrains as well as other irrigated crops.

State inspired irrigation institutions, especially farmers' co-operatives (KSS) or the previous rental system for deep tubewells and Low-lift pumps under the BADC, have generally turned out to be inadequate. Such inappropriate institutions not only resulted in irrigation inefficiency, but also inequality in terms of farmers' access to irrigation and income distribution (BAU 1985; Mandal 1987; Palmer-Jones and Mandal 1988). The growth in minor irrigation, as a result of large-scale privatisation in agriculture, has led to the emergence of a rapidly expanding irrigation water market, which has largely been competitive, more efficient and equitable than previous institutional arrangements (BAU 1986; Mandal 2000). Irrigation privatisation has also demonstrated a significant positive impact in terms of equity, as increasing numbers of small and medium farmers have gained greater access to irrigation benefits through ownership of cheaper tubewells and pumps (Mandal *et al.* 1995).

One innovative system of payment for water is by sharing a quarter of the crop at harvest after the water seller has borne all the irrigation pumping costs. This may seem high compared to payment of cash per unit of land or cash per pumping hour. However, if one translates this as credit advancement to water users for the whole season and also as a premium to risk of crop loss, this crop share payment does not seem so exorbitant.

2.2 Methodology

Qualitative and quantitative data were collected for three locations (tubewell clusters) to assess how irrigation has affected the lives of farmers, and others whose livelihoods are linked to irrigated agriculture, including labourers, and agricultural goods and service providers.

The following activities were completed over the period June-July 2002:

- Questionnaire survey of farm households (60 per cluster). For data on farming practices and output the reference period covered the aman 2001, rabi 2001/2002 and boro 2002 seasons.
- Questionnaire survey of other stakeholders (20 labourers, 5 general merchants and suppliers of agricultural goods, 5 crafts, tradespeople and service providers per scheme).
- Key informant interviews.
- Focus group interviews.
- In-depth investigation by a "process investigator" resident at each location for 6-8 weeks, using a range of data collection methods including semi-structured interviews, case study observation and other informal appraisal methods.

Table 1 summarises the samples selected for the questionnaire surveys and indicates that sample stratification by farm size approximately matched the farm size distribution in the population. The sample selection procedure for farm households is given below.

For each of the three selected villages, areas of irrigated land were divided into 'tubewell clusters' after consultation with villagers and consideration of a resource map of the village and its surrounds. A cluster of STWs, was selected which had an average concentration of wells, and was judged to be representative of both farming conditions for the village and of the socio-economic conditions of farmers. The cluster consisted of 9 STWs in Talki, and 10 STWs in both Mohanpur and Borni.

The STW owners for the selected cluster and other farmers who use water from the same STWs were then listed. Table 1 shows how this population of farmers was then categorised by farm size, and the stratified sample that was then selected at random for each size category.

The other household categories surveyed were labourers, crafts, trades people and service providers, and merchants and suppliers of agricultural goods. These categories were purposively selected to include a range of livelihood activities from households which had economic linkages to the farming activities of the selected tubewell cluster.

Where possible the head of each household was interviewed. In cases where the head of the household was not present, and appropriate household member was interviewed.

Table 1 Distribution of questionnaire survey samples

		Farm households						
Village (District)		Small (Less than 1 ha)		Medium (1.01-3.0 ha)		Large (Above 3 ha)		Total
Talki (Sherpur)	Total No.	(75)	79%	(18)	19%	(2)	2%	(95)
	Sample No.	43	72%	15	25%	2	3%	60
Mohanpur (Jamalpur)	Total No.	(76)	88%	(8)	9%	(2)	2%	(86)
	Sample No.	50	83%	8	13%	2	3%	60
Borni (Netrokona)	Total No.	(51)	65%	(25)	32%	(3)	4%	(79)
	Sample No.	37	62%	20	33%	3	5%	60
Total		130		43		7		180

Study areas		**Other households**			
Village (District)		Labourers	Merchants and suppliers of farm inputs	Crafts, trades and service providers	STW owners
Talki (Sherpur)	Total No.	n/a	n/a	n/a	(52)
	Sample No.	20	5	5	9
Mohanpur (Jamalpur)	Total No.	n/a	n/a	n/a	(80)
	Sample No.	20	5	5	10
Borni (Netrokona)	Total No.	n/a	n/a	n/a	(67)
	Sample No.	20	5	5	10
Total		60	15	15	39

Note: Figures within parentheses indicate population size.

2.3 Village/Tubewell cluster characteristics

All three villages are based in low lying areas of similar topography. Mohanpur and Borni village areas include a large number of beels, and Borni village is surrounded by beels on three sides. Mohanpur is the most susceptible to flooding of the three and has suffered the most from the consequences of two big floods in recent years (1988 and 1998).

Figure 1 shows the location of the three study villages, more detailed maps of each village can be found in Annex 1.

Figure 1 Location of the three study villages

Talki

This village is located in the south-east of Nakla Upazila within Sherpur district. The village is accessible by road from the Sherpur (district) highway. In the period before the use of irrigation the population of this village was 2500 but has now increased to approximately 3500.

Irrigation commenced in 1973 when the first DTW was installed. Then in 1984 STWs were installed for the first time, and by 1992 there were a total of 10 STWs in use. In 1995 the sealed road was constructed which passes through the eastern part of the village and provides good transport and marketing facilities. In 2002 the number of STW owners has increased dramatically to 52.

Mohanpur

The village is located in the north-eastern part of Jamalpur Sadar Upazila within Jamalpur District, and 16 km from Jamalpur town. The village is near to the Jamalpur- Mymensingh highway and is connected to it by three earth tracks. Population is approximately 6000.

A DTW was installed at Mohanpur in 1975 and cultivation of MV Boro paddy commenced in that year. Given reliability problems for the DTW and to guarantee the cultivation of MV Boro rice a STW was first installed by one villager in 1978 (financed by the Bangladesh Krishi Bank). The number of STWs in use has increased from 4 in 1992 to 80 in 2002.

Borni

This village is located in the northwest region of Netrakona Sadar Upazila within Netrakona district, and 9 km from Netrakona town. The village is connected with the Netrakona- Mohongonj sealed road by a 4 km raised earth track. The total area of the village is about 4 km^2 and it is surrounded by three *beels* (water bodies in low lying areas that are largely perennial). The village population is about 5000 people. The main occupations are farming, fishing, labouring and government service.

Irrigated MV Boro paddy production commenced in the village in 1977 when the first DTW was installed. From 1980 the majority of farmers began to grow irrigated MV Boro paddy. The first STWs innovators installed wells in 1982 and 1987 which are now disused. From 1985 superior MVs became available and were cultivated intensively, with farmers obtaining better per hectare yields than ever before. Flooding caused unprecedented damage in 1988. In 1990 government, providing the essential and main access route, constructed the raised earthen track to the village. It wasn't until 1990 that STWs were widely installed, by 1992 10 STWs were operating. In ten years this figure increased to 67.

3. FARM HOUSEHOLD SAMPLE CHARACTERISTICS

3.1 Land distribution

Table 2 Cultivable and total owned holdings of sample households (hectares)

	Talki		Mohanpur		Borni	
	Cultivable	**Total**	**Cultivable**	**Total**	**Cultivable**	**Total**
Mean area (ha)	0.71	0.80	0.60	0.69	1.01	1.18
St. dev.	1.18	1.23	1.03	1.17	0.92	1.04
Median	0.40	0.47	0.25	0.34	0.70	0.85
Maximum	8.10	8.30	7.04	8.18	5.26	5.36
Minimum	0	0.01	0	0.02	0.08	0.13
Sample	60	60	60	60	60	60

Note: total holdings include cultivable land, homestead area, ponds and orchards.
Source: questionnaire survey.

Table 3 Size distribution of owned farm holdings and average owned area, nationally and for selected districts

	Small <1ha	**Medium, 1 to 3.03 ha**	**Large >3.04 ha**	**All farms**
Bangladesh				
Percentage of holdings	79.9	17.6	2.5	100
Percentage of area	43.1	39.4	17.5	100
Average farm size (ha)	0.87	3.61	11.18	1.61
Sherpur district/zila				
Percentage of holdings	81.0	16.9	2.1	100
Percentage of area	41.4	42.1	16.6	100
Average farm size (ha)	0.78	3.80	11.98	1.52
Jamalpur district/zila				
Percentage of holdings	83.4	15.1	1.5	100
Percentage of area	47.1	41.1	11.9	100
Average farm size (ha)	0.82	3.96	11.46	1.46
Netrakona district/zila				
Percentage of holdings	72.2	23.1	4.7	100
Percentage of area	31.7	41.8	26.4	100
Average farm size (ha)	0.96	3.95	12.19	2.18

Notes:
Size categories normally denoted in acres; small <2.49 acres, medium 2.5-7.49 acres, large >7.5 acres.
Owned land is land held with legal title or with "owner-like possession".
Source: The Bangladesh Census of Agriculture 1996.

Mean farm size for all three villages is less than the national average, but close to the average for small farms (Tables 2 and 3). For all three villages the distribution of land ownership is skewed with the majority of households (65-88 percent) having holdings of less than one hectare (Table 1). The median size holding on all three schemes ranges from 0.34 hectare for Mohanpur to 0.85 hectare for Borni (Table 2).

It can be concluded that the distribution of farm size in each village is reasonably representative of conditions in its district (Tables 1, 2 and 3). Compared to the national average, Mohanpur, Talki and their corresponding districts have a greater number of small farms and a smaller average farm size whilst Borni village and Netrakona district have fewer small farms and a larger average farm size (Tables 1, 2 and 3).

3.2 Land tenure

Table 4 Operated holdings of sample households (hectares)

	Talki		Mohanpur		Borni	
	Boro 2002	Aman 2001	Boro 2002	Aman 2001	Boro 2002	Aman 2001
Mean area (ha)	0.91	0.86	0.72	0.72	1.16	1.17
St. dev.	1.04	1.22	1.04	1.04	0.78	1.02
Median	0.63	0.52	0.39	0.39	0.95	0.85
Maximum	7.09	8.30	7.33	7.33	3.43	5.36
Minimum	0.05	0.01	0.07	0.07	0.13	0.13
Sample	60	60	60	60	60	60

Note: operated holdings are total owned land plus land rented in, less land rented out to others.
Source: questionnaire survey.

Table 5 Land tenure for cultivable and operated land

	Talki		Mohanpur		Borni	
	Boro 2002	Aman 2001	Boro 2002	Aman 2001	Boro 2002	Aman 2001
% owner holdings	50	78	57	57	70	100
% tenant holdings	8	0	8	8	0	0
% owner-cum-tenant	42	13	35	35	30	0
% landless	0	8	0	0	0	0
% farmers renting in land	50	13	43	43	30	0
Mean area rented in (ha)	0.34 (n=30)	0.43 (n=8)	0.19 (n=26)	0.19 (n=26)	0.41 (n=18)	0
% farmers renting out land	12	2	20	20	30	3
Mean area rented out (ha)	0.52 (n=7)	0.28 (n=1)	0.26 (n=12)	0.26 (n=12)	0.48 (n=18)	0.29 (n=2)
% rentals sharecropped	100	100	61	61	44	50
% rentals cash rents	0	0	39	39	56	50
Sample	60	60	60	60	60	60

Notes: table does not account for homestead or other non-cultivable land owned.
Owner holdings consist exclusively of owned land.
Tenant holdings consist exclusively of land taken from others for operation.
Owner-cum-tenant holdings are combined owner and tenant holdings.
Source: questionnaire survey.

The mean and median operated holdings are larger than owned cultivable holdings in all villages (Tables 2 and 4), indicating that these farmers are net renters in of land in aggregate. Most farmers are owners or owner-cum-tenants, matching the observation that irrigating households are net renters in of land in aggregate (Table 5). Renting in and out of land is more prevalent in the Boro than Aman season (Table 5). Although land renting in Mohanpur village was generally on an annual rather than seasonal basis, with two crops (MV Boro and T. Aman) typically grown.

It is also notable that 8 percent of farmers in Talki and Mohanpur are tenants for all their cultivated land (although they own at least their homestead area). This 8 percent have no cultivated land in the Aman season in Talki and thus become effectively landless outside the Boro season (Table 5). All land renting

for the sample in Talki was by sharecropping, but there is a more even split between sharecropping and cash rents in Mohanpur and Borni (Table 5).

Although detailed sharecropping information was not collected, it usually occurs on a 50 percent basis, that is the landowner receives 50 percent of the harvest. In all three study villages and their surrounding area, any irrigation water purchased from a nearby STW owner was paid for on a cash basis. However, in other regions of Bangladesh it has been reported that the water supplier bears all pumping costs and receives 25 percent of the harvest; the remaining 75 percent then being divided 50/50 between the sharecropper and the landowner where land is sharecropped.

3.3 STW ownership and irrigated plots

Table 6 STW ownership

	Talki	Mohanpur	Borni
STW owners	6	4	10
% of sample owning STW	10%	7%	17%
Mean STWs owned	1.2	1	1.2
Minimum	1	1	1
Maximum	2	1	2
Mean operated holding in Boro 2002 (ha)	2.19	1.84	2.05
Sample	60	60	60

Source: questionnaire survey.

Table 7 Characteristics of farmer plots irrigated by the sample STWs

	Talki	Mohanpur	Borni
Mean no. of plots per farmer	2.10	2.13	3.47
Median	2	2	3
Maximum	7	8	9
Minimum	1	1	1
Mean total area irrigated from sample STW per farmer (ha)	0.77	0.21	0.54
Mean area per plot (ha)	0.36	0.09	0.15
Mean no. of plots per ha	5.27	12.90	8.10
% of all plots that can be irrigated from >1 STW	24%	28%	0%
Sample	59	60	60

Source: questionnaire survey.

In general STW owners have larger holdings than other farmers. The mean holding size of STW owners (Table 6) is larger than the mean of all farmers surveyed (Tables 2 and 4). The mean area irrigated by sample STWs (Table 7) is also less than the mean area operated (Table 4), indicating that some farmers have other plots in other areas of the village. This is particularly the case for Mohanpur.

The STW survey area selected in Mohanpur appears to have a smaller average plot size than the other two villages, and a relatively high degree of plot fragmentation. The survey area for Borni appears to have a higher degree of fragmentation as indicated by number of plots per farmer for the selected STWs, although average plot size is larger than for Mohanpur (Table 7).

Respondents indicated that approximately a quarter of the plots in the STW survey areas in Talki and Mohanpur could be irrigated from more than one STW, but this did not apply to any plots in Borni.

3.4 Household composition and labour availability

Table 8 Household dependency and labour availability characteristics of sample households

	Talki			Mohanpur			Borni		
Household members	mean	Max	min	Mean	max	min	mean	max	min
Adults >16 years	3.3	9	1	3.3	8	1	4.1	8	2
Children <16 years	1.6	5	0	1.9	4	0	2.6	6	0
% adults that do farm work	0.8	1	0	0.6	1	0.1	0.4	1	0
Dependency ratio[1]	1.2	4	0	3.9	8	1	3.6	10	0.7
% of households with children[2]	77%			83%			92%		
% households with children doing farm work[3]	8%			3%			13%		
% households with adult working away[4]	17%			5%			23%		

Notes:
[1] Dependency ratio is the number of children and non-working adults resident in the household, per adult who does farm work.
[2] Percentage of sample households with one or more children.
[3] Percentage of sample households with one or more children regularly engaged in farm work.
[4] Percentage of sample households with one or more adults living and working away from the scheme.
Source: questionnaire survey.

Values given in Table 8 may involve some minor survey error. For example, in Talki and Borni there were a few households where no adults were reported to do farm work, however, these households may have relied on hired labour for cultivation. It should also be noted that the calculated dependency ratio does not allow for non-farm work by adults still living in the household. These adults are treated as dependants, whereas they may be bringing in income. Compared to a similar assessment made in Nepal, a significantly higher proportion of adults recorded as not doing farmwork in the Bangladesh sample.

Although most households include children under 16 years of age, only a small proportion (3-13 percent) report that children are regularly engaged in farm work (Table 8). This corresponds with data on school attendance (Table 49, Section 6.4) and indicates that households are well motivated and financially able to ensure that children receive schooling. Similarly the incidence of children being employed in the family business for the other household categories (agricultural goods and service providers) was very low.

4. FINANCIAL CAPITAL

Financial "capital" consists of the financial resources that people use to achieve their livelihood objectives. The definition used here includes flows as well as stocks and it can contribute to consumption as well as production. There are three main forms of financial capital: savings in cash, bank deposits or liquid assets such as livestock and jewellery; loans obtained from formal or informal credit-providing institutions; and regular inflows of money including earned income, pensions, transfers from the state, and remittances.

This section assesses the extent to which irrigation development has enhanced the financial capital of stakeholders. This occurs through the direct benefits of increased farm productivity gained by farm households and increased employment for farm labour, and through the indirect benefits generated by linkages with the local economy. Results of the household surveys are presented first, followed by discussion of the key findings from key informant interviews, focus group discussions and process investigators.

4.1 Irrigation impacts on cropping

The transformation of cropping options resulting from the introduction of irrigation in Bangladesh (table 9) is less dramatic than was observed in a similar study in Nepal. The introduction of an irrigated boro paddy crop is the main change, and generally aus and aman crops of Local Variety (LV) paddy have been replaced by boro and aman crops of MV paddy. The use of transplanting has also generally replaced broadcasting for the aman paddy crop, whilst the irrigated boro crop is also usually transplanted. Modern Varieties (MVs) have generally replaced LVs in both aman and boro seasons. At the same time diversity in the cropping pattern has reduced as much less jute and sugarcane are now grown. Farmers also report that fewer of them now grow rabi crops of wheat and mustard, whilst drought resistant pulse crops such as "kheshari" and gram have also largely disappeared.

These changes in cropping pattern, compared to the situation without irrigation, are summarised in Table 10.

Table 9 Comparison of crops grown by sample households, before and after irrigation development (percentage of sample households growing the crop)

	Aus crops			
	Paddy	Jute	Sugar cane	Kheshari
Talki				
Before irrig.	100	57	62	5
Mohanpur				
Before irrig.	100	98	90	0
Borni				
Before irrig.	98	100	2	68

	Aman crops				
	Transplanted Aman (paddy) LV	Transplanted Aman (paddy) MV	Broadcast Aman (paddy)	Sugar Cane	Jute
Talki					
Before irrig.	97	-	2	2	0
After irrig.	0	95	0	22	8
Mohanpur					
Before irrig.	85	-	45	3	0
After irrig.	25	80	0	3	0
Borni					
Before irrig.	17	-	98	0	0
After irrig.	98	5	0	0	0

Note: before irrigation all transplanted aman cultivation was predominantly local variety (LV).

	Rabi crops		
	Mustard	Wheat	Gram
Talki			
Before irrig.	17	47	0
After irrig.	3	10	0
Mohanpur			
Before irrig.	67	75	0
After irrig.	13	27	0
Borni			
Before irrig.	95	80	7
After irrig.	35	35	0

	Boro crops	
	Boro paddy, LV	Boro paddy, MV
Talki		
Before irrig.	0	-
After irrig.	2	90
Mohanpur		
Before irrig.	98	-
After irrig.	0	98
Borni		
Before irrig.	15	-
After irrig.	3	93

Source: questionnaire survey

Table 10 Summary of cropping pattern changes at scheme level

Scheme	Before use of irrigation	Current
Talki	Aus and aman crops of LV paddy (transplanted), and rabi crops of wheat and mustard by some growers (<50%). No Boro paddy. Jute and sugar cane widely grown (<65%). Also some onion, chilli, pulses, potato, aubergine and garlic reported by key informants and process investigator.	Boro and aman crops of MV paddy (transplanted). A little rabi wheat and mustard (<10% of growers). Some sugar cane and jute (<25%). Some potato. Aman paddy, mainly transplanted both before and after irrigation.
Mohanpur	Aus and aman crops of LV paddy (transplanted and broadcast), and rabi crops of wheat and mustard by some growers (<75%). Boro LV paddy widely grown (98%) with use of traditional surface irrigation. Jute and sugar cane very widely grown (90-98%). Also some onion and pulses reported.	Boro crop of MV paddy, and aman crop of MV and LV paddy (transplanted). A little rabi wheat and mustard (<30% of growers). No jute, and very little sugar cane (<3%).
Borni	Aus and aman crops of LV paddy (mainly broadcast), and rabi crops of wheat and mustard by most growers (<95%). Some Boro paddy (15%). Jute universally grown (100%) and some "kheshari" (<70%). Also some pulses reported.	Boro crop of MV paddy, and aman crop of mainly LV paddy (transplanted). Some rabi wheat and mustard (<35% of growers). No sugar cane or jute.

Source: questionnaire survey and Process Investigators reports.

4.2 Irrigation impacts on crop yields

Irrigation can result in higher and less variable yields compared to equivalent rainfed crops. Cultivation of the Boro paddy crop is the main direct benefit of irrigation for farm households in Bangladesh. Table 11 shows that the expected average paddy yield for this crop is 3 to 4 times greater than that of the aus-aman paddy crop which it has tended to replace. Not all of this yield increment is attributable to irrigation, but irrigation allows cultivation of the crop during the season when flood and other weather related threats to cultivation are less, and irrigation also encourages and facilitates use of the green revolution technology package of higher yielding modern varieties and fertiliser.

The expected variation in the best and worse years is also less for irrigated boro paddy than the aus-aman crop. However, variation in yield can still be high, particularly at Borni, indicating that irrigation reliability may not be as good as is needed, or that factors other than soil moisture status are still important in influencing output. Pre-monsoon cyclones and hailstorms remain a major source of risk, particularly when they occur in the period immediately prior to harvest.

The data in Table 11 is based on respondent estimates of the expected or average yield on their land, plus a measure of variation provided by their estimates of yields in the worst and best years. However, it is worth noting that the survey period coincided with the boro harvest of 2002 when yields were expected to have been much reduced by the damaging effects of hailstorms in May. Estimated losses ranged from 60-90% of the value of the crop in Talki and Borni, and from 10-30% in Mohanpur. This was the result of unusually early and severe storms in the pre-monsoon period, and may have influenced the yield estimates provided. In particular the comparatively low Boro yield for Borni village may be a result of biased perceptions following crop damage in 2002. Generally lower yield estimates across crops for Borni may also reflect a greater susceptibility of much of the cropped land to flooding, and the degree to which the village is more remote and less progressive in farming than the other two villages.

Table 11 Expected average crop yields and range of variation, farm household estimates (kg/ha and percentage variation)

	AUS-AMAN PADDY				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Talki					
Before irrig.	**1261**	340	+41	-36	60
Mohanpur					
Before irrig.	**1367**	146	+44	-51	60
Borni					
Before irrig.	**1276**	155	+96	-51	60

	BORO PADDY				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Talki					
With irrig.	**4314**	595	+27	-23	60
Mohanpur					
With irrig.	**5061**	171	+32	-35	60
Borni					
With irrig.	**3726**	804	+78	-59	60

Mean yields in bold for aus-aman and boro are significantly different for each village, $P<0.01$ [2].

	AMAN PADDY				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Talki					
Before irrig.	**2118**	499	+34	-32	60
After irrig.	**2371**	449	+31	-28	60
% change	+12%				
Mohanpur					
Before irrig.	**1850**	161	+38	-33	60
After irrig.	**3293**	0	+21	-21	60
% change	+78%				
Borni					
Before irrig.	**1317**	240	+94	-52	60
After irrig.	**1914**	553	+94	-64	60
% change	+45%				

Mean values in bold are significantly different, $P<0.01$[3].
Source: questionnaire survey.

