Pro-poor Intervention Strategies in Irrigated Agriculture in Asia

Poverty in Irrigated Agriculture: Issues and Options

BANGLADESH

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International Water Management Institute

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Bangladesh Country Report

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Contents

Charts, Maps, Figures, and Tables

Statistical Tables

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Study Background

Irrigation will continue to play a key role in promoting agricultural and rural growth in Bangladesh. However, pro-poor irrigation development, as a strategy for growth as such, has so far been put to a very limited experimentation in this country. It is only generally acknowledged that irrigation interventions are critical for increasing agricultural productivity and accelerating the pace of crop diversification (Hussain and Biltonen, 2001). The Interim Poverty Reduction Strategy Paper (IPRSP) for Bangladesh also asserts that the development of water resources, including irrigation development, flood control and drainage improvement has played a significant role in increasing agricultural production and food security in Bangladesh (GoB, 2002). Availability of irrigation is, indeed, an essential pre-requisite for the adoption of improved technologies and the expansion of the production base. Minor irrigation development and its impact on poverty in rural areas in Bangladesh have been studied recently (Hossain *et. al.*, 2002). Medium and large-scale surface water irrigation projects implemented so far in Bangladesh should also be studied since some lessons can be drawn from them regarding differential poverty incidence and the magnitude of poverty as a result of differential access to irrigation water under a variety of farm-size distributions. The present research seeks to assess poverty in irrigated areas, linking poverty with irrigation in two large surface irrigation systems of the country—the Ganges-Kobadak Project (G-K) and the Pabna Irrigation and Rural Development Project (PIRDP). The study also assesses performance of irrigation systems, institutional interventions and innovations; identifies constraints and opportunities for improving system performance; and identifies and evaluates potential pro-poor interventions for improved irrigation system performance. The overall goal of this study is to promote and catalyze equitable economic growth in rural areas through pro-poor interventions in irrigated agriculture. The immediate objective is to determine realistic options to improve the returns to poor farmers in the low productivity irrigated areas within the context of improving the overall performance and sustainability of the established irrigation systems. Specifically, the following hypotheses are tested in this study.

i) Command areas of specific canal reaches receiving less irrigation water per ha have lower productivity and a higher incidence of poverty;
ii) Under existing conditions, small, marginal and poor farmers receive less benefits from irrigation than large and non-poor farmers;
iii) The greater the degree of operation and maintenance (O&M) cost recovery the better the performance of irrigation management;
iv) Effective implementation of PIM/IMT leads to improved irrigation system performance which in turn reduces poverty;
v) Absence of clearly defined water allocation and distribution procedures, and absence of effective and clear water rights (formal and informal) adversely affects the poor more than the non-poor;
vi) There is scope for performance of irrigation systems under existing conditions, with effective and improved institutional arrangements.

Part — 1

Poverty and Irrigation in