The aman paddy crop remains a predominantly rainfed/monsoon crop, although farmers may use some supplementary irrigation if there are prolonged dry periods. Higher yields now compared to the period before irrigation are mainly attributable to the increased use of transplanting rather than broadcasting, increased use of MVs compared to LVs, and increased use of fertiliser. Supplementary use of irrigation may have also contributed. For the Aman 2001 crop, no Talki farmers, seven percent of Mohanpur farmers, and twenty-seven percent of Borni farmers reported using some irrigation. This corresponds to three percent of the area cropped for Mohanpur, and thirty-seven percent of the area for Borni.

[2] According to T-test for unpaired observations.

[3] According to T-test for matching paired observations and Wilcoxon matched-pairs signed-ranks test (a robust non-parametric test, not requiring the assumption that the variables are normally distributed).

The increase in expected average yield for the aman crop has been greatest at Mohanpur, where some reduction in yield variation was also reported. However, there appears to have been little change in the expected variation in aman yield at Talki and Borni, and if supplementary irrigation plays a significant role this change would be expected to be more noticeable.

4.3 Irrigation impacts on land value

Table 12 shows that Mohanpur has the highest mean, and also greatest variability in land value. One hundred percent of farm household respondents in all three villages agreed that ability to irrigate from a STW increased the value of that land.

Table 12 Reported value of farm land, Tk per hectare

	Talki	Mohanpur	Borni
Mean	452422	587226	230945
St dev	26318	73372	22197
Maximum	494000	741000	247000
Minimum	419900	494000	172900
Respondents	60	60	60

Source: questionnaire survey. $1 USD = 55 Tk (June 2002)

4.4 Changes in input use

Table 13 Input use before irrigation (percentage of farm household respondents using the input)

	Talki				Mohanpur				Borni			
Input	Aus	Aman	Rabi	Boro	Aus	Aman	Rabi	Boro	Aus	Aman	Rabi	Boro
Chemical fertiliser	2	0	2	0	0	0	0	0	0	25	8	0
Pesticides	0	0	0	0	0	0	0	0	2	15	0	0
Hired labour	93	20	12	0	100	100	10	0	85	92	0	0
HYVs	2	0	2	0	0	0	0	0	2	2	0	0
Power tillers	2	2	0	0	0	0	0	0	0	0	0	0

Source: questionnaire survey.

The development and use of irrigation has been associated with the increased and more intensive use of agricultural inputs in each of the three villages. The boro season rice crop is particularly input intensive, compared both to cropping prior to irrigation, and to rice cultivation in other seasons in the current situation. Use of chemical fertilisers or pesticides was rare prior to irrigation when the main purchased input was only hired labour (Table 13), but is now widespread for the major crops (Table 14). Nitrogenous fertiliser (urea) is commonly used in all villages for both the aman and boro rice crops, but other nutrients are also commonly applied in the boro season, and at Mohanpur in the aman season. Compost is commonly used as an organic fertiliser at all three villages, but a much smaller proportion of growers uses manure from livestock.

Use of power tillers for land preparation has become almost universal at Mohanpur and Borni, though less so at Talki. The use of contract labour for the major agricultural tasks such as harvesting is not a major feature of farming practice, although it is utilised by a third of growers at Borni (this was a significant practice observed in a similar study in the Nepal terai).

Table 14a Input use for major crops after irrigation (percentage of farm household respondents who used inputs in Aman 2001)

Aman 2001	Talki			Mohanpur			Borni		
Input	T.Aman MV	T. Aman LV	S. cane	T.Aman MV	T. Aman LV	S. cane	T.Aman MV	T. Aman LV	S. cane
Pesticides	75	n.a.	8	0	0	0	33	7	n.a.
Power tiller	14	n.a	0	96	80	0	67	83	n.a
Contract farm labour	7	n.a.	0	0	0	0	67	32	n.a.
Daily farm labourers	65	n.a	8	98	87	0	33	83	n.a
Manure	4	n.a.	0	17	33	0	0	56	n.a.
Compost	53	n.a	8	94	87	0	0	17	n.a
Urea	91	n.a.	8	98	87	0	33	92	n.a.
Muriate of potash	9	n.a	8	96	87	0	100	17	n.a
DSP	7	n.a.	8	88	73	0	67	3	n.a.
Zinc sulphate	0	n.a	0	23	33	0	0	2	n.a
No. of growers	**57**	**0**	**13**	**48**	**15**	**2**	**3**	**59**	**0**

Table 14b Input use for major crops after irrigation (percentage of farm household respondents who used inputs in Rabi 2001/2002)

Rabi 2001/2002	Talki		Mohanpur		Borni	
Input	Mustard	Wheat	Mustard	Wheat	Mustard	Wheat
Pesticides	0	0	0	0	0	0
Power tiller	0	0	0	6	14	14
Contract farm labour	0	0	0	0	5	0
Daily farm labourers	0	0	0	6	10	5
Manure	0	0	0	13	19	10
Compost	50	0	0	13	0	0
Urea	50	0	0	13	0	5
Muriate of potash	0	0	0	13	0	5
DSP	50	0	0	0	0	5
Zinc sulphate	0	0	0	6	0	0
No. of growers	**2**	**6**	**8**	**16**	**21**	**21**

Table 14c Input use for major crops after irrigation (percentage of farm household respondents who used inputs in Boro 2002)

Boro 2002	Talki		Mohanpur		Borni	
Input	Rice MV	Rice LV	Rice MV	Rice LV	Rice MV	Rice LV
Pesticides	72	100	92	n.a.	45	0
Power tiller	26	100	97	n.a	96	0
Contract farm labour	6	0	5	n.a.	36	0
Daily farm labourers	96	100	97	n.a	80	0
Manure	7	0	68	n.a.	41	0
Compost	100	100	100	n.a	23	0
Urea	100	100	100	n.a.	98	0
Muriate of potash	100	100	100	n.a	100	0
DSP	93	100	98	n.a.	96	0
Zinc sulphate	0	0	63	n.a	46	0
No. of growers	**54**	**1**	**59**	**0**	**56**	**2**

Source: questionnaire survey.

It is apparent from tables 13 and 14 that the adoption of irrigation in the three sites has proceeded in parallel with the increased use of high yielding modern varieties, and of pesticides and chemical fertilisers, i.e. adoption of the "green revolution" package of technology.

4.5 Irrigation impacts on labour use

It is expected that irrigation will result in higher and more continuous employment for farm labour. This appears to be the case for Mohanpur and Borni (Table 15), whereas the majority of survey responses indicated no change for Talki.

Table 15 Reported change in use of hired labour since start of use of tubewell irrigation (percentage of farm household respondents regularly hiring labour)

Change in hired labour use (%)	Talki	Mohanpur	Borni
Increased	12	88	90
Decreased	0	12	0
No change	88	0	10
Respondents	**60**	**59**	**58**

Source: questionnaire survey.

At Talki increased labour demand for weeding was cited as the main reason for increased use of hired labour. One respondent attributed irrigation use and another suggested transplanting as reasons for an increased labour demand.

At Mohanpur greater intensity of land use, higher yields and a growth in farm work without increased family labour were cited as the main reasons for increased use of hired labour. Cultivation of HYVs was also cited by one respondent. Those respondents reporting a decrease in labour use had small enough portions of land for their labour needs to be met within the family, or were placing an increased importance on non-farm activities compared to farm work.

At Borni an increase in the available farm work, increased need for weeding, boro cultivation and higher wages since irrigation were cited as the main reasons for increased use of hired labour.

Table 16 Source of hired labour (number of responses)

	Talki		Mohanpur		Borni	
	Before irrign.	Now	Before irrign.	Now	Before irrign.	Now
Local area (<1 day away)	57	59	60	60	31	59
>1 day away (same district)	1				2	1
Another district	1				15	
No hired labour					12	

Source: questionnaire survey.

Table 16 shows that both before and since the use of irrigation the majority of hired labour has been drawn from the immediate local area. Less than one day away indicates that labourers generally return to their own homes at night. The responses for Borni indicate that less labour now comes from further away than was the case in the period prior to irrigation.

Table 17 Wage rates for hired labour (Tk/day), Boro season 2002

	Talki (n=58)		Mohanpur (n=60)		Borni (n=54)	
	Mean	Mode	Mean	Mode	Mean	Mode
Wage rate, Tk/day	65.3	70	70.5	70	60.6	60
Number of meals provided	3	3	3	3	2.7	3

Source: questionnaire survey. $1 USD = 55 Tk (June 2002)

Hired labour at Talki and Mohanpur was universally reported as being paid a daily rate, rather than on a contract or piecework basis. Six instances of contract labour were reported for Borni, otherwise labourers there were also paid a daily wage.

Reported wage rates for farm labour for the Boro 2002 season ranged from 50-100 taka per day. Table 17 shows that both the mean and modal wage were slightly lower at Borni than the other two villages. It was common for three meals to be provided.

Reported contract labour rates for piecework at Borni village were as follows:

- Transplanting: 50-75 Tk per kutta (1500-2300 per ha)
- Weeding: 30-65 Tk per kutta (900-2000 per ha)
- Harvesting: 80-120 Tk per kutta (2400-3700 per ha).

Table 18 Percentage of farm household respondents employed as farm labourers by other households (by season)

Location	Talki		Mohanpur		Borni	
Type of agriculture respondents employed in	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Aman	20	10	5	23	12	3
Rabi	5	20	13	10	3	2
Boro	28	3	23	3	30	2
Respondents, n	60	60	60	60	60	60

Source: questionnaire survey.

Table 18 shows that although the majority of farm household respondents (household heads) do not generally work as paid labour on other farms, a significant minority do. Incidence of this is most common during the boro season on irrigated land, reflecting the higher productivity and labour demands of the irrigated crop in this season.

4.6 Livestock

Table 20 shows that poultry (chickens and often ducks) are kept by most. Cows are kept by over 70 percent of households in Talki and Borni, but by much fewer households in Mohanpur (13 percent). In all three villages typically only 1-3 head are kept and thus this is primarily for own consumption of dairy products. Goats are kept by less than half of all households, and less than 25 percent in Mohanpur.

Table 20 Percentage of farm household respondents owning livestock and mean number owned per household

Livestock	Talki		Mohanpur		Borni	
	Percentage owning	No. owned	Percentage owning	No. owned	Percentage owning	No. owned
Cow	77	2.9	13	1.4	72	1.7
Bull	3	1.5	17	1.9	32	1.3
Buffalo	0	-	2	2	0	-
Goat	47	3.8	23	2.1	35	2.5
Sheep	0	-	0	-	2	5
Poultry	92	11	78	6.4	83	21
Respondents	60		60		60	

Source: questionnaire survey.

Table 21 confirms the lesser importance of livestock production at Mohanpur compared to the other two villages. Mean income from livestock was highest at Borni, although also most unevenly distributed amongst households.

Following the introduction of irrigation in Mohanpur and Borni, livestock numbers are almost universally reported to have decreased (Table 22). The main reason given for this in both villages was a shortage of grazing land. Some respondents from Borni indicated that some grazing land had been converted to crop land. This particularly applies to land use in the boro season. Reduced cultivation of fodder crops was also mentioned. Quarrels over grazing land were cited by some Mohanpur respondents as a reason for the reduction in livestock numbers. Problems of animal disease and increased use of power tillers in place of draught animals were also mentioned.

Table 21 Reported income from livestock, 2001/2002

	Talki	Mohanpur	Borni
Mean income from all livestock (Tk)	2536	624	4311
Maximum (Tk)	11601	6360	26205
Minimum (Tk)	0	0	0
Standard deviation (Tk)	3184	1240	6308
Sample (n)	60	60	60
% sample reporting some livestock income	82%	47%	82%
Mean income reported (Tk)	3105	1337	5279
Minimum (Tk)	200	200	50
Number reporting some livestock income (n)	49	28	49

Source: questionnaire survey. $1 USD = 55 Tk (June 2002)

Table 22 Percentage of farm household respondents reporting a change in the number of livestock kept since they started using irrigation

Change in livestock numbers	Talki	Mohanpur	Borni
Respondents reporting an increase	0	0	2
Respondents reporting an decrease	8	100	96
Respondents reporting no change	92	0	2
Total no. of respondents	60	60	60

Source: questionnaire survey.

The situation for Talki differs from the other villages as the majority of respondents indicated that there had been no change in livestock numbers, perhaps reflecting greater availability of grazing. Cattle ownership is also noticeably higher for this village (Table 20). The five respondents who did report a decrease in livestock numbers cited a lack of grazing and increased use of power tillers as the reasons for this.

Overall it appears that irrigation development has tended to be associated with a reduction in livestock numbers. This implies a reduction in output of livestock products. There does not appear to have been a matching intensification of production as was observed in a similar study in Nepal, where the adoption of improved breeds and stall feeding after introduction of irrigation was common. The majority of households that kept large numbers of livestock before irrigation may have reverted to production for own consumption only, rather than seeking to supply the market. Decreasing livestock numbers means a decreased local supply of manure as a fertiliser or for use as fuel. The exceptions to this lack of intensification are examples of intensive housed poultry production, of which there were examples in Mohanpur and Borni.

4.7 Other sources of income

Table 23 provides some indication of the extent to which income sources for the farm household as a whole are diversified. Income from these sources was very variable and thus the mean figures given are purely indicative. Small businesses and other sources of income reported included: fishing, aquaculture, a power thresher, selling irrigation water, rickshaw vans, selling cosmetics and sweets, and trading rice, vegetables, banana and betal.

Table 23 Percentage of farm households receiving income from other sources and mean income earned from that source (Tk)

	Talki		Mohanpur		Borni	
Income source	%	Tk	%	Tk	%	Tk
Fruit trees	33	1205	13	538	25	587
Renting out land	0	-	28	42367	13	10098
Sharecropped land	27	9375	37	6425	20	4619
Salaried employment	8	10400	18	41291	12	18857
Small business	22	8485	37	27909	5	9000
Non-farm labour	33	6200	2	24000	12	7286
Pension	2	1858	0	-	0	-
Family remittances	0	-	0	-	0	-
Other	0	-	13	17688	2	200000
Respondents	60		60		60	

Source: questionnaire survey. ($1 USD = 55 Tk (June 2002)

Table 24 summarises the income earned in aggregate from these other "non-farm" sources. Tables 23 and 24 show that although the majority of households benefit from at least one "non-farm" source of income, these sources are diverse and no one source is particularly common in all three cases.

Table 24 Mean household income from other sources, and percentage of households gaining non-farm income

	Talki	Mohanpur	Borni
Mean income from other sources (Tk)	7704	34993	9250
Maximum (Tk)	27358	206300	210000
Minimum (Tk)	0	0	0
Standard deviation (Tk)	7748	45367	28495
Sample (n)	60	60	60
% sample reporting some 'other income'	78%	85%	63%
Mean income reported (Tk)	9835	41168	14606
Minimum (Tk)	500	400	200
Number reporting 'other income' (n)	47	51	38

Notes:
Other sources excludes irrigated and rainfed cropping, livestock and casual farm labour.
Source: questionnaire survey. ($1 USD = 55 Tk (June 2002)

4.8 Credit and savings

Table 25 indicates that with irrigation the majority of respondents have reported an increased need for production credit. Reasons cited for this were universally the increased requirement for and cost of inputs of fertiliser in particular, also, pesticides, STW water, seed and power tiller use. However, 22 percent of farm households at Mohanpur reported a decreased need for production credit, citing increased yields and incomes as the explanation, thus reflecting increased ability amongst some households to self-finance input requirements.

Table 25 Percentage of farm household respondents reporting change in the need for credit since they started using irrigation

	Talki	Mohanpur	Borni
Need for production credit			
Increased need	73	58	97
Decreased need	0	22	2
No change	27	20	2
Respondents, n	60	60	58
Need for consumption credit			
Increased need	48	8	0
Decreased need	3	90	98
No change	48	2	2
Respondents, n	60	60	58

Source: questionnaire survey.

The need to borrow for consumption purposes has clearly declined with irrigation for Mohanpur and Borni (Table 25). This decline may reflect an improvement in household food security. This was confirmed by the explanations given. For Mohanpur the reason given was generally the increases in yield and income that had been achieved. For Borni this was in almost all cases phrased in terms of increased own production of rice and thus reduced need to purchase the staple food.

The same situation does not appear to hold for Talki where half of the respondents reported an increased need for consumption credit and the other half reported no change. For those reporting an increased need the explanation cited in all villages was an increase in household size. The majority of those reporting no change in the need for consumption credit did explain that they were able to finance consumption from the sale of their own crops (23 cases), and/or their own business (4 cases), sale of livestock (1 case), or non-farm labour (1 case).

Table 26 indicates the source of working capital reported for production and consumption expenditure. It indicates that a majority of households in Talki were able to self-finance both production and consumption mainly from crop sales, whereas in Borni there was a heavy reliance on loans, most of which were obtained from local money lenders. The responses for Mohanpur indicate that neighbours and relatives are used as the main source of finance for production and consumption expenditure when needed, but the responses are incomplete and this finding may not be wholly reliable.

Table 26 Reported source of finance for crop production expenses and for consumption expenditure (percentage of farm household respondents)

Source of finance	Talki		Mohanpur		Borni	
	Production	Consumption	Production	Consumption	Production	Consumption
Livestock sales	3	4	0	0	0	0
Crop sales	64	63	0	0	0	0
Own business	8	11	0	0	0	0
Non-farm work	3	2	0	0	0	0
Neighbours or relatives	5	4	100	100	9	28
Savings group	0	-	0	-	9	-
Moneylenders	0	0	0	0	62	72
NGO	0	-	0	-	15	-
Bank	0	-	0	-	5	-
Loan of unspecified source	15	18	0	0	0	0
Respondents (n)	**59**	**57**	**42**	**37**	**55**	**53**

Source: questionnaire survey.

4.9 Savings

Table 27 suggests that there has been a substantial increase in the number of households able to make savings from their income since the use of irrigation began. Clearly this is likely to be attributable to the higher productivity arising from the irrigated boro crop and increased use of other inputs such as modern varieties and fertiliser. However, over 40 percent of farm households in Talki and Mohanpur and 80 percent of households in Borni are still unable to make regular savings. This clearly limits their ability to invest in improved productive activities, to invest in enhancing their human or social capital, or to diversify their livelihoods. It is likely that a combination of farm size and lack of alternative local employment opportunities are constraining both income and the ability to save.

Savings were notably more common in Talki than the other two villages prior to irrigation, and land and livestock purchase were the main uses of savings. Since irrigation there has been increased savings in all three villages and some use of bank deposit accounts. Use or form of savings is diverse, although purchase of land appears to have been a priority use in all three villages. It is notable that purchase of livestock as a form of savings has not increased greatly (matching findings on livestock trends in section 4.6). Savings groups also appear to have played a more important role in Mohanpur.

Table 27 Percentage of farm household respondents reporting an ability to save and the form of saving taken before and after use of irrigation

	Talki		Mohanpur		Borni	
	Before	After	Before	After	Before	After
Able to save	**37**	**58**	**2**	**57**	**3**	**20**
Form						
Cash	0	3	2	8	0	0
Bank	0	2	0	15	0	7
Livestock	8	12	0	2	3	5
Jewellery	0	2	0	2	0	0
Saving's group	3	3	0	22	0	0
Loans to others	0	0	0	2	2	2
Land purchase	32	45	0	17	0	8
Other	0	0	0	2	0	0
Respondents	**60**	**60**	**60**	**60**	**60**	**60**

Notes:
Percentages for form of savings may sum to more than the percentage able to save as more than one form may apply to one respondent.
Source: questionnaire survey.

4.10 Survey results for other household categories

4.10.1 Labourers

Of the sample of 60 labourers (20 from each village), 58 respondents were married and only two single. The average age of respondent was 36 years old, though the ages ranged from 16 to 70. Compared to the farmer households surveyed (Table 8), the labourer households tend to be smaller in terms of the number of adult members (Table 28). It is notable, however, that a similarly low proportion of children under 16 were reported as being employed in the main occupation of the household, i.e. as farm labourers.

Table 28 Household characteristics of sample labourer households

	Talki	Mohanpur	Borni
Number of Household members	mean	mean	mean
Adults >16 years	2.4	1.9	2.5
Children <16 years	1.9	1.6	2.3
% of h.holds with children[1]	75	85	85
% h.holds with children doing farm work[2]	0	5	10

Notes:
[1] Percentage of sample households with one or more children.
[2] Percentage of sample households with one or more children regularly engaged in farm work.
Source: questionnaire survey.

Fifty-nine of the 60 respondents lived in the local area (they were able to sleep at home after a working day), and only one came from another district. This confirmed that farm labour was predominantly drawn from the immediate local area for each of the three sites. Indeed, 57 (95 percent) of the respondents had been born in the selected village, whilst the three "newcomers" had come from neighbouring districts, and had been there for 12, 10 and 5 years, respectively. All three had worked as labourers in their previous

location. The labourer respondents had worked in the current location for an average of 18 years, with a minimum of 2 and a maximum of 55 years.

Table 29 shows that almost all the labourer households sampled owned their homestead plots. 45-50 percent also owned small plots of cultivable land, though these are small compared to the mean size of holding of the farmer household sample (Table 2), and inadequate for household subsistence alone. Despite the small plot sizes this data does confirm that the majority of labourer households are permanent residents. It can be concluded that they have a long-term 'stake' in any benefits from agricultural improvement and development, and more generally in the socio-economic development of the community.

Table 30 indicates that 20-25 percent of labourer households may also sharecrop a small plot of land, whilst approximately 10% may rent land on a cash rent basis. However, there was considerable variation in the incidence of these two practices at the three locations.

Accounting for cultivable land that is owned, sharecropped or rented for a cash rent, Table 31 shows that 50-70 percent of labourer households have access to at least a small plot of land, and could thus produce some of their own rice requirement or alternative crops. The majority of labourer households may thus benefit directly from irrigation development, to the extent that they are able to cultivate irrigated crops, as well as benefiting from the increased and more continuous levels of farm employment that widespread use of irrigation tends to promote.

Table 29 Land ownership by labourer households (mean area owned in hectares)

	Average (all three villages)	**Talki**	**Mohanpur**	**Borni**
Mean area of cultivable land owned (ha)	0.101	0.076	0.134	0.093
% of households that own cultivable land	47%	45%	45%	50%
Mean homestead area owned (ha)	0.041	0.042	0.034	0.045
% of households that own homestead land	97%	90%	100%	100%
Total mean area of all land owned (ha)	0.089	0.072	0.096	0.098
% of households that own land	100%	100%	100%	100%
Sample (n)	60	20	20	20

Source: questionnaire survey.

Table 30 Land sharecropped or rented by labourer households (mean area in hectares)

	Average (all three villages)	Talki	Mohanpur	Borni
Mean area of land sharecropped (ha)	0.22	0.14	0.22	0.33
% of households sharecropping	23%	20%	35%	15%
Mean area of rented land (ha)	0.11	0	0.08	0.18
% of households renting land	12%	0%	25%	10%
Sample (n)	60	20	20	20

Source: questionnaire survey.

Table 31 Land cultivation by labourer households (mean area in hectares for total of land owned, sharecropped or rented)

	Average (all three villages)	Talki	Mohanpur	Borni
Mean area of land cultivated (ha)	0.18	0.13	0.22	0.16
% of households cultivating land	63%	50%	70%	70%
Sample (n)	60	20	20	20

Source: questionnaire survey.

In terms of the average number of days worked on farm land in each season, the irrigated boro crop clearly provides the most employment to labourers (Table 32). Over 90 percent of labourer households gain at least some on-farm employment during the aman and boro seasons, whilst the incidence of farm employment and number of days worked is less during the rabi season, particularly in Mohanpur. All respondents stated that opportunities for farm work had increased in the boro season since the use of irrigation, whilst there had been relatively little change in the other seasons.

All the labourer respondents from Talki claimed to work only in the village and its immediate area, whilst this was true for 90 percent of the respondents from Mohanpur but only 50 percent of those from Borni. Chittagong and Dhaka were cited as the most common alternative locations for seasonal work. Twenty percent of labourers indicated that they would usually work for the same farmer, whilst the remainder indicated that this would happen some of the time but not always. Labourers from Borni all suggested that since use of irrigation started it had become less common to always work for the same farmer. In the other villages the response was mainly that the situation had not changed.

Table 32 On-farm employment of labourers by season

	Average (all three villages)	Talki	Mohanpur	Borni
Farm work (mean days worked)				
Aman	46	39	55	43
Rabi	22	22	2	42
Boro	71	62	69	81
% of labourer households doing farm work				
Aman	98	95	100	100
Rabi	70	90	20	100
Boro	98	95	100	100
Sample (n)	60	20	20	20

Source: questionnaire survey.

Farm labouring was reported to be the main occupation and source of income for 85 percent of the respondents. For the remaining 15 percent, cultivation of own or rented (including sharecropped) land was most important (with the exception of one respondent for whom the main occupation was fishing). However, 60 percent of labourers reported that they also regularly had jobs other than farm work. Such employment was always casual, with the exception of one example of a permanent job assisting on buses. The most common casual employment was 'pulling' a rickshaw-van (20-25 percent of respondents). Next most common was fishing (12 percent) and petty trade (5 percent).

The majority of labourer households thus tend to rely on at least three sources of income, i.e. on-farm and off-farm labour, and own cultivation. Although it is difficult to make direct comparisons using the available survey data, it can be concluded that their livelihoods are if anything more diversified than those of the 'farmer households' surveyed. The range of income generating opportunities open to labourers is, however, more limited.

Labourers almost universally reported that they received wages for farm work in both money and food (there was one exception, who reported receiving a notably higher wage and no meals). The prevailing wage rate for farm labour ranged from 50 to 70 taka per day (mean 64, mode 60) plus three meals. Higher peak period rates of 70-80 taka per day were reported by process investigators for the boro season, and even up to 120 taka per day for harvesting. Over 85 percent of the respondents suggested that the purchasing power of the daily wage from farm labour had increased a little in the period since the introduction of irrigation. This increase in purchasing power may reflect a reduction in the cost of purchased food in real terms. Similarly, 85 percent reported that their families had become better off financially during the period they had been working as labourers in the village.

Only 13 percent of respondents indicated that they were able to save money. Purchase of livestock (3 responses) and savings groups (2 responses) were the main mechanisms for savings reported.

4.10.2 Agricultural goods and service providers

Table 33 shows the occupations of the households surveyed.

Table 33 Primary occupation of other survey respondents (number of households surveyed)

Occupation	Talki	Mohanpur	Borni
Tailor	2	1	1
Pump mechanic	3	1	1
Power tilling		1	1
Carpenter		1	1
Shopkeeper*	3		4
Trading/business		4	
Miller		1	1
Farm input suppliers#	2	1	1

Notes:
*Shopkeeper: Those selling daily goods and necessities, e.g. pulses, rice, oil, toothpaste, soap, clothes; teashops.
Farm input suppliers: Those selling fertiliser, seed, veterinary medicines, farm equipment, pesticides, rice mills, 2-wheel tractors, spare parts, etc.
Source: questionnaire survey.

From 30 respondents, 27 (90 percent) had their main home within the selected village, and only one lived more than 1 km from the village.

Only 13 percent of respondent households reported that children under 16 worked in or helped with the household business. This was a similarly low proportion to that reported for farmer and labourer households.

Of craftsmen and service providers, 60 percent were self-employed and the remainder employed by someone else. About 30 percent had been farmers before taking up their current occupation. 93 percent had always lived and worked in that location, and the one respondent who had settled there had been there for 24 years. Nine of the fifteen households of this category surveyed, employed others in their business, with numbers employed ranging from 1 to 10.

Craftsmen and service providers indicated that their customers were mostly farmers (50 percent of respondents) or partly farmers and partly others (50 percent). There was also an even division between those whose customers were mainly from the selected villages and those who serviced a wider area.

The merchants and input suppliers interviewed were all self-employed, and owned their own businesses. All except one supplied and drew most of their customers from the selected villages and surrounding areas.

Table 34 shows that a high incidence of merchants and input suppliers own homestead plots and cultivable land.

Table 34 Land ownership by other surveyed households (mean area owned in hectares)

	Craftsmen and service providers	General merchants and farm input suppliers
Mean area of cultivable land owned (ha)	0.73	0.77
% of households that own cultivable land	60	73
Mean homestead area owned (ha)	0.08	0.09
% of households that own homestead land	100	93
Total mean area of all land owned (ha)	0.88	0.90
% of households that own land	100	100
Sample (n)	15	15

Source: questionnaire survey.

5 of the craftsmen and service providers surveyed (30 percent), and 2 of the merchants and input suppliers (13 percent) sharecropped some cultivable land. A further 3 respondents from both categories rented land on a cash rent basis. One service provider (a miller), and two merchants/input suppliers were able to rent out land (again for cash rents). These transactions in land only occurred in the boro season and not during the aman season.

Craftsmen and service providers reported that the income gained from selling to farmers was highly seasonal. Nine (60 percent) said that the aman season was the most difficult for them, and the remainder that it was the rabi season. Fourteen (93 percent) reported that there was most demand from farmers for their services during the boro season (1 respondent indicated the rabi season). It was explained that increased productivity in the boro season had increased farmer incomes and purchasing power, increasing demand for goods such as clothes and furniture. Mechanics and pump and power tiller operators also cited the much greater demand for their services during the boro season.

Despite this seasonality, craftsmen and service providers, reported that the income from their main occupation was normally sufficient to support their family (93 percent of respondents). All were normally paid in cash. Payments in kind were now the exception but, where occurring, payments would be made in rice. Most of these households reported other sources of income from farming their own or rented land, and on-farm labour. Thirteen of this group (87 percent) often provided their services on credit to farmers, and of these 8 reported that they were usually repaid on schedule, the others that they were rarely repaid as agreed. All reported that they had become better off since starting this job. Reasons given were a general rise in income and employment opportunities, particularly those associated with irrigated boro season production. Seven (47 percent) reported that they had been able to save money since working in this occupation. Purchase of livestock had been the main form of investment for savings, although bank and savings group accounts and purchase of land were also cited.

Only 3 merchants and input suppliers (20 percent) reported that they could make a steady income throughout the year. For the rest the income was seasonal and the aman and rabi seasons were the most difficult, whereas the boro season provided most business from farmers. Input suppliers emphasised the increased use of farm inputs and machinery in the boro season, with an associated increase in demand for spare parts, etc. Shopkeepers emphasised that increased boro production brought higher farm incomes and

demand for their goods. All reported an income adequate to support their family, and that they were always paid in cash. Most respondents had other sources of income, and these were mainly farming own or rented land, and a few cases of permanent employment or other small businesses. No cases of casual labouring were reported by this household category.

All except one merchant and input suppler provided goods on credit to farmers. In general this credit was provided for a period of a few days only, but some lenders had provided credit for a period of a month or even up to the end of the season. Most reported that repayment was usually as agreed, although 5 said that this was rarely the case. Eleven (73 percent) were better off since starting work in this occupation, the remainder suggesting that their situation had remained unchanged. Improvement was attributed to the increased farm productivity in the area, increased farm incomes and thus generally greater demand for their products and better business opportunities. Eight (53 percent) reported being able to save since working in this occupation. Cash, bank deposits and loans to others were the most common uses or forms of savings, although purchase of land, livestock, and jewellery were all cited at least once.

As with the labourer households the picture that emerges for these other households is one of permanent residence in, or near to, the farming villages and of small scale businesses closely matched to the needs of the farming community. There could, however, be an element of bias in the sample. Livelihoods are again often diversified, and the cultivation of own or rented land may also be an important source of income for these households. As with labourers, the majority of such households may therefore stand to gain both directly and indirectly from the stimulus provided to farm production by irrigation use.

4.11 Additional observations from key informants, focus group discussions and process investigators

The following observations draw on information collected from key informants, focus group discussions and by the process investigators.

In all three villages, respondents emphasised that the increase in productivity of boro and aman season paddy resulting from the use of irrigation and other improved inputs had improved food security and farm incomes. There had also been a significant improvement in the demand for labour (in both farm and non-farm employment) and the wage rate of labourers.

For all three locations labour shortages were reported for the peak periods of labour requirement in the boro and aman seasons, i.e. transplanting, weeding and harvesting. Before the use of irrigation, farmers would have found their own labour to be surplus for up to five months. Since irrigation farmers are now generally employed on their own land throughout the year (or on neighbouring larger farms in the case of marginal farmers, see Table 18). Harvesting and processing (threshing, drying and de-husking/milling) the increased output of paddy is labour intensive. These activities remain major source of casual employment for both men and women, despite the now widespread use of power threshers and rice mills. Although labour requirements have increased it is reported that fewer farm labourers are now permanently employed. Farms tend to rely more heavily on their own household labour and hire in casual or contract labour when required to supplement this.

The increase that has also taken place in non-farm employment is illustrated by the growth in demand for crafts, trades and other services reported for the period since use of irrigation started (Table 35). Increased demand for the services of carpenters is attributed to the demand for house improvements and for furniture following the improvement in household incomes. Similarly, there has been increased demand for masonry work, with more villagers building and repairing houses, shops, temples and mosques. For example, in the period since irrigation six mosques have been constructed in Mohanpur, and the number of priests employed has therefore also increased. Other skilled trades such as tailoring are also in greater demand, and provide more continuous stable employment than farm labouring. Similarly, increased farm mechanisation with the use of STWs, power tillers, power threshers and rice mills has increased demand for the services of mechanics and blacksmiths. Young members of landless or marginal farming

households are reported to be entering this range of trades, typically receiving training 'on-the-job' by working alongside those more experienced.

The increased production of paddy, particularly in the boro season, has also provided a stimulus to petty commodity trading activities. The number of small traders who buy paddy, rice or other farm outputs such as vegetables, beans and pulses has notably increased. Such traders need to move the produce purchased to local markets and by doing so, contribute to the evidently increased demand for local transport services, primarily provided by bicycles, rickshaws and rickshaw vans, and auto-rickshaws. These modes of transport have largely replaced bullock carts, and demand for transport services has also responded to improved incomes for farmer and labourer households. Improvements to the network of both surfaced and earthen roads and tracks has also induced an expansion in the supply of services by these vehicles.

Table 35 Increase in numbers of crafts and trades people, service providers and traders

	Talki		Mohanpur		Borni		
	Before irrigation	After irrigation	Before irrigation	After irrigation	Before irrigation	After irrigation	Approximate daily wage (Tk)
Carpenters	0	2	4	15	2	7	150-200
Tailors	4	13	0	7	3	10	150
Masons	na	Na	0	3	1	4	250
Mechanics	na	Na	0	15	2	4	300
Farm Labourers	less	more	less	more	180	300	60-120
Maid servant	10	25	more	less	na	na	na
Barber	3	5	2	1	na	na	na
Rickshaw/ van driver	5	38	less	more	5	20	85-100
Fishermen	11	15	15	120	2	10	na
Small traders	10	40	10	40	5	15	na

Source: process investigators' reports.

For Talki village it was also reported that there has been an increase in the number of women from poorer households employed as maid servants by households with large farms. Tasks will be varied around the home, but also tend to specifically include winnowing, threshing and storage of the household's own rice crop.

The observed increases in the numbers of people engaged in the non-farm occupations listed in Table 35 cannot be attributed solely to irrigation development. However, along with other stimuli such as improvements to the road network, increased farm productivity and incomes must be contributing to the increased demand for goods and services. This is a manifestation of the expected linkages from improved farm productivity. Forward and backward linkages arise from an increased demand for farm inputs and for processing and marketing of outputs. Consumption linkages develop as farm and farm labourer households have more income to spend on goods and services. It is also notable that much of this increased demand is for locally produced goods and services (or non-tradeables), rather than just 'imported' manufactured consumer goods from outside the immediate local area. As a result the outcome is relatively more poverty reducing in terms of the increased opportunities for local non-farm employment.

Increased demand for labour has strengthened the position of labourers both financially in helping to push the wage rate up and in the added security of providing more continuously available work. Although the number of landless labourers was reported to have risen in line with population growth (not quantified in the surveys), a smaller proportion are now involved in farm labouring as opportunities for non-farm work have increased. Most evident is the number of farm labourers switching to rickshaw pulling as their main occupation. The establishment of rice mills, factories and garment factories in urban areas has also led to an increase in the number of non-farm labourers.

Some differences between the study villages existed in terms of the opportunities for landless labour. Non-farm labour is generally reported to offer a higher wage than farm labour, although this is not always the case. Despite this very few labourers in Talki and Mohanpur are reported as still needing to seasonally migrate from the village for work because of the increased non-farm employment opportunities. However, in Borni, which is recognised as a poorer village with a higher proportion of landless households, significant numbers of labourers still migrate in the rabi season to neighbouring districts to seek employment.

In all villages it was reported that *beel* areas have been lost as land has been taken for cultivation and fish stocks have been declining as a result of over fishing and reported disease and death of fish from increased agro-chemical pollution of these water bodies. Despite these trends the number of fishers has been increasing in each of the villages. This may reflect the fact that fishing typically has low entry costs as an activity, and is serving as an occupation of last resort for some landless labourers still failing to find alternative and more remunerative farm or non-farm employment. It may also reflect some increase in the practice of aquaculture and pond fishing.

5. PHYSICAL CAPITAL

"Development of rural infrastructure" is one of the five objectives under the Rural Development and Institutions Programme of the government of Bangladesh's Fifth Five Year Plan (1997-2002). Specific elements for the achievement of the objectives, among others, include:

- development of rural infrastructure such as growth centres, and roads, bridges and culverts connecting such centres.
- provision of small irrigation and flood control related structures.

Groundwater irrigation has been the principal factor in increasing irrigated area since the early 1970s. Initially, groundwater was developed using diesel powered DTWs, which can irrigate up to 25 ha per well. DTWs were financed and owned by the public sector. Since 1975, privately owned, diesel powered STWs, each irrigating about 5ha; have been the dominant well technology (Pitman 1989). Figure 2 shows how the national area irrigated by STW overtook the area irrigated by DTW in about 1980.

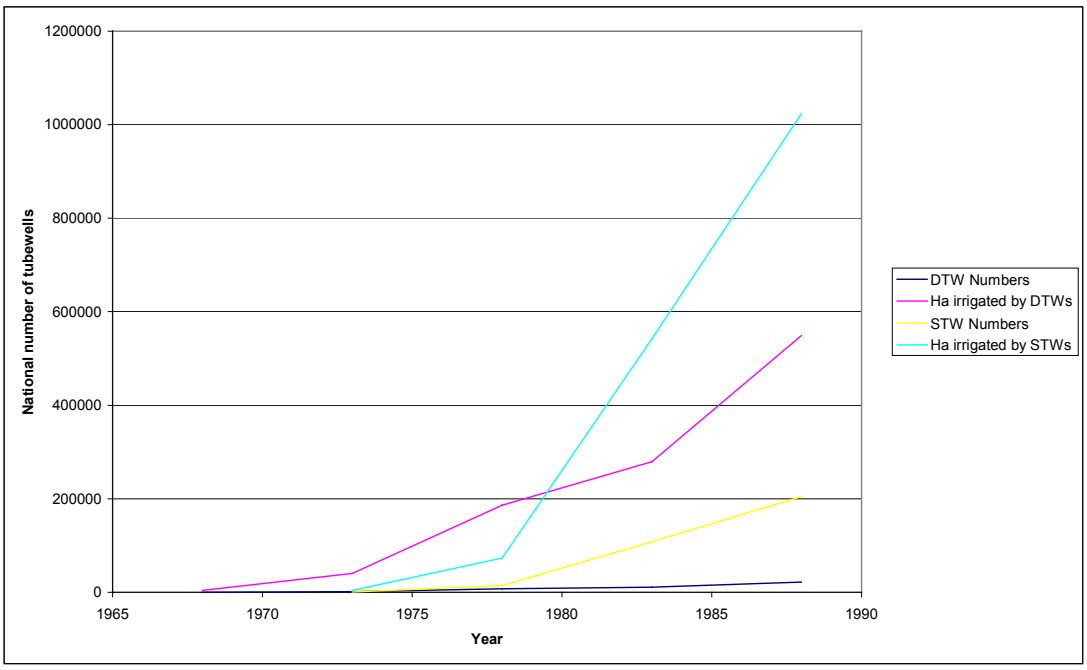


Figure 2 National growth of tubewells for irrigation in Bangladesh

In keeping with this national trend, TW development in the study villages did not occur instantaneously but has gradually developed as the technology has become available and more affordable. Pinpointing the exact date of transfer from the "before irrigation" to "after irrigation" scenario is complicated. This is further complicated by the existence of DTWs, which provided a level of irrigation in the villages from a period commencing around 1974. The DTWs in Mohanpur functioned with a greater degree of success than in the other two villages. Three DTWs were used for periods of 6 to 8 years and one of them is still functioning to date. In Borni village two of the three DTWs functioned for substantial periods of time. One DTW is still operational whilst the other failed in 1994. In contrast to the other villages, Talki village only had one DTW, which ceased to operate in 1989. It can be concluded that the development of Talki and Borni's physical capital has probably been affected most significantly by the introduction of STW irrigation, whereas Figure 3 suggests that the development of physical capital in Mohanpur may have been influenced more by the introduction of DTWs in the mid 70's.

There are no significant differences in physical capital amongst the three villages except that Borni village is the furthest from a good (sealed) road and therefore the least accessible. Mohanpur appears to have the highest standard of housing, with the largest number of farmers having made improvements. Borni houses are not dissimilar from those in Mohanpur. Mohanpur farmers currently enjoy the highest level of access to services. This is mainly due to the proximity of a main road to market and the high number of rice mills in the vicinity of the village.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Talki			Madrasa (religious school)				Deep Tubewell															Village shop						Culvert Culvert Rice mill	Madrasa (religious school) Village shop Road Culvert Rice mill	Village shop Rice mill		Village shop Rice mill	Madrasa (religious school) Village shop Rice mill Village shop		Primary school Rice mill	Village shop Rice mill	Village shop
Mohanpur								Deep tubewell Deep tubewell	Primary school			Deep tubewell Deep tubewell Culvert Culvert Culvert		Village dirt road construction		Village shop Village shop Village shop			Rice mill Electricity Culvert Culvert	Village shop Village shop		Rice mill Community health clinic	Culvert Culvert Culvert	Village shop Village shop Culvert	Primary school	Primary school Rice mill Rice mill Culvert					Madrasa (religious school)				
Borni								Deep tubewell Madrasha				Deep tubewell Culvert Culvert	Rice mill	Village shop		Village shop	Deep tubewell		Rice mill Village shop Culvert	Madrasha				Village shop Road Culvert				Village shop	Medicine shop	Village shop Culvert		Culvert Culvert	Village shop Medicine shop	Village shop Rice mill Culvert Culvert Culvert		

Introduction of STW irrigation
Introduction of DTW irrigation
Dirt road construction

Source: process investigators' reports

Figure 3 Pattern of physical infrastructure development in the three study villages

From the pattern of infrastructure development shown in figure 3 it can be assumed that for the three study villages irrigation from STWs began in 1992. The average year of installation, depth and flow of STWs is given in Table 36.

Table 36 STW installation data

Average	Talki	Mohanpur	Borni
Number of tubewells 1992	10	4	10
Number of tubewells 2002	52	80	67
Mean year of installation	1996	1999	1997
Average depth of well (m)	25	30	29
Average discharge (l/s)	19	13	11

Source: process investigators' reports.

5.1 Housing

In all three villages both farmers and labourers have lived in their current houses for an average of 30 years, although there is also evidence to suggest that there has been recent in-migration to the villages of Mohanpur and Borni. This was less apparent for Talki, where sampled farmers had lived in their current location for a minimum of 11 years. Of all the groups interviewed, crafts, tradespeople and service providers had lived in their current house for 10 years less on average. This may suggest an increase in demand for these groups since irrigation which has encouraged a number to move into the study villages.

Table 37 Number of years lived in current house

	Number of years lived in current house		
	Average	Max	Min
Talki	34	60	11
Mohanpur	34	65	1
Borni	26	60	2

Source: questionnaire survey

The process investigators' reports indicate an increase in the number of households in each village. Nationally, there was a 57 percent average increase in the number of households from 1974 to 1991 (Bangladesh Bureau of Statistics 2000). Talki and Borni villages fall broadly in line with this figure, but Mohanpur exceeds it with a 200 percent increase over the same period (Table 38). As a percentage the increase in household numbers has not been as significant as that observed in a similar study in Nepal (Angood et al 2003), suggesting that in-migration has not occurred to the same degree as in Nepal. Increases in the number of households can instead be largely attributed to population growth and the division of families.

Table 38 Household number and size for districts of Bangladesh and study villages

Area	Number of households 1974	Number of households 1991/2002	% Increase in households	Average number of people per household
Sherpur[1]	-	239,000	-	4.9
Jamalpur[1]	-	388,000	-	5.0
Netrokona[1]	-	334,000	-	5.4
Bangladesh[2]	12,678,000	19,980,000	57	5.3
Talki (Sherpur)[3]	500	815	63	4.5
Mohanpur (Jamalpur)[3]	500	1500	200	5.2
Borni (Netrakona)[3]	600	920	53	6.8

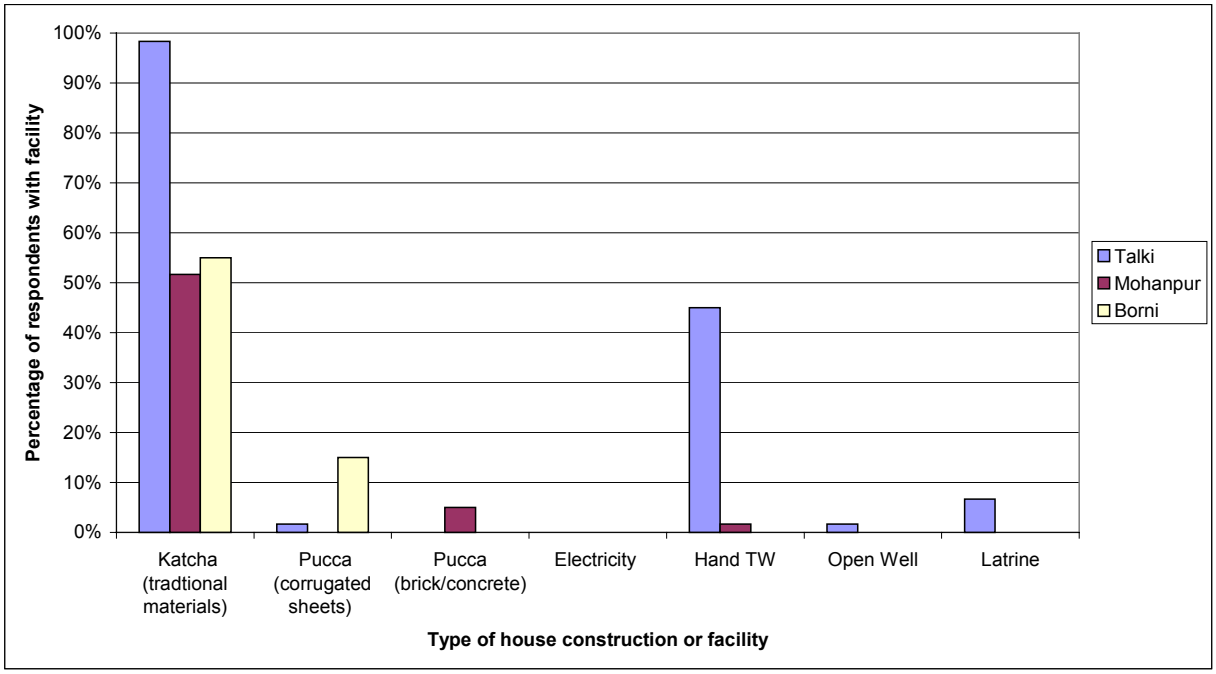
Source: [1]Statistical Pocketbook of Bangladesh, 1999 (data from 1991 population census); [2]Statistical Yearbook of Bangladesh 1999 (data from 1991 population census) [3]process investigators' reports and farmer questionnaires.

The quality of housing has increased significantly across the villages over the period since the introduction of irrigation. Table 39 shows that in the case of Mohanpur and Borni, the majority of farmers have made some sort of improvements to their house. In this respect, Talki village is similar to the Nepal study villages, with only 50 percent of households making some sort of improvements to their houses. Improvements include tin roofs and walls, additional rooms, partial brick/concrete construction, and in some cases new brick/concrete house construction. Improvements using corrugated tin sheets are the most common for all villages. The improvements were made five years ago on average.

Table 39 Percentage of households who have made improvements to their houses since irrigation

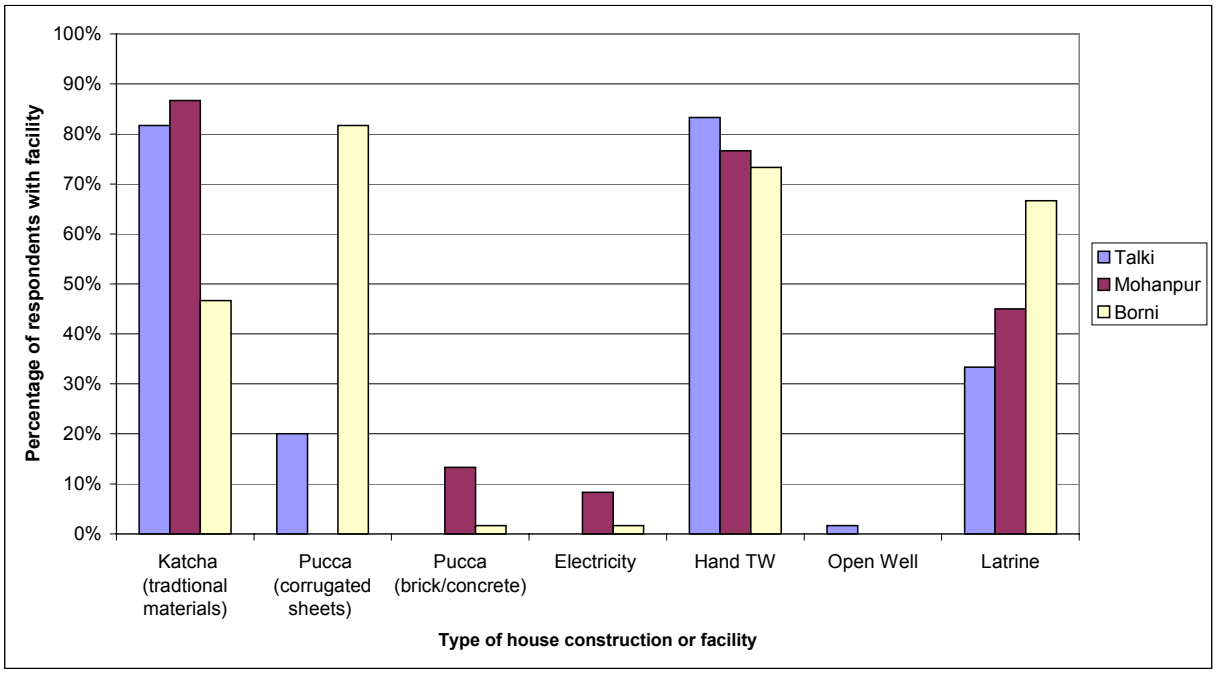
Village	% of farm households	% of labourer households
Talki	48	15
Mohanpur	92	95
Borni	88	100

Source: questionnaire survey



Source: questionnaire survey

Figure 4 Construction of family home and associated household facilities before irrigation



Source: questionnaire survey

Figure 5 Current construction of family home and associated household facilities

Other improvements made by farmers include construction of chicken sheds and aquaculture ponds as some farmers seek to diversify their livelihood strategy. Aquaculture is possible through the ready availability of water from STWs and is currently more profitable than arable farming, although it does require a relatively large initial investment. Labourers in Mohanpur and Borni have made a similar degree of improvement to their houses as farmers (though noting the small sample size for labourers). Talki labourers, however, have made significantly fewer improvements.

Figure 4 shows that before irrigation the majority of households were made of traditional materials and lacked even basic household facilities. Since the onset of irrigation the general quality of housing has improved. All three villages contain a significant percentage of households with hand tubewells and latrines (Figure 5). Since irrigation, Borni has seen a significant shift from traditional housing construction to the use of corrugated sheets. 82 percent of Borni respondents now use corrugated sheets in their house construction compared with 15 percent before irrigation.

Of the three villages, the largest number (13 percent) of farmers with fully *pucca* (brick and concrete construction) houses live in Mohanpur. A greater proportion of labourers' houses are constructed from *katcha* (traditional – wood, mud and thatch) materials in fact only 30 percent of Borni labourers have constructed their house in any other manner (corrugated sheets). A lower percentage of labourers have access to hand tubewells (HTWs) or latrines than farmers. However, a significant number of Mohanpur labourers possess latrines. In 1991 the national average number of katcha houses in rural areas was about 83 percent. This figure decreased slightly to 78 percent in 1994 (Bangladesh Bureau of Statistics 2000). 12 percent of rural houses were of corrugated sheets and 3 percent brick/concrete. 82 percent of respondents in Talki and 87 percent of respondents in Mohanpur currently live in katcha houses suggesting that house development in these villages is slightly behind the national trend. Borni however, appears to be ahead of the national 1991 statistics with only 47 percent of its farmers currently owning a katcha house.

National statistics for roofing construction indicate that 50 percent of houses in rural areas have roofs constructed from traditional material and 50 percent from corrugated sheets (Bangladesh Bureau of Statistics 2000). All three villages appear to have lower numbers of such improved roofs than these statistics suggest, but since the introduction of irrigation, 22 percent of Talki, 65 percent of Mohanpur and 30 percent of Borni respondents have added a new roof or improved their roofs with tin.

Only a very small percentage of Mohanpur farmers (8 percent) and a negligible number of Borni farmers (2 percent) now have electricity. In 1991, 7 percent of rural households were electrified compared to 14 percent in 1994 (Bangladesh Bureau of Statistics 2000). All three villages appear to be significantly behind these national statistics.

According to Table 40, with the exception of Talki, the average number of people per room has decreased significantly since the introduction of irrigation. Mohanpur had the highest number of people per room (about 5) before irrigation. Since the advent of irrigation this has been reduced to just over three people per room. This corresponds with the finding that of the three villages Mohanpur farmers have made the most improvements to their houses and Talki farmers have made the least. Talki has the smallest population of the three villages. Although the average number of people per household in Borni is larger than the district average (Table 38) there has still been a reduction in the number of people per room.

Table 40 Number of people per room

		Number of people per room		
		Average	**Max**	**Min**
Talki	Before irrigation	1.9	5.0	1.0
	Now	2.4	6.0	1.0
Mohanpur	Before irrigation	4.9	9.0	1.0
	Now	3.3	7.0	0.5
Borni	Before irrigation	2.8	12.0	0.8
	Now	2.3	7.0	0.5

Source: questionnaire survey

A resounding 100 percent of Borni and 97 percent of Mohanpur respondents gave a change in housing and living conditions as a main reason for an improvement in health.

5.2 Water and sanitation facilities (primary health)

National statistics state that 78 percent of rural households had access to tubewells for drinking water in 1991 and 91 percent in 1994 (Bangladesh Bureau of Statistics 2000). A similar percentage in all three villages currently own tubewells for their drinking water supply and 100 percent of respondents reported using a tubewell as their actual source of drinking water.

45 percent of rural households are reported to have a basic toilet as part of their house in 1991 (Bangladesh Bureau of Statistics 2000). Mohanpur has a comparative number of households with a toilet. Borni is ahead with 67 percent of respondents owning a toilet and Talki is lagging behind with only 33 percent of respondents owning a toilet.

All three study villages now have a high percentage of farmers with HTWs (Talki, 83 percent; Mohanpur 77 percent; Borni, 73 percent). This significant increase in the number in existence, compared to the time before irrigation, is illustrated in Table 41.

Table 41 Percentage of farmers with HTWs and latrines

		HTWs		Latrines	
		Total village numbers	**% of respondents owning**	**Total village numbers**	**% of respondents owning**
Talki	Before irrigation	60	45	50	7
	Now	490	83	400	33
Mohanpur	Before irrigation	20	2	20	0
	Now	200	77	1500	45
Borni	Before irrigation	60	0	120	0
	Now	506	73	460	67

Source: questionnaire survey

In fact, with the exception of HTWs in Talki, all villages had virtually no HTWs or latrines prior to irrigation. HTWs were generally constructed around the time that STW irrigation was introduced. Latrines, however, have mainly become available in the last two to four years. Only a small minority of farmers across all villages claim to have received any form of subsidy for the construction of their HTWs or latrines. The most significant is in Mohanpur where 18 percent farmers received a subsidy for the construction of HTWs. Of all the groups interviewed, there were lower numbers of labourers with HTWs (about 50 percent). The numbers of general merchants and suppliers of goods and services, and crafts and tradespeople with latrines is on average higher than that of farmers or labourers.

100 percent of farmers across all villages now profess to the use of HTWs as their source of drinking water. The HTWs are on average 15 metres or 1 minute's walk from the house. All farmers generally use the same source of water for either bathing or laundry purposes. 98 percent of Mohanpur farmers use HTWs for these purposes. In Talki, however, 50 percent of farmers use a pond, and in Borni, which has the highest number of ponds around the village, 100 percent of farmers use a pond for these purposes. The ponds used for bathing or laundry in both Talki and Borni are generally 25 metres from the house. When asked for reasons for a change in health, 100 percent of Borni and 93 percent of Mohanpur respondents cited a change in drinking water supply as one of the main reasons.

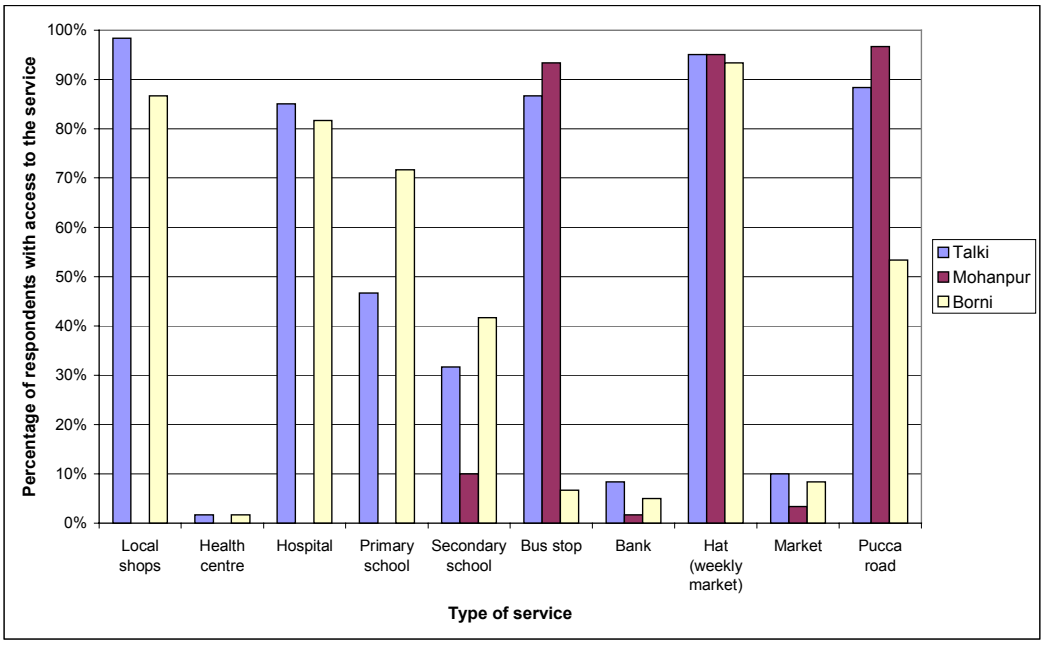
100 percent of the labourers interviewed also stated HTWs to be their main source of drinking water. Labourers report an average distance of 20 metres or 1.5 minutes to their HTW which was slightly higher than that reported by farmers. Only 65 percent of Mohanpur labourers use HTWs for bathing or laundry purposes. Talki and Borni labourers use their ponds for the same activities as the farmers. The ponds in all three villages are on average further away for labourers 33 metres or 2.5 minute's walk from the house.

5.3 Local services and access to services

Easily accessible local services are an important complement to irrigation development. The development of services can be directly inspired by demand as a result of irrigation development or can occur in parallel to irrigation development and help to maximise its potential. Access to services is improved both as new services are provided and as users of the services are more able to afford them. The development of roads alongside irrigation greatly increases marketing opportunities for farmers. Increased income and expenditure as a result of irrigation helps sustain services and encourages the development of new services. This is especially evident in the increased development of shops since irrigation.

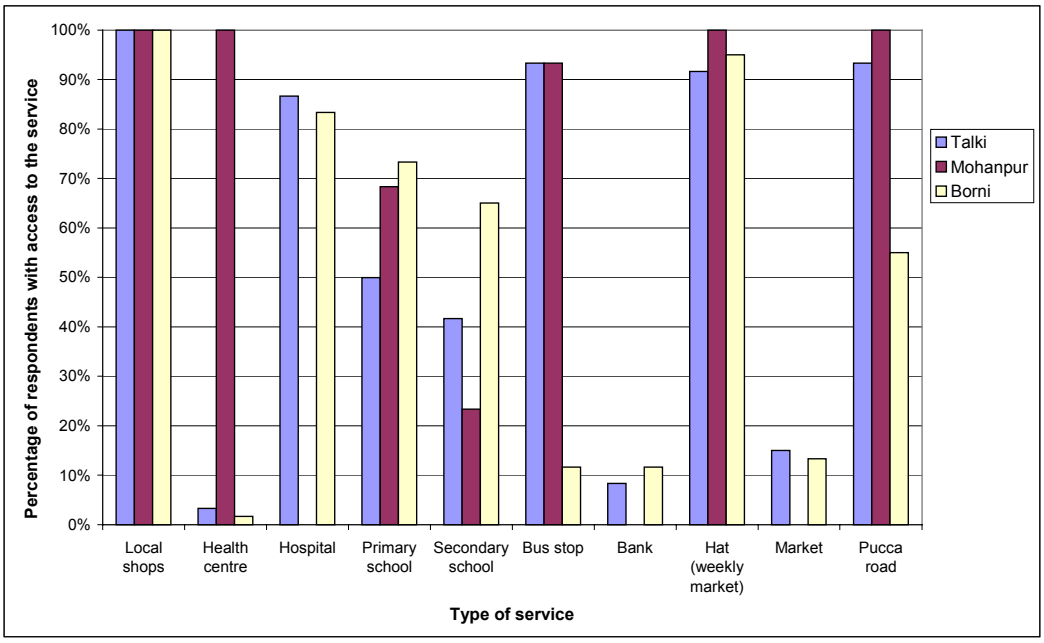
Compared to the situation before irrigation there has been a minimal increase in the number of farm households in Talki and Borni village with access to each of the services shown in Figures 6 and 7. Both villages have seen improvements made to the dirt road running through the centre of the village around the time of introduction of STW irrigation. Further to this general pattern, Borni has seen a significant increase in the number of farm households with access to a secondary school. Of the three villages, Borni is the furthest from a sealed road and is therefore arguably the village with the most limited access to local services.

The time taken to reach most services available to Talki and Borni farm households has decreased, on average, by 5 to 10 minutes. The biggest exception is that the time taken for Talki farm households to access a sealed road has dramatically decreased by 45 minutes. This corresponds with a reduction in the distance to the road of 3km. Although the distance to the health centre for Borni farm households has been reduced by 4km, only a very small number of farm households use this service as it is still an average distance of 3km away from most homes. In the same way the distance to a bank has been reduced by 2km since irrigation, but with only a small increase in the number of Borni farm households making use of the facility as it still requires a journey of 6km.



Source: questionnaire survey

Figure 6 Access to local services before irrigation



Source: questionnaire survey

Figure 7 Current access to local services

Mohanpur is different to the other villages in its development of its access to services. Before irrigation, the main services accessible were the sealed road, weekly market and bus stop. The dirt road through the centre of the village was constructed in 1980, 10 years before similar roads in the other villages.

Analysis of the access to services by labourer households across all three villages revealed that, compared to farmers, a slightly lower percentage of labourer households (only 20 percent) currently have access to a secondary school. The only other significant difference between farmer households' and labourer households' access to service is that a lower number (40 percent) of Borni labourer households' have access to the hospital. Compared to farmer households, a greater number of general merchants and crafts and tradespeople households use a bank (about 30 percent).

Distances and time taken for Mohanpur farm households to reach those local services, which have been in place since before irrigation, have remained constant. It appears that the bank and the market used by a small number of farm households before irrigation are no longer available. Conversely, since irrigation a number of local shops, a health centre and a primary school have been constructed and access to these services is now high. 90 percent of Mohanpur respondents cited a change in the provision of medical services and immunisations as a major reason for the improvement of health in the village. The new health centre was constructed locally at an average distance of under 1km for most farm households. 100 percent of Mohanpur respondents said that the new school is the main reason for increased school attendance. Access to a primary school has risen from 0 to 68 percent and access to secondary school has also improved from 10 percent to 23 percent. An even more significant response to the provision of new services is the fact that 100 percent of Mohanpur farm households now use the new local shops. The analysis suggests that new services provided at a distance greater than 1km from a household are unlikely to be widely used.

Table 43 Change in mechanisation

	Before irrigation			After irrigation		
	Talki	**Mohanpur**	**Borni**	**Talki**	**Mohanpur**	**Borni**
Rickshaw / van	4	3	2	30	60	20
Bicycle	30	20	120	150	800	300
Power tiller	0	0	0	2	15	10
Power thresher	-		0			8
Rice mill	0	0	3	8	4	8

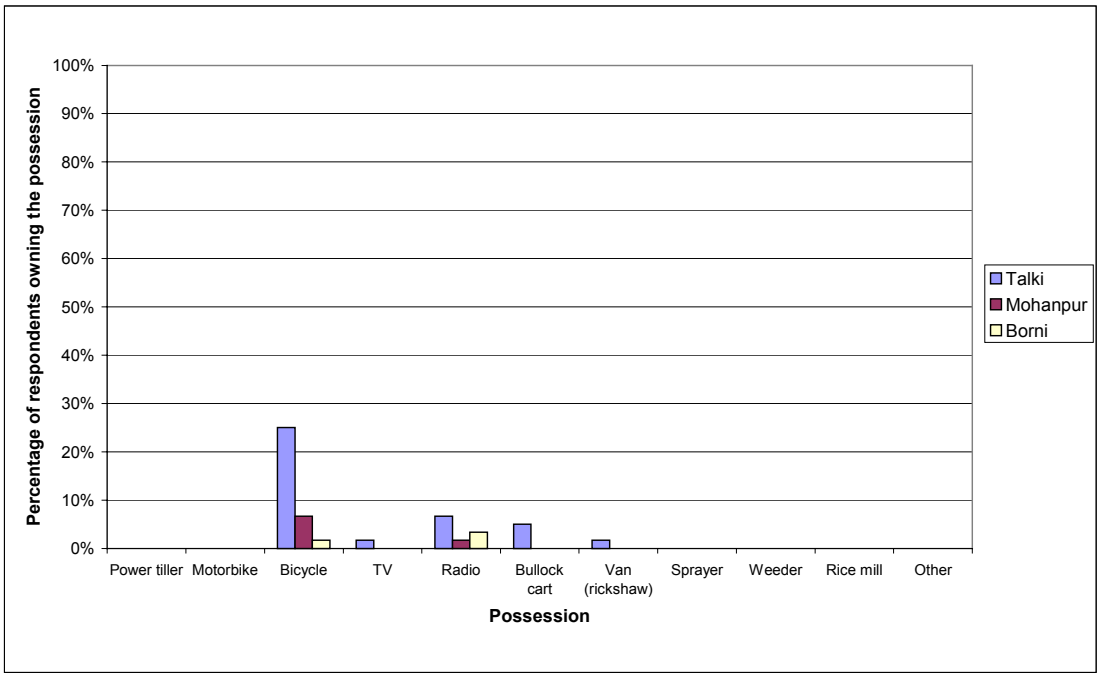
Source: process investigators' reports

Table 43 shows a large increase in the number of cycle rickshaws, vans, and mechanised farm equipment over the period since the adoption of irrigation. New and improved roads to all villages have helped enable cycle transport to develop. An increase in the number of bicycles and the improved road construction may in part explain the reduction in the time taken to reach services, where no apparent new service has been provided. In the case of Borni village there has been a distinct shift from the use of boats as the principle means of transport to market to the use of bicycles. This was in part due to the construction of flood bunds, which blocked the boat route to market. Indications are that the three-wheeled cycle "van" is replacing the bullock and cart as the main source of transport for produce. This is partly due to the fact the number of livestock is decreasing as grazing land has become increasingly scarce and rice production has become the main source of farm income.

Figures 8 and 9 show that there has been an increase in the number of household possessions owned by farmers and other villagers across all three villages. In fact before irrigation, most households, with the exception of a few Talki farmers, owned few or no possessions. There has been an increase in the number of radios possessed in all three villages and televisions in Talki and Mohanpur. This may indicate increased wealth and spending power. There has been a dramatic increase in the number of Borni respondents possessing weeders from 0 to 95 percent. This could be an indication that farmers are

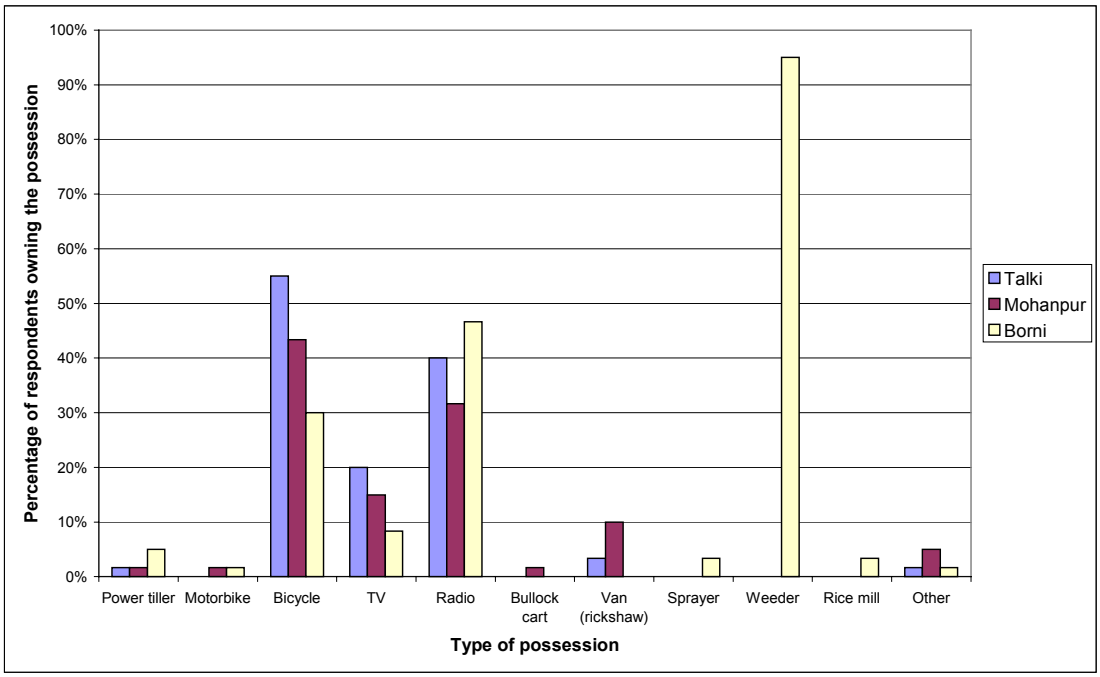
reinvesting farming profits in agricultural equipment. “Other” possessions include a sickle for a Talki farmer, a power thresher in Borni and 3 autovans in Mohanpur.

From the data collected it appears that general merchants and suppliers of agricultural goods and services are the group with the greatest number of household possessions and highest of housing. 12 out of 15 interviewed across all three villages had radios and 8 out of 15 had televisions. Crafts, tradespeople and service providers have similar possessions to farmers.



Source: questionnaire survey

Figure 8 Percentage of farmers owning different household possessions before irrigation



Source: questionnaire survey

Figure 9 Current percentage of farmers owning different household possessions

6. HUMAN CAPITAL

6.1 Background

Mohanpur and Borni are similar in terms of population size, although Borni's population is concentrated over a smaller area. Table 44 shows that Talki has the smallest population of the three villages and the lowest percentage of landless households (16 percent).

Table 44 Population of the three study villages

	Talki	Mohanpur	Borni
Population	3000	6000	5000
Percentage landless (labourers)	16	25	40
Percentage sharecroppers	5	1	1

Source: principle supervisor's report

6.2 Food and diet

Interestingly, 100 percent of farmers interviewed stated that they regularly consumed rice both before and after irrigation. This suggests that farmers were sufficient in rice before irrigation and have simply increased their surplus for sale since irrigation. This focus on rice production as opposed to vegetables reflects the demand, the high market value, and low risk associated with growing rice. An emphasis on the value of vegetable consumption may help to encourage a more balanced diet for all the villagers. Training in vegetable irrigation techniques for farmers and an improvement in vegetable marketing for both farmers and shopkeepers may help to tip the balance away from paddy cultivation and thus further improve villagers' nutrition. Women have been identified as a key group involved in vegetable cultivation so training packages would need to identify and reflect their needs.

Table 45 depicts overall food production both before and after irrigation. With the exception of Talki village, farmers reported a significant shift from food deficiency to surplus food production since the introduction of irrigation. It is worth noting that at the time of the survey, Talki farmers had just lost 75 percent of their current harvest due to a heavy storm. This had a significant enough effect to skew the results of this question.

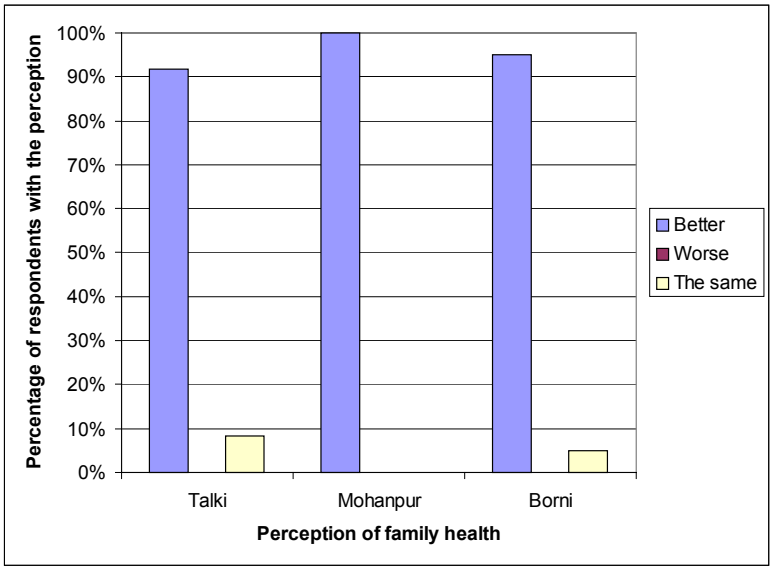
Table 45 Food production over a five year period before and after irrigation (figures are farmer years: No. of farmers × No. of years)

	Talki		Mohanpur		Borni	
	Before irrigation	Since irrigation	Before irrigation	Since irrigation	Before irrigation	Since irrigation
Not enough food	126	162	200	78	368	80
Just enough food	20	13	30	109	122	225
Surplus to sell	154	125	70	113	10	143

Source: questionnaire survey

6.3 Family health

There was a unanimous opinion amongst the farmers interviewed that family health had improved since the introduction of irrigation. The responses shown in Figure 10 show this clearly and in fact, farmers in the Bangladesh study were much more sure of this relationship than in the Nepal study.

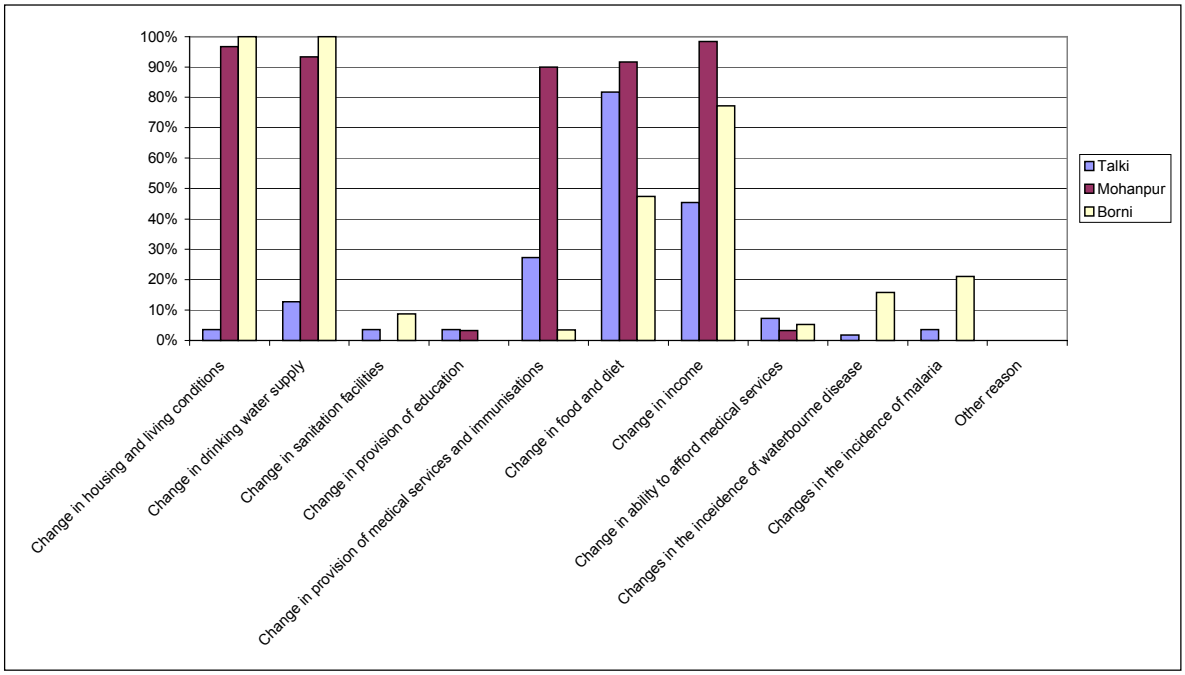


Source: questionnaire survey

Figure 10 Farmers perception of family health since irrigation

Figure 11 shows the reasons farmers gave for this improvement in health. Accumulating the percentage of respondents for all three villages reveals that the main reasons for this change in health were "a change in income" and "a change in food and diet".

Mohanpur and Borni farmers also cited a "change in housing and living conditions" and a "change in drinking water supply" as important factors. Due to the construction of a new health clinic in 1988, Mohanpur farmers added a " change in the provision of medical services and immunisations" as a further reason for health improvement. During process investigators' interviews, Borni farmers added that an increase in health awareness in the village has led to an increase in the number of village doctors. There are now five local doctors and one trained doctor in the village.



Source: questionnaire survey

Figure 11 Reasons given as to why family health has improved since irrigation

6.4 Education and literacy

Data from all three villages indicates a marked increase in the number of school children. Comparisons between Tables 46 and 47 show that the relative increases in both student and teacher numbers are higher than the national trends. According to the questionnaire survey, the main reasons were thought to be an improved economic condition, parents' willingness to send children to school and the food for education programme. In Mohanpur, 40 percent of students are reported to currently benefit from the food for education programme and free education is offered to female students. Process investigations in Borni revealed that in comparison to the other villages, a high number of incentives existed to encourage farmers to send their children to school. These included the food for education programme, free tuition and textbooks and a stipend. Tuition is also free for female students attending secondary school.

Teaching is viewed as a well paid and honourable job and as a result many educated villagers become teachers. In spite of a general increase in student and teacher numbers, Talki villagers opined that there was still a deficit of schools and teachers. In all villages, teachers were found to be a source of new technological information on issues such as the use of HYV rice.

Table 46 Increase in student and teacher numbers

	Talki			Mohanpur			Borni		
	Before irrigation	After irrigation	% increase	Before irrigation	After irrigation	% increase	Before irrigation	After irrigation	% increase
Students	180	450	250	310	1200	387	230	505	220
Teachers	7	12	170	4	24	600	10	21	210

Source: Process investigators' reports

Table 47 Trends in education – Bangladesh

No. of schools	1978	1983	1988	1993	1998	1988-1998 % increase
Primary	41,787	43,219	44,202	50,898	66,235	150
Secondary	7,946	8,664	9,177	11,382	13,419	146
No. Of students						
Total students	9,896,000	11,525,000	14,899,000	18,875,000	23,916,000	160
Primary	7,557,000	8,955,000	11,755,000	14,202,000	17,627,000	150
Secondary	2,339,000	2,570,000	3,144,000	4,673,000	6,289,000	200
No. Of teachers						
Total teachers	257,587	271,253	291,387	344,434	412,131	140
Primary	171,024	178,589	189,191	214,779	250,990	132
Secondary	86,563	92,664	102,196	129,655	161,141	158

Source: (i) Bangladesh Bureau of Educational Information and Statistics
(ii) District Education Officers, M/O. Education.

According to Table 48, Talki has the highest adult literacy rate, whilst Mohanpur has the lowest. Whilst the literacy rates for farmers are higher than the national average, those for labourers are consistently below the average. The figures for school age children attending school (Table 49) reflect the pattern of adult literacy rates. Talki villagers were thought that an increase in literacy levels has led to an increase in the number of villagers employed outside the village in government service.

The process investigators reported that in Talki, the number of girls attending school has increased but on the whole, women are still less educated than men. On average, women attending school, finish by at least class 5. In Mohanpur it was found that although the numbers of primary female students has increased to equal male students, the numbers of female students pursuing secondary education is significantly lower than male.

Table 48 Adult literacy rates – Bangladesh (1991 and 2002)

District	Sherpur	Jampalpur	Netrokona	Bangladesh
Male[1]	27	30	35	44
Female[1]	13	16	20	26
Both[1]	20	23	28	35
Village (District)	Talki (Sherpur)	Mohanpur (Jamalpur)	Borni (Netrokona)	
Farmers[2]	79	48	65	
Labourers[2]	30	45	35	
ALL[3]	35	30	34	

Source: [1]population census, 1991; [2]questionnaire survey 2002, [3]principal supervisor's report (results of focus group and key informant interviews)

Table 49 Percentage of school age children attending school

	Talki	Mohanpur	Borni
Boys	91	61	79
Girls	97	80	85
TOTAL	94	70	81

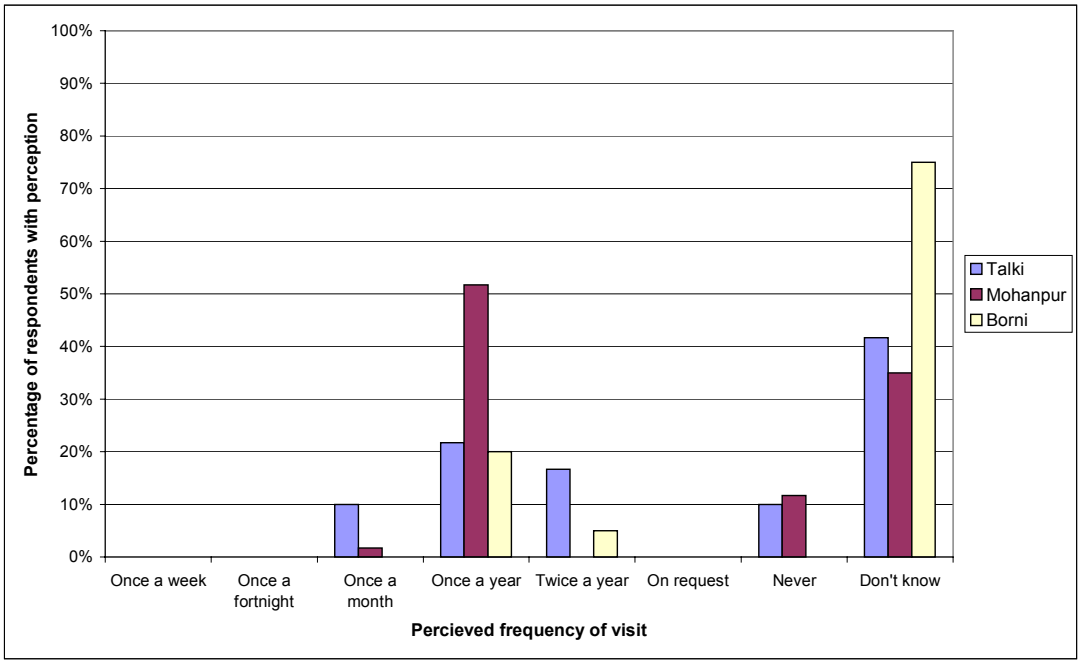
Source: questionnaire survey

6.5 Training, knowledge transfer and information exchange

Focus group discussions revealed that irrigation together with modern seed varieties and improved cultivation techniques have contributed to a higher level of production as well as income. The source of the improved cultivation techniques is, however, not clear.

Access to training and agricultural knowledge is minimal in all three villages. Figure 12 reveals that Block Supervisors visit all three villages infrequently. Borni farmers perhaps suffer from the lowest level of access to this extension service.

Given infrequent visits by the Block Supervisor, farmers report that their information on crop cultivation and fertilizers comes from other sources, such as: agricultural input sellers, relatives and neighbours and, to some extent school teachers (see section on education and literacy). Mohanpur farmers rely most heavily on information from input sellers. It is worth noting that information from such sources may, however, not be fully reliable. Table 50 suggests that although Mohanpur farmers have the greatest knowledge of Block Supervisors visits, it is Talki farmers who make by far the most use of their Block Supervisor.



Source: questionnaire survey

Figure 12 How often farmers perceive that a Block Supervisor visits their village

Table 50 Perceived frequency and usefulness of Block Supervisor visits

	Talki	Mohanpur	Borni
Percentage of farmers who meet Block Supervisor	49	17	17
Percentage of farmers who find Block Supervisor to be useful	49	17	15
Percentage of farmers who know who the Block Supervisor is	57	50	23

Source: questionnaire survey

Although the survey revealed a distinct lack of agricultural training, farmers unanimously expressed an interest to receive training on improving cultivation of HYVs to achieve maximum yield.

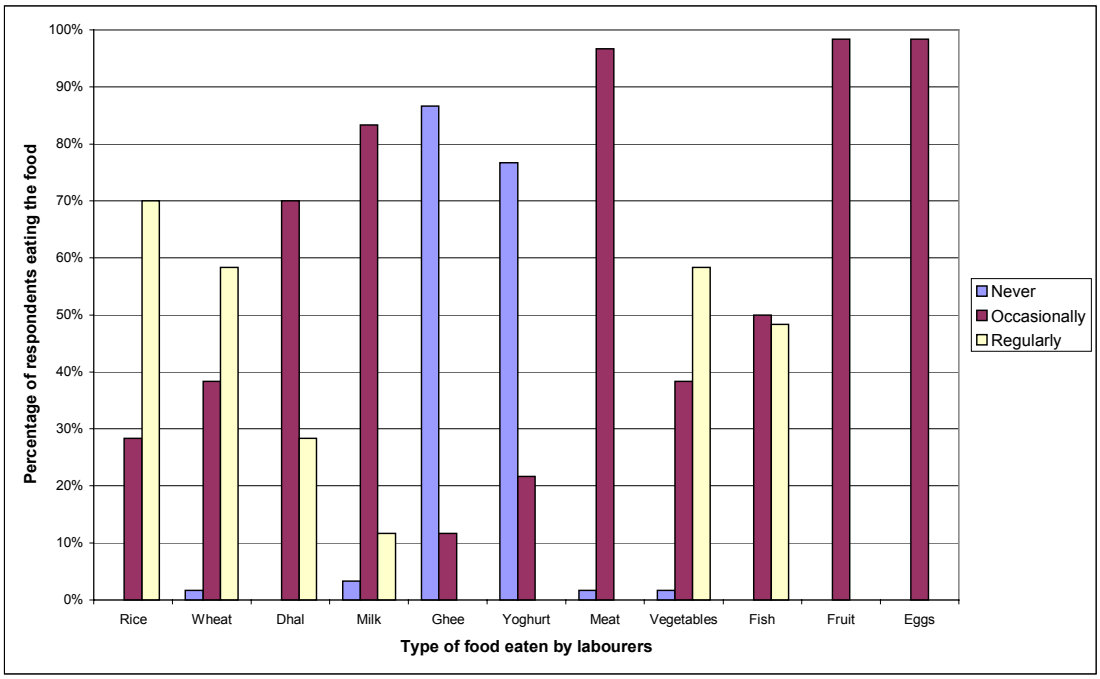
Other training received by villagers varies. In general it has occurred in an informal, ad hoc and small scale way. Talki villagers have received training from NGOs active in the area. CARE Bangladesh have run training programmes on vegetable farming and BRAC (Bangladesh Rural Advancement Committee) have trained and employed 3 female health workers. Some farmers have taken up non-farm activities, such as carpentry. In Mohanpur village these farmers received training from a skilled carpenter before making the change. After the installation of STWs, there was a need for mechanics. In Borni village, the first mechanic received training outside of the village and subsequently passed the knowledge on to others starting the trade within the village.

Market information is principally sought from neighbours, relatives and the local shops and market. Apart from neighbours as the main source of market information for the three villages, Mohanpur farmers rely most heavily on the local market itself and Borni farmers rely on local shops.

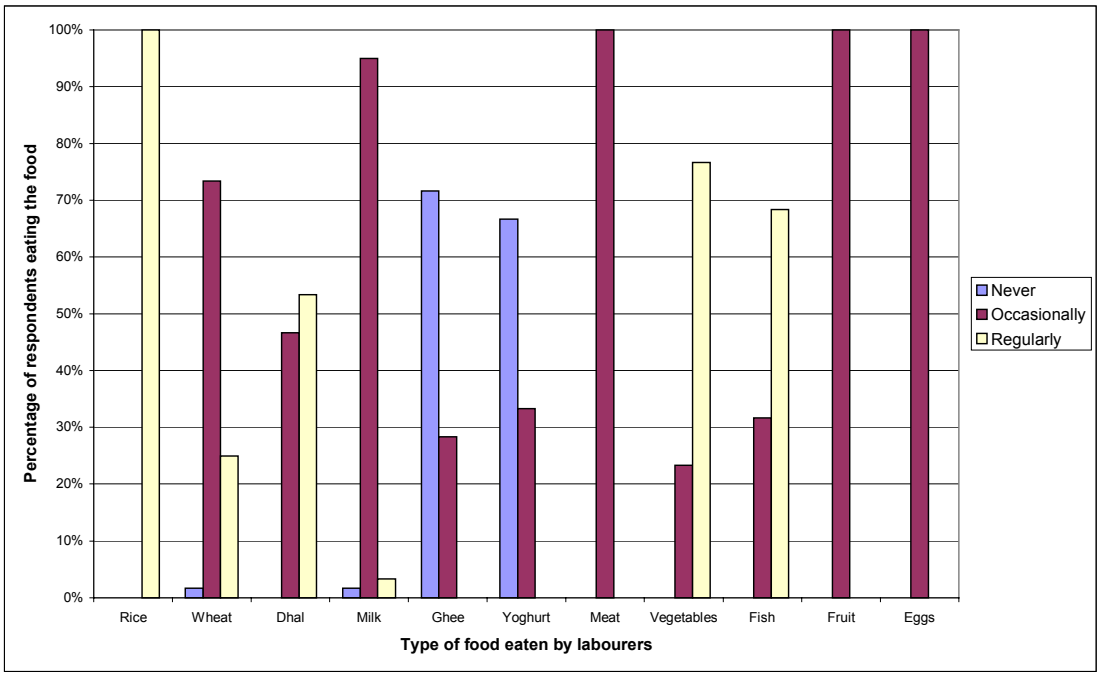
6.6 Impacts on labourers, crafts and tradespeople and general merchants and service providers

The pattern of food consumption habits for labourers shown in Figure 13 is similar but more pronounced than that of farmers. Since irrigation, wheat and dal have become less significant crops. Irrigation has helped to place greater emphasis on the production and subsequent consumption of rice crops. Milk consumption has remained more or less static, probably due to the low emphasis on livestock farming both before and after irrigation. Consumption of expensive food items such as yoghurt, fish, vegetables and

ghee has risen and perhaps reflects the increased income and purchasing power of both labourers and farmers. To some extent it also shows an improvement in diet. Meat has, however, remained a very expensive item and is still only eaten occasionally.



(a) Before irrigation



(b) After irrigation

Source: questionnaire survey

Figure 13 Foods eaten by labourers before (a) and after irrigation (b)

7. SOCIAL CAPITAL

7.1 Background

The information for this section has been gathered in questionnaire surveys at the three sites, by process investigators closely involved in the sites, and from team site visits. Many aspects have been covered and the section reflects analysis and interpretation of the information by the research team. Social capital is not easily measured; it includes assessment of a number of key sources such as families, communities, businesses, civil society and how they support people in their everyday lives. It relates to many resources and processes, including the less tangible resources upon which people draw; e.g. networks and complex patterns of obligation, membership of groups and relationships of trust, reciprocity and development, and sharing of knowledge.

The link between irrigation and social capital is difficult to disentangle because it occurs in a dynamic setting in which irrigation development is only one of many changing variables. These might include road building, flood defences, NGO activity, educational opportunities, changes in market conditions or regulations relating to water and irrigation. However, changes in food security, cash reserves, health and education spending, and use or neglect of new technologies that follow crop production often influence social behaviour and institutional arrangements.

Irrigation at the sites mainly results from the adoption of STW technology which has been facilitated by the Bangladesh government via liberalisation of the market for STW equipment. In addition irrigation is supported by credit services that enables farmers to invest directly. The generally disappointing results of DTW programmes gave impetus to this policy. New social capacity arising directly from irrigation is possibly limited by the relatively low demand for group or communal activity to manage a STW, in contrast to what was needed in the earlier DTW development phase. Indeed, poor social cohesion was blamed for limiting the benefits of the DTW programme and for its ultimate failure. It is also possible that an increase in individual wealth might lead to the deterioration of formerly useful social constructs that protected the chronically poor.

Costs and benefits associated with shallow tube wells are in line with small farmers' management capacities and provide good conditions for sustained development. The relatively small scale of the technology allows for a better spread in the countryside, thus the poorer farmers, who cannot themselves invest, stand a better chance of being able to buy water even if the amount is limited. The STW plays a significant role in providing food security for rural people. Prior to irrigation farmers relied on a main rice crop and a variety of crops of shorter season and lower water requirements. Some of the non-rice crops were alternative food crops such as wheat, pulses and onions, others were cash crops such as jute and tobacco, both of which had declining world prices. Living standards were low and it was common for people to starve.

Living standards have improved in all the locations and this section considers what this means for families and the men, women and children in them and how their changed condition affects the social structures in the area. Parallel developments have taken place, such as improvement to roads and access to transport, electricity, drinking water and developments in other agricultural production such as poultry farming. Improved roads and paths support increased social capital, making it easier for people to travel to meetings, ceremonies and classes and participate in events after dark. Thus non-irrigation government activity and NGO programmes also contribute to social capital. Irrigation cannot be identified as the single cause of the change, but increased income from irrigated production, helps other developments occur and this leads to greater sustainability. Social capital is not isolated from the other capitals and it can be seen from Table 51 that the findings relating to each livelihood capital affects others.

Table 51 Assessment of capital assets by village

	Borni	Talki	Mohanpur	Issues relevant in all 3 villages
Physical	Rice mills, STW and HTW important.	Rice mills, STW and HTW important.	Rice mills and STW and HTW important.	Women benefit from reduced labour.
Natural	People claim that the impacts of bad weather are greater since irrigation. Crops are in the field in bad weather because of the extended growing season. Decreases in pasture and *beel* have implications for access to fish, meat and possibly fuel.	Less pasture available with implications for protein consumption and possibly fuel availability.	Less pasture available with implications for protein consumption, fuel availability. Less fish in *beels* due to excess fishing /poor water.	Increases pressure on common resources, implications for nature, bio-diversity and very poor people who rely on common pasture land.
Financial	More money available since irrigation increased crop yield.	More money available. Credit important to women: external stimulus from Grameen Bank.	More money available since intro of irrigation. Vegetable sales important –NGO stimulus.	More money available, more working capital and greater economic activity generally.
Human	More children in school. Reduced workloads.	More children in school. CARE offers training on organisation to adults. Reduced workloads for men and women due to power tillers and rice mills.	More children in school. Reduced workload.	Education likely to raise ambitions, change attitudes of younger people. One or two young girls now ride bikes.
Social	Barni Biddut Unnayan Samity (raising electric connection money), DTW committee, East Barni Udayan (social), Football club, School and 'Madrasha' committees. No formal women groups. Women keen to be employed off farm but not keen to migrate to Dhaka.	Interaction with NGO on vegetable growing. Increase in number of mosques. Boys' clubs No formal women groups.	BRAC health programme targets mothers and babies, DTW committee, School and 'Madrasha' committee, *Beel* co-operative. No formal women groups.	No apparent reduction in the social networks, some possible strengthening as women increase social activity and participate in NGO programmes and meet at work, etc.

Changes in physical capital have reduced labour requirements, freeing time and energy for community and educational activities (both as components of projects and more generally as part of formal education) in the social and human capital sectors. There are also links between the increased availability of money and the establishment of 'Madrasha' (religious schools) and football clubs.

7.2 Similarities and differences between the study villages

Mohanpur is the largest village with an estimated 6000 people, Borni comes next with around 5000 and Talki is the smallest with only 3500. The entire area is predominantly Muslim but in Borni there is a significant Hindu population. Relations between the two groups are cordial and social cohesion is limited only by dietary requirements with which people cope easily. Many people invest in rickshaws to improve their own mobility and also to earn off-farm income. Local transport is important to access markets and services. Most crops are transferred to market privately.

The communities are relatively stable, depending almost exclusively on agriculture and surrounding natural assets. People are farmers, labourers and fishermen. The numbers of artisans and service providers is growing as income from rice increases, and they are assured of a living serving farm families. The economy is rice-based and jobs labouring in farms and in rice mills have increased. However, manufacturing employment in rural areas is less now than it was when jute and tobacco were commonly grown. In general the diversity of crops is diminishing and people reported this in relation to the variety of food is less since wheat, dal and other pulses, sugarcane and mustard are now rarely grown. Less pasture has reduced the availability of meat and milk and a reduction in available manure makes people more reliant on chemical fertiliser. The village populations are growing and there is some out-migration in search of waged work.

7.3 Changes in social capital

Religious observance is a focal point of village life and education, religion and social interaction are closely linked. The questionnaire examines the differences in social behaviour before and after irrigation started in each area. Questions addressed interdependence within the community; the help that was given and received was investigated. Over all the villages, approximately two thirds of the people interviewed said they received help at some time and 60% said they were more willing to give help since they practised irrigation. The feelings were not the same in all the villages. Tables 52 and 53 show who gave help and how their willingness to do so had changed.

Table 52 How willingness to help had changed since the adoption of irrigation (%)

	Borni	Talki	Mohanpur
More willing	83	2	97
No Change	13	87	0
Less willing	3	11	0

Source: questionnaire survey.

Table 53 Who respondents helped, and how often (%)[4]

Village	Borni			Talki			Mohanpur		
Who help was given to	Relatives	Neighbours	Poor	Relatives	Neighbours	Poor	Relatives	Neighbours	Poor
Never	62	20	52	27	45	42	26	26	17
Occasionally	38	45	47	65	47	47	74	74	83
Monthly	0	3	0	3	5	3	0	0	0
Weekly	0	0	0	3	2	3	0	0	0
Daily	0	0	0	2	3	5	0	0	0

Source: questionnaire survey.

[4] Some questions remained unanswered so that percentages do not always add to 100.

Almost everyone was more willing to help others now compared to before irrigation. In Talki there was generally a lower increase in willingness than in the other villages. It is hard to interpret this without more comparative information about the past, but it is possible that a recent storm there influenced people's views. Despite this, income in this village seems to have risen three to four-fold after irrigation, with one individual's income rising to more then ten times the previous level. There are also more instances of regular assistance being given and it may be that this too is connected to recent storm damage. It is possible that people see no need to offer more assistance. In Borni and Mohanpur, willingness to offer help has increased almost universally and is linked to increased ability to help.

In Borni and Talki, help is commonly given to neighbours, poor people, and relatives with the people of Talki seeming more inclined to help relatives, whereas in Mohanpur the level of assistance given is generally higher and is spread across the three groups fairly evenly. Overall there seems to be high motivation to help the less fortunate in an even-handed way.

7.4 Informal networks

The fact that many people both give and receive help suggests a high degree of reciprocity and a culture of obligations. This is indicative of strong social networks and established social capital, as might be expected in populations where frequent natural disaster requires people to pull together for survival. The number of Mosques and 'Madrasha' built as incomes have risen illustrates the importance of religion. The charitable and equalising impact of these cultural preferences is significant in distributing benefit to those who might otherwise be left out.

7.5 Formal committees

Formal committees are associated with the managing of schools, DTWs, clubs and 'Madrashas' (Table 54), but committees are relatively few compared to Nepal. Education and information are available from two main sources; government primary and secondary schools and religious-based 'Madrashas'. Schools provide western-based education while 'Madrashas' prioritise religious teachings but nowadays provide some general education and have rapidly expanding curricula. The expansion of the 'Madrasha' system is a significant element in improving the access of poorer children to education as well as providing the people involved in the committees with valuable experience of managing facilities for their community. Groups set up by NGO activity, often savings related, or fishing groups and labour were the only group types mentioned, and only about a quarter of the respondents were involved overall.

Table 54 Village Organisations[5]

	Barni	Talki	Mohanpur
DTW committee	1 DTW		1 DTW
Beel committee	3	2	4
School or 'Madrasha' committees	1 School cttee 2 'Madrasha' (1)	3 'Madrasha'(1) 1 Primary school	3 ,'Madrasha'' committees (0)
Mosques and Temples Cttee	2 Mosques 3 Temples (2)	6 Mosques (2)	8 Mosques (2)
Other committees	1 Electrification committee (0) 1 E. Barni Udayan Club for Mutual help (0)	2 Boys' club (0) NGO savings groups	

[5] Bracketed figures show the numbers of such committees before irrigation development. No brackets imply that the number remains the same as before irrigation, but it should be remembered that activity levels might have changed in either direction.

People refer to beel co-operatives although the beel belongs to government.

Beel co-operatives control fishing and, by controlling commercial fishermen's use of the beel, protect fish populations for sustainable use by the villagers. Villagers' access to fish for their own consumption appears to be threatened by diminishing fish stocks, although pond-grown fish are increasingly available if they can be afforded. Community business is formalised through local government organisation at village level and representation and assistance for local people is channelled through the Union Parishad member.

7.6 Changing work roles

As the expanded rice area pushes the forest back from the homesteads and reduces *beel* size, there are changes in the way people use natural resources. Women increasingly expect men to collect firewood because of the distances involved. Women are able to obtain water to grow vegetables, either from STWs or HTWs. They do not seem to regard this as farming. The vegetables are grown either in backyards or on small areas of land designated by the husbands. However, vegetables have a relatively high market value and are commonly sold by the husbands, most women getting only a small share of the proceeds. Men are too busy to spend time catching *beel* fish and women rely more on fishermen and pond fish for fish to feed the family, which may be a poor proposition for poor people. Both men and women benefit from labour saving technologies such as power-tillers and the rice mills but women are unable to take advantage of the time this releases because the employment they could formerly find in tobacco and jute processing has gone. Some women are exploring entrepreneurial activity like garment making for local markets.

7.7 Gender concerns

Women are not closely involved in the development of physical capital for irrigation, largely because men have the major role in land ownership and tenure. However, women are strongly affected by irrigation development and investment in rice mills and other technology in response to improved production. In all the villages, women benefit from reduced workloads and in some instances a number of women benefit from paid employment at the local rice-mills. These women enjoy the society of other women workers, which they see as an additional benefit. Hand tube wells benefit women in particular. Although HTWs primarily provide domestic water and improve hygiene for women and children, some backyard vegetable growing has developed using the water, adding nutritional and cash benefits.

Compared to the situation before irrigation, there is now less access to natural capital and common resources such as forest, common grazing and common freshwater beels for fishing. For better-off women, the reduction in the availability of common resources is compensated for by increased purchasing power from the additional rice grown and sold. In poorer families, additional rice is generally consumed and a reduction in the access to protein sources such as fish and goats may be significant. Poor women have little opportunity to buy poultry and meat, due mainly to a shortage of money but also because locally produced poultry is often sold in distant markets. They therefore reported very low consumption rates but possibly had access to fish alternatives (although these are said to be decreasing). Pond grown fish are available but at a price. Although additional rice has reduced the risk of hunger, the longer-term implications of the change in diet may be negative for poor families and should be investigated.

Financial capital is clearly relatively new to women. Cash reserves or other financial assets are still uncommon among women who are not in paid employment and there is clearly high motivation among women to take up income earning opportunities. The limited opportunities available to women were pointed out in all the villages. The women were primarily interested in income generation outside the agricultural primary production sector thus the issues of land tenure were relatively under-explored in the discussions. It was not clear if the women preferred non-farm work because it paid better or if social contact and escape from drudgery were important. They did not have expectation of access to land, although some widows had land. However, among women who had been able to accumulate cash, there was interest in investing in STWs, rickshaws and cattle. Treadle pumps were not specifically mentioned.

Human capital has been increased by education in all three villages and by the arrival of increased numbers of artisans and skilled people from elsewhere. The numbers of girls in education has increased and at Talki more girls than boys attend the 'Madrasha', and in Mohanpur girls outnumber boys in all the schools. At Borni, figures for primary education show roughly equal numbers of boys and girls. There are significantly fewer girls at secondary school and the 'Madrasha' takes boys only.

In-comers are drawn to communities once farm production increases and farmers have money to spend. Although both men and women benefit, it is questionable whether they do so equally. NGO and government activities target women particularly with health and nutrition programmes and in some places this extends to training in horticulture, marketing and post harvest processing. However, women complain that they do not manage to control the income from the vegetables they grow and feel they get a rather small share of the benefit. NGOs focus on women resulted from concerns for family health and perceptions about educational advantages of males who generally had more ready access to places in school and remained there for longer periods. Although this seems already to be changing, men's control of money encourages the growth of services preferred by them.

The traditional social capital of the villages remains strong but is changing. It is clear that mechanisms exist to provide for the less fortunate, but it was difficult for the women to describe how the arrangements might have changed over time. Rich women were able to spend more on domestic help as a result of increased income, which was one way of helping poorer families. In one place it was suggested that medium-term loans of food are provided but that recipients must repay, with interest, within the year. At another, the 'food for work' solution was preferred and no repayment was involved. These often seem to be solutions arranged entirely by women. The reality is undoubtedly complex and requires detailed analysis before any statements could be made about growth or deterioration of social capital.

The women generally spend all their lives in the villages, which are expanding and improving as people build separate and better built houses. People are highly motivated to improve their houses as their economic condition improves. The health impacts are positive but the social impacts are still unclear.

7.8 Differences among women

The women in each village do not form a single homogenous group. In seeking to improve the impacts of irrigation it helps to understand the impact of irrigation on different groups. The analysis differentiated between rich women, i.e. those who have relatively large farms (in terms of cultivable lands), who own STWs, power tillers (PT), rice husking machines and semi-pucca tin shed houses, and poor women who generally have none of these assets. The poor typically have less than 0.2 hectares of cultivable land and their standard of living is very low compared with other women of the study village. Most of their husbands earn money by labouring.

It also differentiated between old and young. The cut off age for young women was 25, and in the young group some were married while many of them were still unmarried. Among the old women most were widows, depending on their sons, but including a few distressed women who had no assistance.

Group discussions were held with around 8 women from each type identified to gain a better understanding of how they had been affected by irrigation, giving women equal chances to participate according to a structured discussion format. The essence of the group discussion is presented in the following sections.

7.9 Women's views about limitations to and opportunities for benefit in their particular group

Among the rich women STW investment has led to increased modern variety 'Boro' yields and better income. Most women now have sufficient food, cloths and necessities. They also spend less time at work now because rice-husking mills are available in each village and they can afford servants to help with household work. One woman of Mohanpur village, in Jamalpur district, mentioned that her family had made tremendous economic progress due to irrigated modern variety rice production and bought luxury

items such as: colour television, video cassette recorder, radio, motorcycles, etc. Another woman had earned sufficient money to have a boiler rice mill. It is evident that the villagers of Mohanpur made this tremendous progress due to irrigated rice production. Rich women can save a part of their income and some are able to purchase a little cultivable land or jewellery for themselves and their daughters. They can spend more money on consumption goods for their children. Some women have constructed semi-pucca houses (locally called 'half buildings') instead of tin sheds. Better-off women can supply irrigation water to their vegetable plots. As a consequence, they cultivate more vegetables in the homestead area than ever before and can generate further income. An added advantage of the STWs is that in the peak dry season (March-April) they can provide drinking water when hand tube wells cannot lift sufficient groundwater for drinking purpose. This advantage applies irrespective of women's status.

On the other hand, among poor women, who have only tiny plots to cultivate vegetables, the advantages of irrigation (in terms of production) are more limited than for the rich. It is possible that the nutritional impact of vegetable growing is significant but the income effect is likely to be small. However, their day labourer husbands now get more wages since the introduction of the seed-water-fertiliser technology. Women of this group also work in rice mills and earn a little money, which is of great financial help. Many of them take part in post-harvest activities at the houses of relatively richer farmers, or do domestic work in the farmhouses, and earn in kind (a certain amount of rice/paddy) and cash as wages. Poor women thus enjoy better economic conditions since the introduction of irrigated rice in absolute if not relative terms. Women labourers of Talki village earn around Tk 30/day in rice mills. Some of the women of Borni village who work in a rice mill get Tk 900 per month. Many women now eat three meals a day for the first time ever. More importantly, the high yields that come from the adoption of minor irrigation technology have lowered rice prices, relative to wages and put rice within the purchasing power of poor women.

The young women depended mainly on agriculture, and yield increases from irrigation were very important to them. Some from Talki village and Mohanpur were married to village shopkeepers and one owned her own shop. During the harvesting period sales of modern variety Boro rice go up, and so do women's incomes. One young women at Talki, whose husband is a carpenter, says that after a good rice harvest villagers give more attention to furniture for their houses. As a result her husband can earn a substantial income at that time. Many women grow irrigated vegetables in their homestead to use for home consumption and to sell to increase their income. With the cash they earn, they can purchase clothes. They have enough food and can also spend on their children's education.

In all the villages, old women depend on the incomes of their husbands or sons. Age limits the work these elderly husbands can manage. Their son's wives can often afford servants now so that the old mothers can rest. Some have sons who have diversified into different activities, such as pump mechanics and shopkeepers, and may be able to help their mothers. Fishing is an important food and cash source for the elderly, particularly if land is scarce. Combined with increases in yield for those with land, and lower prices for others, they feel their income has increased and they can take meals 3 times a day. Some feel they can easily help others.

7.10 Women's views on the relative importance of tube well technology and reasons for investing in tube wells

Rich, poor, young and old agreed that increased yields from irrigation, plus an increase in the area of rice cultivation that irrigation had made possible, were catalysts to adoption of other technologies such as the power tiller and the rice mill. Without irrigation there would have been no point in investing in these technologies, as the volumes of rice produced would not have warranted it. The young women pointed out that their husbands no longer wanted to be bothered with draft animals and also that the reduction in available pasture and consequent shortage of draft animals made the switch to mechanisation imperative.

Only rich women had any experience of investment in shallow tube wells but they left the investment decisions to men. There was a clear gender division of decision-making; the women's centred on family and health but men also had say in these decisions. Men dominated decisions on investment and

technology. All groups of women seemed to agree that because men earn the money they have a right to make decisions. Only one rich woman took agricultural investment decisions and she did so because her husband ran a distant (probably more lucrative) business. Apart from their lack of control of money, poor and young women felt they would need much more knowledge before they could take part in such decision-making and before their husbands would take notice of their input.

7.11 Women's views on the relevance of irrigation investment to their aspirations

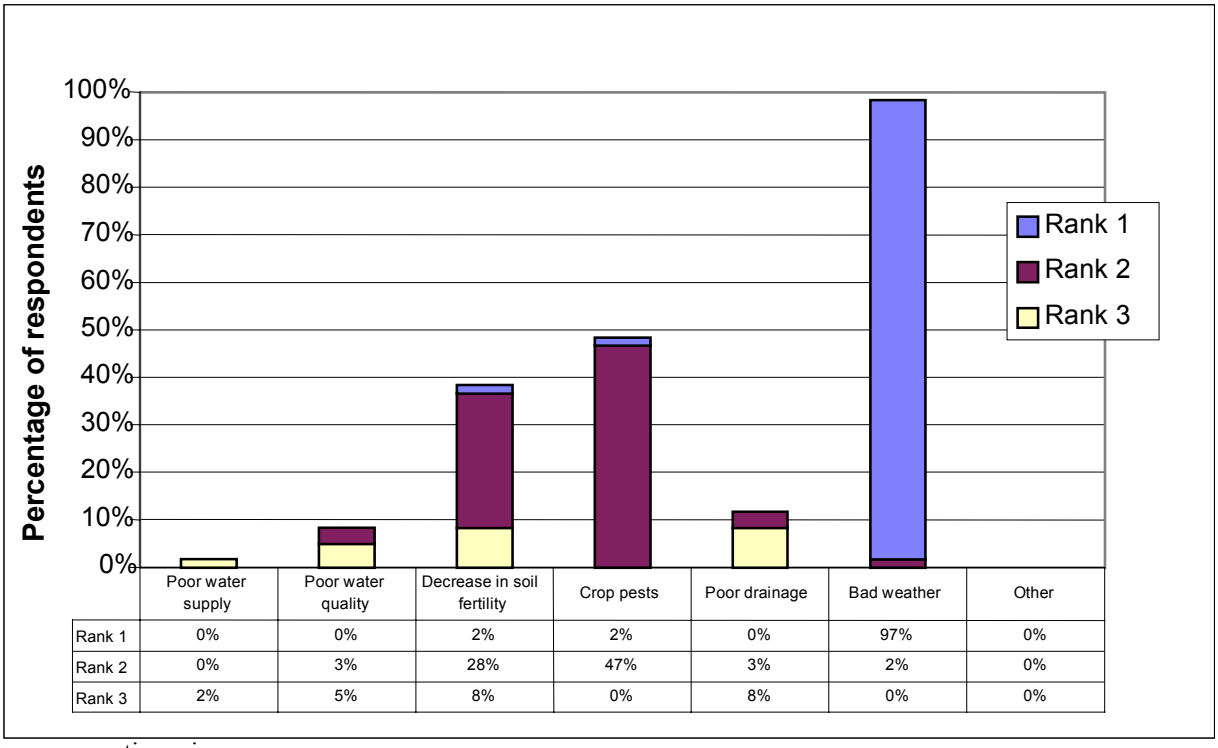
Many women feel land was an important asset that must come before investing in a tube well. Ownership of land was important for status as well as for farming for food and income and is a useful asset when planning for children's marriages. The elderly, who tended to have land already, felt investment in a STW was in line with their needs. On the other hand, young women would rather invest in sewing machines to sew their own clothes and to establish businesses and earn income.

8. NATURAL CAPITAL

8.1 Introduction

When examining changes in the status of natural capital stock which have resulted from the introduction and extension of irrigation, it is important to bear in mind the relative importance of the factors which influence the ability of households to use their resources productively. The survey data used to create Figures 14 and 15 illustrate dramatically that the factor having the greatest negative influence on productivity in both Talki and Mohanpur is bad weather. In both villages this factor is consistently ranked 1 by the vast majority of farm households. In Borni (Figure 16) it is seen as an important determinant, but less so than the quantity of water supplied, which is ranked first by 58 percent of farmers. The factor consistently given a ranking of 2 in terms of its negative impact in each village is the incidence of crop pests, and while a decrease in soil fertility is seen as important in Talki and Borni, poor drainage is more important in Mohanpur (with most farmers ranking it second or third). Poor quality of water is seen as negative factor by 8 percent of farm households in Talki, 0 percent in Mohanpur and 20 percent in Borni.

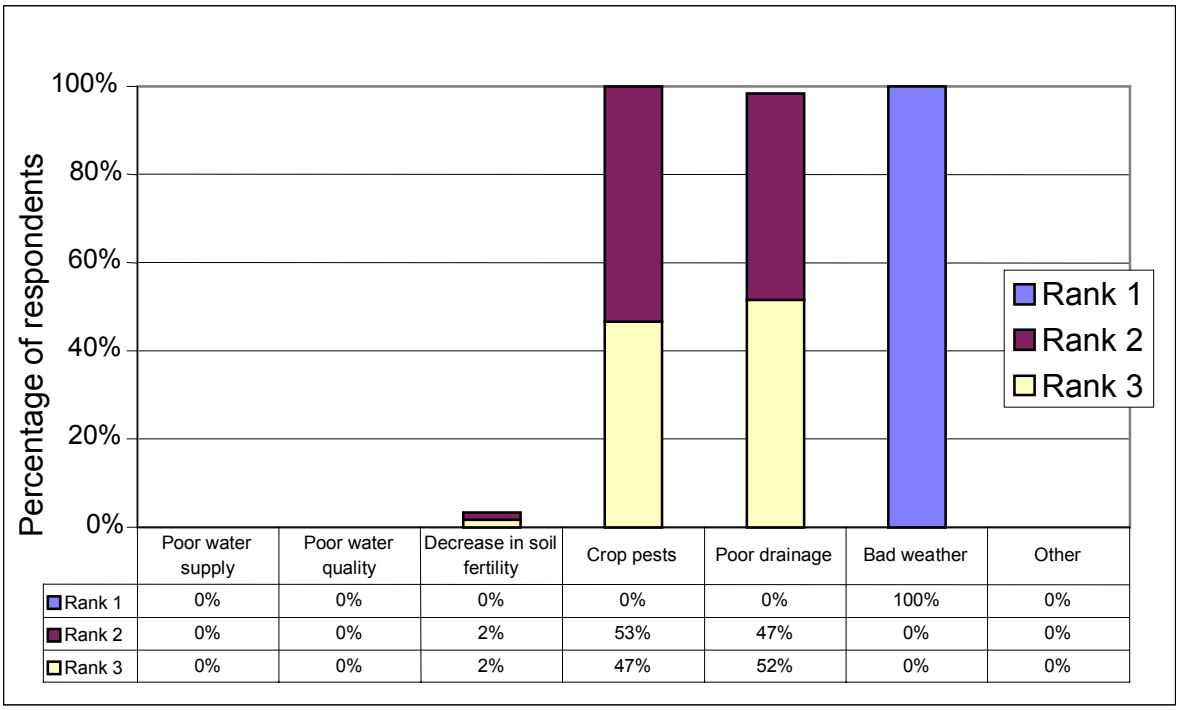
It is in this context that the environmental impacts discussed below must be considered. It is notable that the key factor is the one which the farmers have little or no control over.



	Poor water supply	Poor water quality	Decrease in soil fertility	Crop pests	Poor drainage	Bad weather	Other
Rank 1	0%	0%	2%	2%	0%	97%	0%
Rank 2	0%	3%	28%	47%	3%	2%	0%
Rank 3	2%	5%	8%	0%	8%	0%	0%

Source: questionnaire survey

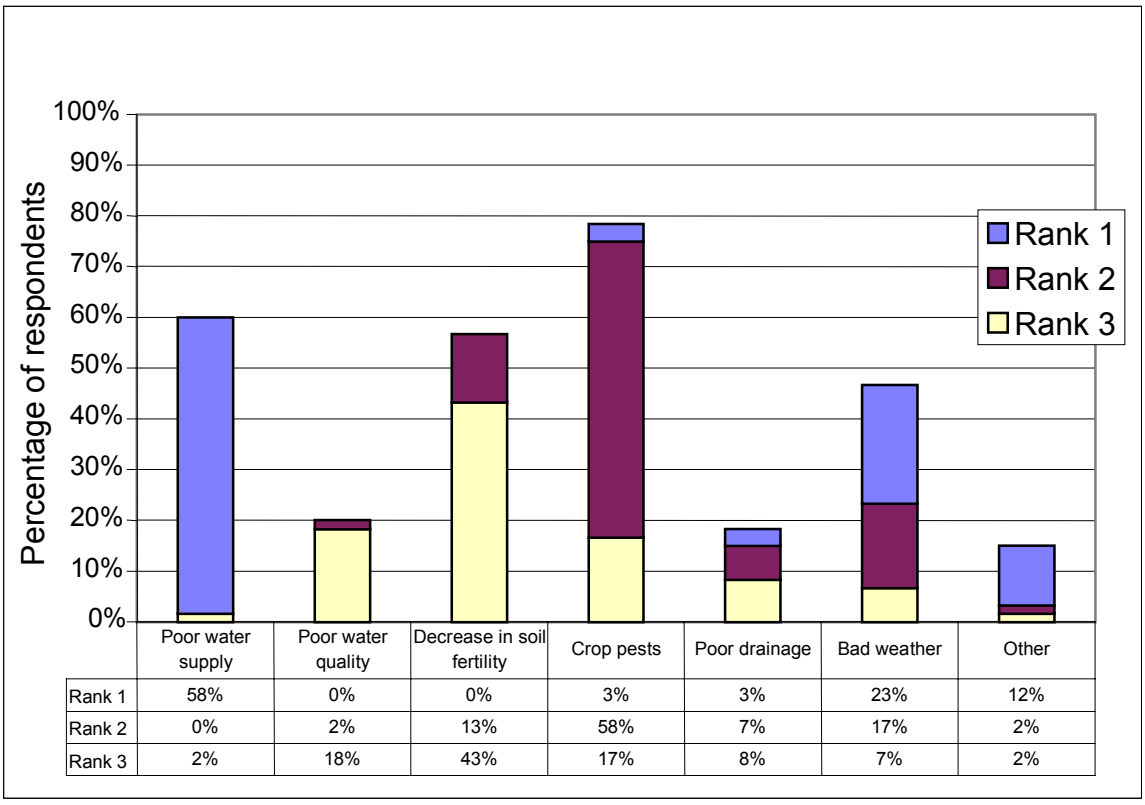
Figure 14 Factors negatively affecting farm productivity in Talki village (ranked according to perceived importance)



	Poor water supply	Poor water quality	Decrease in soil fertility	Crop pests	Poor drainage	Bad weather	Other
Rank 1	0%	0%	0%	0%	0%	100%	0%
Rank 2	0%	0%	2%	53%	47%	0%	0%
Rank 3	0%	0%	2%	47%	52%	0%	0%

Source: questionnaire survey

Figure 15 Factors negatively affecting farm productivity in Mohanpur village (ranked according to perceived importance)



	Poor water supply	Poor water quality	Decrease in soil fertility	Crop pests	Poor drainage	Bad weather	Other
Rank 1	58%	0%	0%	3%	3%	23%	12%
Rank 2	0%	2%	13%	58%	7%	17%	2%
Rank 3	2%	18%	43%	17%	8%	7%	2%

Source: questionnaire survey

Figure 16 Factors negatively affecting farm productivity in Borni village (ranked according to perceived importance)

Impacts on components of the natural capital stock (availability of water, water table depth etc.) are now considered in turn.

8.2 Availability of water

Whilst the availability of water for irrigation is seen as a key factor affecting productivity in Borni, all households in all villages (whether farm or non-farm) have relatively easy access to water for drinking, from hand tubewells (average distance from an HTW is about 15 metres with a maximum of 200 meters in Borni); and for washing and livestock, although the sources for the latter vary. In Talki 30 farm households use HTW and 30 use ponds, in Mohanpur all but one use HTWs and in Borni all use ponds for washing and livestock.

It is certainly the case that water is available to a greater extent now than before irrigation, particularly in the dry season. However, the increased use of water has had some potentially detrimental impacts upon the natural resource stock as indicated by a change in the water table depth (see section 8.3).

8.3 Water table depth

Although it is not possible to speculate about the significance of reductions in the water table, the magnitude of change is notable in all villages. Using the depth of STWs as an indicator of water table depth, the following observations were made. In Borni, early wells were sunk at between 60 – 80 feet, whilst more recent wells must be sunk at between 80 – 100ft. The costs of drilling to this additional depth are reported to be moderate and are far outweighed by the demand for the water from the beneficiaries for continued use. In Mohanpur a similar picture emerges with depths of early wells at 60 – 70 ft and more recent at 80 - 90ft. It should however be noted that there is some difference in the depth of the water table across the area this village, with depths in East Parra exceeding 100ft, but in West Parra about 40ft. This is likely to be related to geological factors as much as to increased use.

Field investigations revealed that during the peak irrigation period of the Boro season (March and April), a few hand tubewells (HTWs) which are used for drinking water, ran dry in each of the study villages. The situation, however, gets worse if any rainfall does not occur in the early Boro season. Moreover, some ditches and ponds dried up due to indiscriminate use and withdrawal of excessive groundwater by STWs for MV Boro rice cultivation. As a result, inland fish culture has been adversely affected. In comparison with the "before irrigation" situation, this implies that fish caught from nearby ditches/water bodies are now in more limited supply for either for home consumption and/or for selling to the local market.

8.4 Quality of available water

The farmers' perceptions realted to changes in the quality of water are recorded in Table 55.

Table 55 Perceptions of farmers regarding change in water quality (as percentage of all farm households)

Village	Increase in iron concentration in water	Water quality (unspecified)	
		Decrease	Unchanged
Talki	67%	36%	54%
Mohanpur	18%	0%	100%
Borni	97%	33%	67%

Source: questionnaire survey.

Arsenic pollution[6] was not generally perceived to be a problem amongst the villagers and there was no obvious evidence of health problems that are associated with it. In Borni one 800ft TW has been installed

[6] Irrigation waters from three STWs at each study site were tested in the middle of irrigation season (17-19 March 2003) by a local NGO. No arsenic was found in the water of any of the nine sample STWs.

for drinking water, but this was as a result of a blanket government programme to reduce the arsenic contamination of drinking water and there was no prior testing. In Mohanpur only one of the STWs tested positive for arsenic and was closed and the pump moved. Arsenic contamination appears to be an issue that the government is taking seriously, but as yet there is no systematic testing. Samples taken from the beel areas suggest that there is no evidence of arsenic contamination, suggesting that it is not present in the irrigation water runoff.

There was also a suggestion that runoff from fields with increased chemical loading from fields is polluting the beel area. Table 56 reports results of tests carried out on beel water for the main nutrients. It should be noted however that samples were collected during the rainy season, when the beels tend to be filled with rainwater rather than irrigation water runoff. The results of these tests, which do not indicate any significant pollution[7] may therefore understate the problem.

Table 56 Chemical properties of beel water of three selected villages of Bangladesh

Village with district	pH	P (ppm)	NH_4^-N (ppm)	NO_3^-N (ppm)	HCO_3^-	CO_3^{--}
Borni Netrakona	5.05	0.299	0.77	0.63	40	Nil
Mohanpur Jamalpur	6.00	0.334	0.96	0.63	34	Nil
Talki Sherpur	5.86	0.163	0.91	0.49	52	Nil

Source: Field survey (2002).

8.5 Intensity of land use

With an increase in the availability of water during the Boro season, the intensity of land use has increased markedly. Most farmers previously grew one to two crops per plot per year but this has increased to 2 to 3 crops. This has resulted in a change in the cropping pattern, most notably, a reduction in the use of fallow (which has had a knock-on effect on livestock – see below), and a reduction in the use of leguminous crops. Figure 17 illustrates the significant reduction in land left fallow.

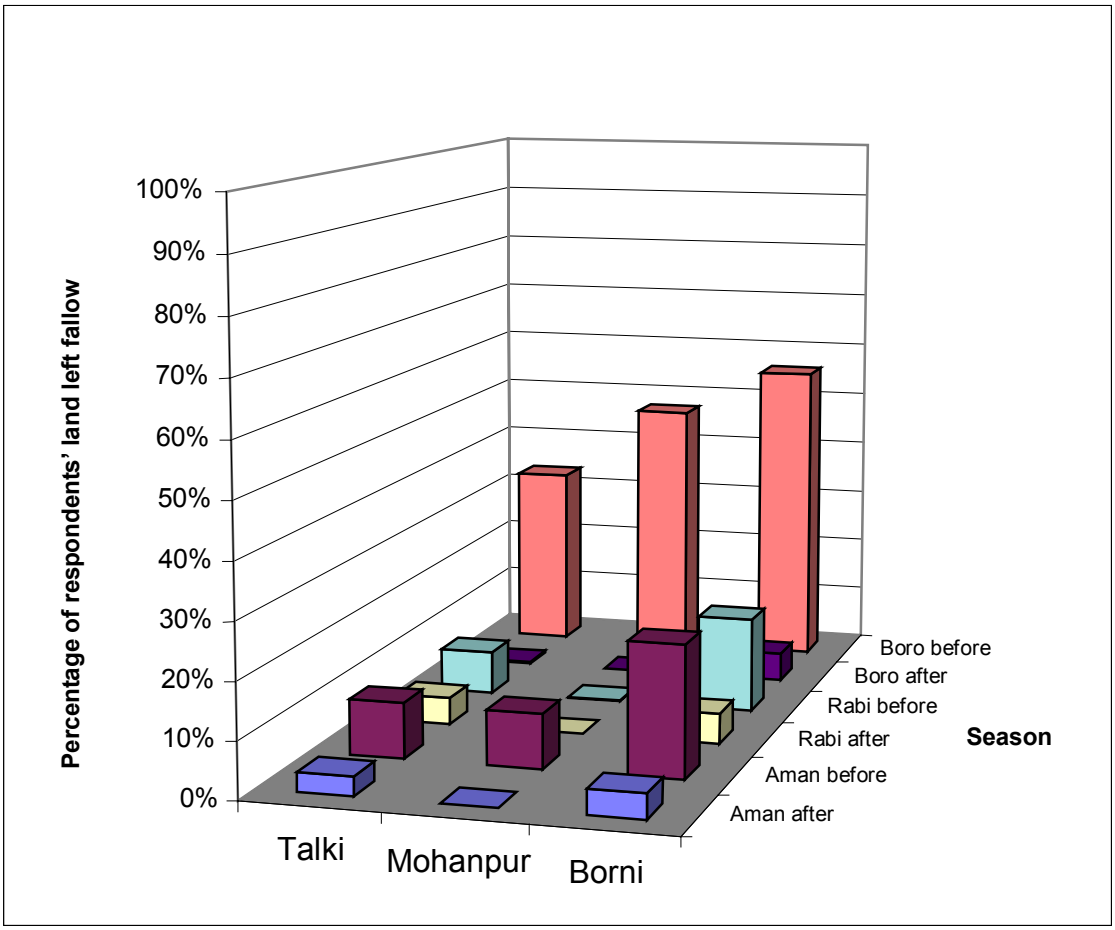
Comparisons can be made both across seasons and across villages. There has been a reduction in the area left fallow in all seasons. The reduction in the Boro season is most apparent and is related to the increased access to available water during this period. There have also been significant decreases in the Aman and Rabi seasons, albeit from a lower base. Comparing across villages, it is notable that in Mohanpur there is now no area left fallow during any of the seasons. In the Boro season, this implied a drop in the average area left fallow from 47 to 0 percent. In Borni farmers leave an average of 5 percent per season fallow, but in Boro this implies a reduction from 56 percent. Interestingly, in Talki, the area left fallow before irrigation was lower than in the other villages but the decrease following irrigation was not so dramatic.

It is probable that the reduction in the area left fallow in Aman and Rabi is related to increased access to other inputs and reduced livestock numbers brought about by Boro season cultivation, as much as increased availability of water.

The implications in terms of environmental impacts of the increase in cropping intensity are manifested in:

- Increased pest and insect damage
- Reduced livestock numbers
- Reduced soil fertility.

[7] For example, a water concentration exceeding 45ppm of nitrate is considered harmful to infants.



Source: questionnaire survey

Figure 17 Percentage of land left fallow by season before and after irrigation

8.6 Increased pest and insect damage

Although no data was collected on the incidence or significance of pest damage, it was noted from Figures 14 to 16 that in the factors affecting farm productivity negatively, crop pests are ranked consistently highly in all villages. A change in the rotation of crops, with greater levels of monoculture, is likely to contribute to this increase in pest and insect damage.

Field observations suggest that Borni is relatively monocultural. It used to be more diversified but factors such as the closure of a nearby tobacco factory have reduced the opportunity for the production of non traditional crops. In Talki greater crop diversity was observed, including sugar cane for home processing (no local sugar mill), and relatively more jute. In Mohanpur there is some level of diversity in cropping pattern but greater evidence of diversity into other enterprises e.g. poultry. The extent of diversity appears dependent on: market opportunities, knowledge, extension and perceptions of risk with respect to levels of food self sufficiency.

8.7 Reduced livestock numbers

With the exception of one or two respondents in each village, all farm households suggested that the area for livestock grazing had been reduced as a result of increased use of irrigation (In Talki 59/60; Mohanpur 59/60; and Borni 58/60).

The more specific reasons provided were similar in each village:

- MV straw is not suitable for local breeds
- The change in cropping pattern resulting in:
  - less growing of green fodder
  - reduction or elimination of fallow
  - labour for minding cattle has become more expensive
  - feed prices are much higher
  - there is less use of animal draft since the introduction of power tillers.

Two impacts of the decrease in the reduction of cattle are a reduction in milk for human consumption (although this is not seen as an issue as little is consumed in rural areas and households can buy it relatively easily) and a contribution to the decline in soil fertility (see below).

8.8 Soil fertility

On the field visits, the perceived reduction in soil fertility came across as one of the most obvious impacts of irrigation, although this is not necessarily reflected in Figures 14 to 16 as being an important factor in influencing crop yields. Indications from each of the process investigators' reports are that soil fertility is perceived to have fallen since the introduction of irrigation. At that stage of the investigation, there had been no soil tests to which the farmers had been party

The percentage of farmers reporting a reduction in soil fertility was as follows:

Talki	90%
Mohanpur	100%
Borni	92%

Farmers suggest that the reduction in soil fertility is reflected in falling yields (although the evidence for this is not readily apparent and it is not clear how farmers "measure" the decline). It may be that an increasing use of HYVs with higher yields is offsetting a decline visible in traditional varieties. It is also possible that the yield of HYVs is more variable due to greater responsiveness to both fertiliser use (or underuse) and the application of irrigation water.

Soil samples were collected from three types of land in each village[8]. The key aggregate results are reproduced in Table 57.

[8] See Anwar and Miah (2002) for detail of methodology and soil test results

Table 57 Maximum, minimum and average values for different soil properties in the three selected villages in Bangladesh

Village with district	pH			Organic matter (%)			Total N (%)			Available P (ppm)			Exchangeable K (meq/100g soil)		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Barni Netrakona	6.36	4.78	5.31	2.91	1.14	2.17	0.140	0.057	0.104	25	09	16.33	0.5	0.125	0.444
Mohanpur Jamalpur	5.67	4.87	5.27	2.55	1.03	2.0	0.128	0.052	0.100	28	05	17.44	0.505	0.143	0.316
Talki Sherpur	6.28	5.17	5.64	3.14	1.21	2.08	0.157	0.061	0.104	48	21	34.33	0.484	0.253	0.342

Source: field survey

The soil pH is slightly acidic, a factor common in areas of high precipitation, and is not considered to be a yield limiting factor. Soil Organic Matter (SOM) is, however, considered to be low in the majority of plots, with a standard of 2-3% considered the minimum required content. SOM is therefore a limiting factor in most plots. The low values for SOM are caused by the high temperatures in the region and the propensity to use inorganic rather than organic fertilisers.

Levels of total N also fall below critical levels. Again, this is attributed to the reduced use of crop residues, livestock manure and legumes, and is linked to increased leaching associated with irrigation water application.

In order to understand the relationship between low content of these key nutrients in the soils and changes in fertiliser application rates, data was collected on the fertiliser application rates on the plots (18 out of the sampled 27) that were currently being cultivated. The collected data are reproduced in Table 58 along with the recommended rates supplied by BARC (1997). From Table 58, it can be seen that 10 of the 18 plots received appropriate applications of N, but that the remaining 8 received applications in excess of the recommended rates. Similar patterns are observed for phosphate and potassium application.

Table 58 Actual and recommended doses of fertilisers (kg/ha) for MV Boro Rice in the selected villages

Study villages with land type	Plot No	Yield goal (t/ha)	Recommended doses (kg/ha)			Actual application (kg/ha)		
			N	P	K	N	P	K
Village Borni	1	6.0 ± 0.6	129.5	25.16	-	120	15	20
		4.5 ± 0.5	92.09	17.61	-			
Medium low	2	6.0 ± 0.6	130.0	21.82	-	120	20	10
		4.5 ± 0.5	92.45	15.27	-			
	3	6.0 ± 0.6	125.5	-	-	130	20	15
		4.5 ± 0.5	89.25	-	-			
	1	6.0 ± 0.6	110.5	13.49	-	130	10	10
		4.5 ± 0.5	78.58	9.44	-			
	2	6.0 ± 0.6	116.5	21.87	-	110	20	5
Low		4.5 ± 0.5	82.84	15.27	-			
	3	6.0 ± 0.6	145.5	6.83	-	120	20	-
		4.5 ± 0.5	103.47	4.78	-			
Village Mohanpur	1	6.0 ± 0.6	124.0	-	41.81	130	20	20
		4.5 ± 0.5	88.18	-	29.87			
	2	6.0 ± 0.6	128.0	-	58.99	130	30	20
Medium high		4.5 ± 0.5	91.02	-	42.13			
	3	6.0 ± 0.6	129.5	9.44	-	100	20	10
		4.5 ± 0.5	92.09	6.85	-			
	1	6.0 ± 0.6	125.0	-	-	130	30	20
		4.5 ± 0.5	88.89	-	-			
Medium low	2	6.0 ± 0.6	125.0	6.83	-	120	20	10
		4.5 ± 0.5	88.89	4.78	-			
	3	6.0 ± 0.6	116.5	26.83	5.23	125	30	10
		4.5 ± 0.5	82.84	18.78	3.73			
	1	6.0 ± 0.6	154.0	29.98	-	130	25	10
		4.5 ± 0.5	109.51	20.98	-			
	2	6.0 ± 0.6	130.5	8.5	-	110	20	10
Low		4.5 ± 0.5	92.8	5.24	-			
	3	6.0 ± 0.6	141.5	31.65	-	125	25	15
		4.5 ± 0.5	100.62	22.15	-			
Village Talki	1	6.0 ± 0.6	125.5	-	-	120	20	15
		4.5 ± 0.5	89.24	-	-			
Low	2	6.0 ± 0.6	103	-	-	110	15	10
		4.5 ± 0.5	73.24	-	-			
	3	6.0 ± 0.6	102	-	-	115	20	10
		4.5 ± 0.5	72.53	-	-			

Source: Table 5 (Anwar and Miah 2002).

The results in Tables 57 and 58 are therefore consistent in that the application of high levels of N can reduce levels of available phosphorous and potassium in the soil.

In assessing the "health" of the soils in the selected villages, it would appear that the over application of inorganic fertilisers and reduced use of organic fertilisers is having a detrimental effect to the extent that it is limiting yield potential.

Although the main reason given by farmers was the overuse of inorganic fertilisers, the problems observed could equally be due to the use of an inappropriate mix, with urea being more readily available than other nutrients. As discussed above, the reduction in land left fallow and associated reduced use of legumes in the rotation[9], and reduced grazing for livestock (and thus in livestock numbers and resulting organic manure) are also likely to have contributed.

8.9 Other natural capital resources

Two other components of the natural capital stock that have also changed over the past two decades include:

- the forest resource
- fish stocks.

8.9.1 Forest resource

In all villages, there has been a reduction in the number of trees (both fruit and timber). Although associating these reductions with the increase in irrigated agriculture is difficult, the following trends are apparent:

In Borni, privately owned forest surround the homesteads. These are used for construction and fuelwood and fruit collection. Clearing for agriculture was also noted. In Talki, the pattern is similar and although new plantations are being created, there is evidence that more is cut than replanted. In Mohanpur the price of wood for construction has risen such to make the fabrication of concrete pillars as a substitute a viable option.

Whilst timber is used for house construction, which has increased, although it is not clear the extent to which this is due to increased income from farming or related activities as opposed to increased population size.

8.9.2 Fish resources

Again, patterns of deterioration in the status of the fishery resources in the beel areas were similar across villages. Direct impacts of irrigation via a reduced beel area and increased runoff of farm chemicals[10] and an indirect impact via an excessive demand for fish (resulting in higher prices and overfishing) have been observed.

In Borni, the beel size has reduced due to increased cultivation of the beel areas. In Talki perceptions (and apparent scientific evidence) suggest that increased use of fertilisers and pesticides has resulted in a reduction in the regenerative capacity of fish stocks. There is also more catching of fingerlings. In this village, areas of beels are leased from the government. There is a restriction on fishing for sale (not for own use) but 25% of the value of the catch must be turned over to the lease owner. In Mohanpur, where the resource is generally privately owned, fish culture is seen as highly profitable but is limited by land area and cost of preparing ponds. There has been some conflict with a neighbouring village over the use of the resource, which required government intervention for resolution.

[9] There was some evidence of green manure in Talki but in sporadic plots.
[10] Although this was not demonstrated by soil tests, the results may have been influenced by time of sampling.

9. CONCLUSIONS

Many households in Bangladesh nowadays receive a substantial proportion of their total income in the form of remittances from family members working elsewhere, either within or outside the country. The purpose of the project was to assess the impact of irrigated agriculture on livelihoods. It was therefore ensured that within the study villages, farming is still the main source of income for the majority of households.

According to the national categorisation, a rural area is defined as poor when 80% of farm households hold less than 1 ha. Of the selected study villages, Talki (79%) and Mohanpur (88%) are thus both poor areas. Borni (65%), with average total landholdings of 1.2 ha. and 33% of farmers holding 1.0-3.0 ha. (medium), would appear to be slightly better-off. In fact, the village has a higher proportion of landless labour with limited prospects than either of the other two villages.

1. The primary impact of irrigation from privately-owned STWs has been to allow farmers to grow a crop of high-yielding (boro) rice in the dry season, supplementing a (generally) rain fed improved aman crop, in place of a relatively low-yielding, rainfed, broadcast aus-aman cropping pattern. The mean boro crop yield for the three study villages in 2002 was around 4.5 T/ha which is substantially greater than pre-irrigation yields, despite hailstorms at the time of harvest. The positive impact on household incomes may be judged by the fact that the average yields for aus, prior to general use of STWs, was around 1.3 T/ha, and for aman 1.7 T/ha.

   The increase in annual crop yield results from a package of measures including transplanted, high yielding rice varieties, irrigation and greater agricultural inputs. Yields are also generally less variable than for rainfed cropping. The national average yield for HYV boro rice in 1998-99 was 3.1 T/ha (Bangladesh Bureau of Statistics, 1999).

   Irrigation has led to a reduction in animal husbandry. There are a number of reasons for the change: firstly, fallow, forest and beel areas, formerly used as grazing areas, have been lost to boro rice production; secondly, HYV rice produces less straw for fodder; thirdly, the widespread use of power tillers has reduced the need for draft animals. Cattle and goats are now much fewer in all three villages. Most households now keep animals for their own use, rather than for commercial purposes. The reduction in supply of manure has some adverse consequences for the environment (see 5).

   In other respects, farmers are diversifying their activities, using capital accumulated from greater rice production. Intensive poultry production and aquaculture are favoured enterprises.

2. Deep tube wells, originally installed in the villages by the government, were identified. One or two are still in operation irrigating a limited area, but they have generally been replaced by privately-owned shallow tube wells. A few STWs were installed at each village around twenty years ago, but it was not until the early 1990s, after costs fell, that large numbers began to be used. Some farmers who previously bought their water from a nearby STW have been able to buy their own well from the profits of irrigated production. STWs can be managed and maintained successfully by individuals. The larger capacity DTWs tended to fail because the technology was more complex and required excellent co-operation between large numbers of users (see 4).

   Many houses have been improved since irrigation became widespread. Typically, galvanized sheet cladding replaces existing mud walls, whilst latrines and hand tube wells are installed. A reduction in the cost of water supply and sanitation technology has helped the trend.

   Road improvements have made a large, parallel, contribution to the development of all three villages. Better access to markets has reduced the cost of inputs and expanded the market for produce. Local transport services have benefited. Many poor villagers now obtain a basic living from driving rickshaws or ‘vans’.

Ordinary farmers and labourers have been able to acquire a range of household goods. Increased spending power has stimulated the off-farm economy. Many shops, providing both agricultural and general goods, have sprung up round the schemes. There are new rice mills in all three areas.

3. It was very clear from the investigations in the three villages that people principally attribute improvements in their livelihoods to irrigation from STWs.

   Many more children are now attending school. Farmers' are willing to spend part of their increased income on their children's education, in support of the government's education policies. Richer members of the community are funding the construction of Madrasas (religious training centres).

   Within the study villages, farm households are now more fully employed on their own farms or on the land of larger farmers. Members of marginal and landless households can also find greater farm employment throughout the year. More people are involved in farming in all three villages, yet farmers report a shortage of labour at peak periods, when labourers can command higher wages. More women are involved in rice cultivation, particularly in processing – parboiling and drying. New local mills have released many from the drudgery of manual milling. Time and effort saved through the increased use of power tillers, and to a lesser extent power threshers, can be used elsewhere. Extended cropping, requiring labour for tasks such as transplanting and harvesting, have compensated for reduced employment in land preparation and threshing.

   Increased demand for locally - produced goods and services has led to diversified employment for landless and marginal households. Non-farm employment now rivals that in agriculture.
   In the study villages, there is regular employment for rural mechanics servicing irrigation and other farm equipment, for local blacksmiths and workshops manufacturing spare parts, for carpenters and masons working on house construction/ improvements, for maid servants in wealthier households, and for 'van' and rickshaw drivers transporting people, fuel, fertilisers, seeds and crops. Non-farm labour is generally reported to be better-paid than work on farm.

   Household food security has improved dramatically with irrigation, but vegetables are neither widely grown nor bought. Despite the lack of balance in their diet, villagers are healthier. They are now able to buy necessary health care and medicines.

   Farmers generally seem to obtain information on agricultural techniques from others. They lack a source of reliable information/training on irrigated cultivation, as Block Supervisors rarely visit.

4. The communities are relatively harmonious, but there are few social groupings carrying out joint activities. Collective action to purchase inputs or to sell crops does not feature in any of the villages. Most commercial activities are undertaken by small private enterprises. A large element in the success of STWs seems to be that they are owned by individuals, and do not require co-operative action by large numbers of farmers.

   As in most parts of Bangladesh, various NGOs have provided support at intervals. There are also strong religious influences, which support charitable and educational facilities in the villages. In Borni, where there is a substantial Hindu minority, the Muslim and Hindu communities seem to co-exist without obvious strains.

   Mechanised agricultural processing (and hand tube wells) have released labour, particularly female, to take up small rural enterprises, in a general expansion of economic activity in the villages. Extended schooling, increased literacy and women's emerging role in the economy will continue to exert profound impacts on family and community life.

   The combined effect of expansion in both the farm and non-farm sectors has led to a reduction in seasonal out-migration in search of work. Generally in Bangladesh, irrigation has encouraged seasonal inter-district labour migration linked to the harvest. In two out of the three study villages, out-

migration is now rare. In these villages, labour requirements are largely met from within, rather than from external sources. Seasonal out-migration for employment continues at Borni village, where the proportion of landless households is higher than in either of the other villages.

Despite the improvements, poverty still haunts landless and marginal farming households, for whom irrigation has helped to prevent starvation and deterioration in living standards rather than to introduce major change. For the poorest households, employment is restricted to unskilled and relatively lowly paid tasks, offering very limited potential for savings. The difficulties faced during slack periods of the year were emphasised in focus group discussions at each of the three villages. However, the growing non-farm labour market reduces risk.

It must be recognised that where land is unequally distributed, irrigation development will inevitably initially favour larger farmers. However, provided they can obtain access to water, small farmers will also benefit. In Bangladesh, the process has been supported by effective systems of rural credit, by affordable irrigation equipment, and by the emergence of water markets. It was noticeable that very large numbers of people have access to at least small plots of cultivable land - often fragmented - no doubt partly the result of inheritance practices. Landless households may rent or sharecrop small plots, most commonly during the boro season. Even where they do not meet the full subsistence needs of a household, they make an important contribution to poor livelihoods.

5. In the studies of small schemes in Nepal, Angood et al. (2003) identified some negative environmental impacts of irrigated agriculture, but they were outweighed by positive indirect benefits from reduced pressure on fragile surrounding lands. In Bangladesh, negative impacts are also evident, but intensified production on existing land is accompanied by extended cropping on beels, forests and former grazing land.

   Generally, water table depth, water quality, soil fertility, forest resources, *beel* areas and fish resources are in decline. In common with mono-cropping systems elsewhere in the world, heavy dependence on a single crop, paddy rice, potentially threatens the stability and diversity of the overall agricultural system. There must therefore be some questions about the sustainability of present practices.

   There are also some negative implications for the traditional livelihoods of the poor. Farmers may want to drain beel lands in the dry season, whilst poor households try to conserve them for fish cultivation. Similarly, clearance of 'weeds', wild vegetables, medicinal plants, fruits, fuel. and wild species from marginal lands, in preparation for paddy cultivation, may be a net loss to the poor. Grazing land and numbers of livestock, which are assets of particular value in 'buffering', or coping strategies for the poor, are being reduced.

   There remains, however, the unavoidable fact that the region is highly vulnerable to natural disasters. The government cannot offer insurance against crop damage, only a programme to supply food to vulnerable groups. In this context, irrigation has provided a safety net by allowing farmers to cultivate at a less risky time of year. Adverse impacts on the natural capital stock are, by comparison, relatively minor.

6. Overall, from the evidence of this study, it can be concluded that irrigation development in Bangladesh has been an effective tool for poverty reduction, increasing cropping intensity, grain production, household incomes, waged labour employment and livelihood diversification. It has also had a major impact on the off-farm economy in surrounding areas.

   The work confirms the conclusion of the Nepal case study (Angood *et al* 2003), that irrigation is most effective as part of a package of measures to support and vitalize the rural economy, of which Bangladeshi agriculture is the backbone. Investment in irrigated agriculture provides a strong stimulus to the rural community. Investments in other, complementary, developments, such as roads, schools and healthcare can strengthen impacts, but require a flourishing agricultural sector. Education, without prospect of local employment, will encourage people to migrate to the cities.

10. ACKNOWLEDGEMENTS

Acknowledgement is due to John Skutsch at HR Wallingford for providing overall guidance to the project and reviewing the report.

The assistance of the collaborating partners, Bangladesh Agricultural University (BAU), Mymensingh and Prof. M. A. Sattar Mandal is gratefully acknowledged. Special thanks is given to Professor Md. Tofazzal Hossain Miah for his contribution to the study and his help in selecting the study sites and organising the fieldwork.

Training facilities and support for the pre-survey training workshop were kindly provided by BAU. Thanks is due to the students from the Department of Agricultural Economics, BAU, who kindly administered the questionnaire surveys. Data collection would not have been complete without the diligent and hard work of the Process Investigators resident in the three study villages for the period of the study. Shapon Kumar Brouya was process investigator at Borni, Sofiulla Rubel at Mohanpur and Rayan Hayat Sarwer at Talki village. Questionnaire administration and Process Investigations were carried out under the supervision of Md. Mojammel Haque. Thanks are extended to the families who accommodated the Process Investigators during their period of residency on scheme and made them feel so welcome. Thanks are also due to Md. Parvez Anwar for his collection and analysis of water and soil quality data and Taslima Khatun for her additional study on the gender issues related to STW development in the three villages.

Above all, thanks is given to all the men and women of Borni, Mohanpur and Talki villages who donated their valuable time to answering questions and participating in discussions.

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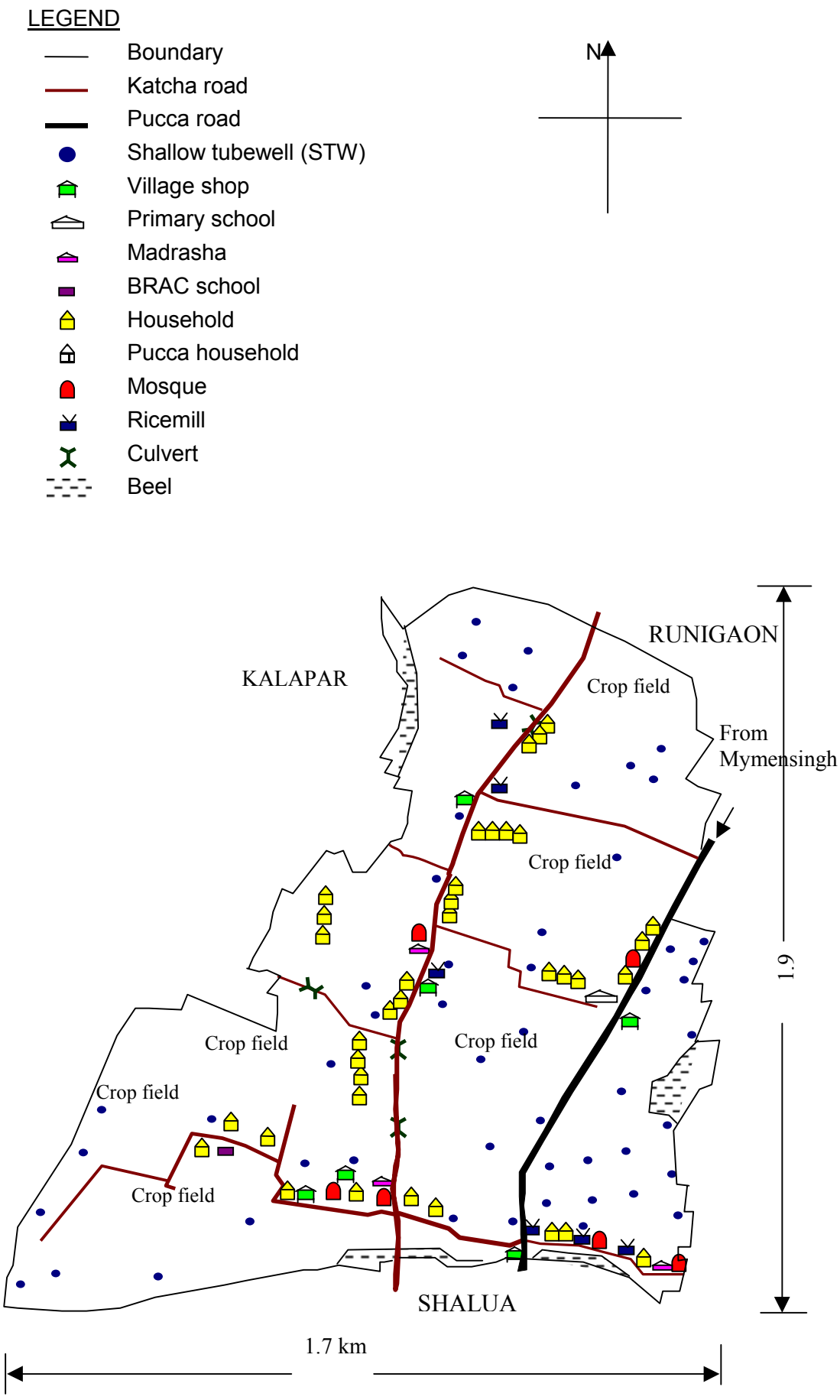
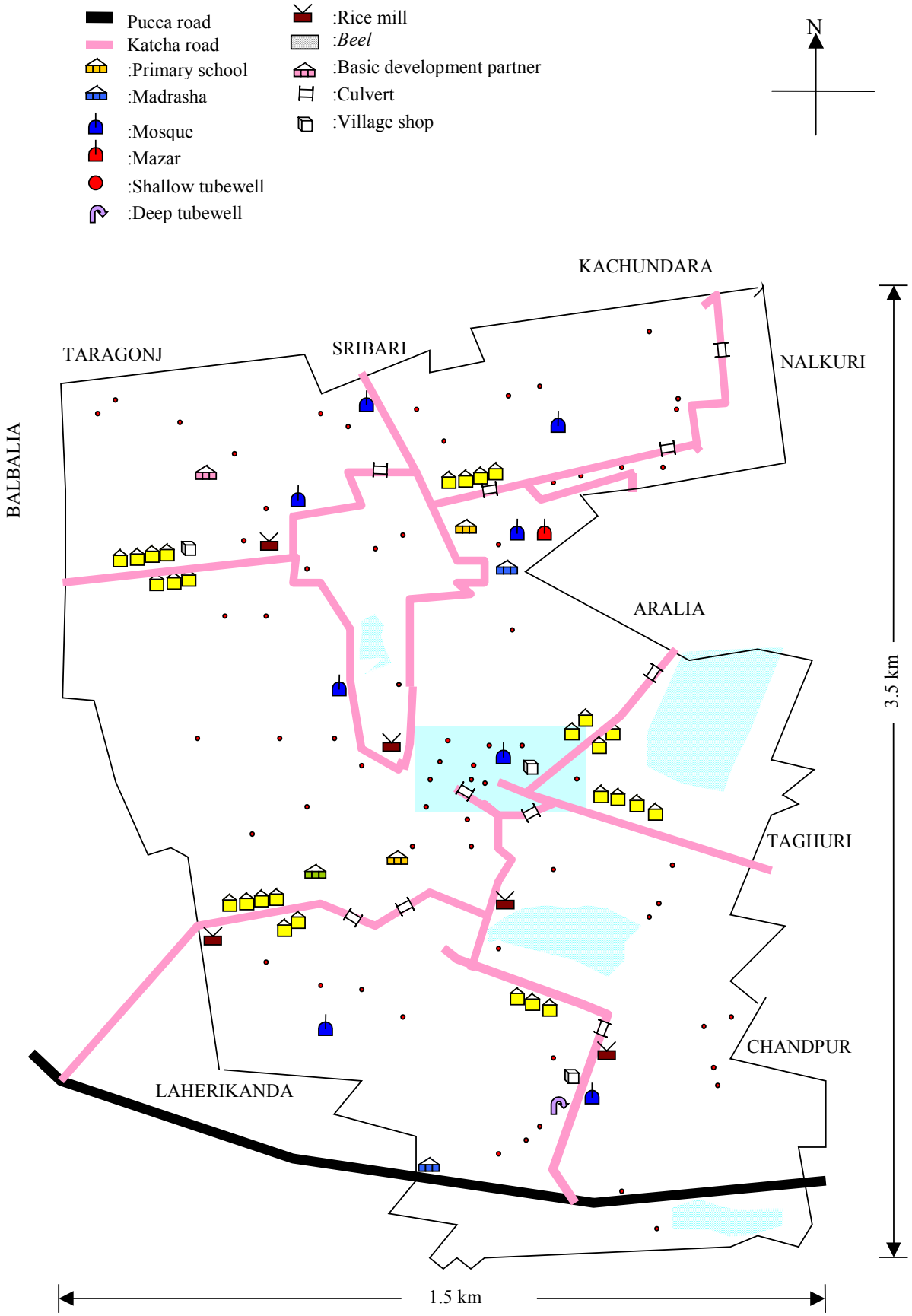
Annex 1

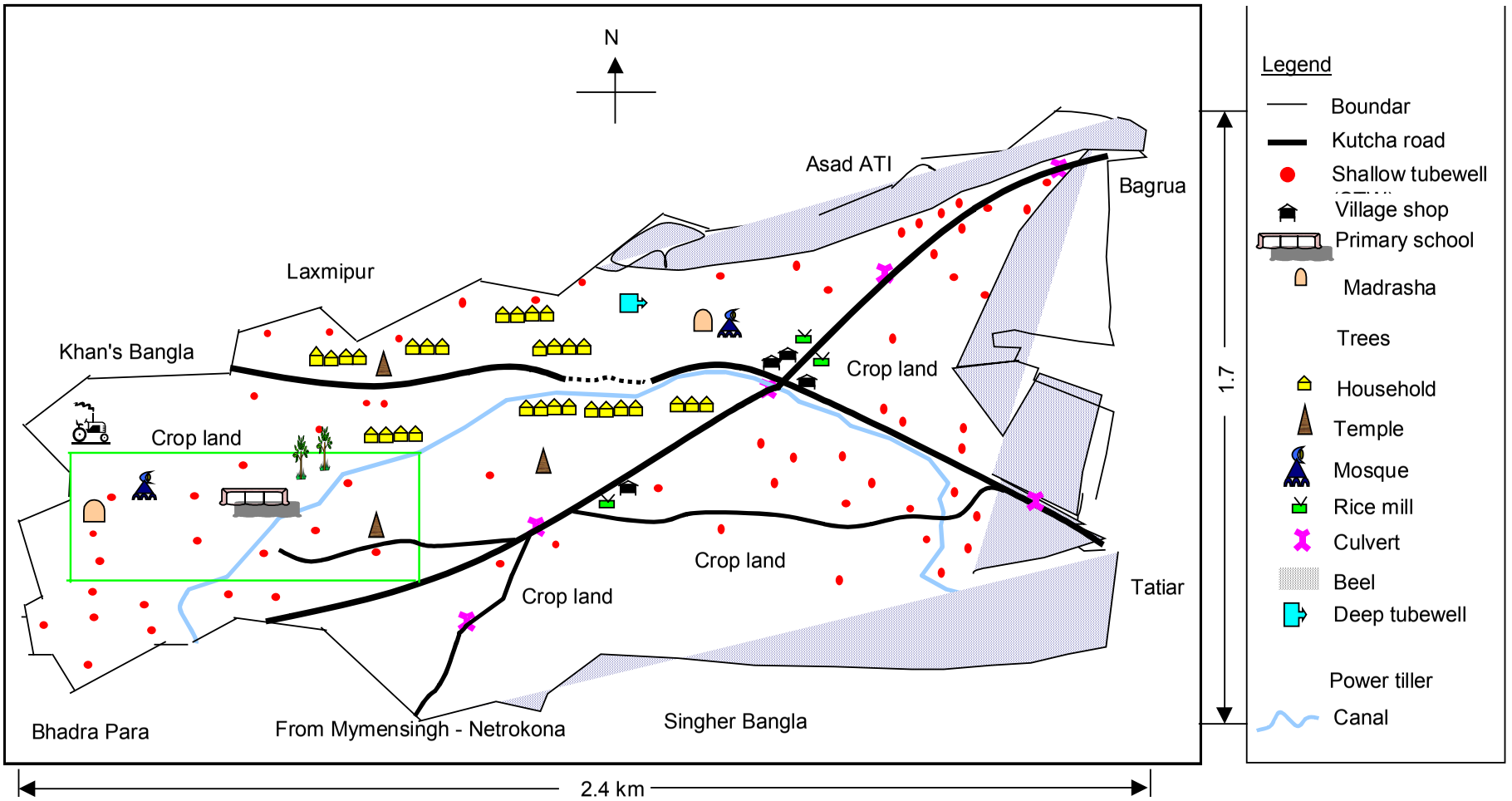
Village maps

Talki village and STW location





Resource Map of Mohanpur Village in Jamalpur District



Resource Map of Borni Village of Netrokona Sadar Upazila in Netrokona District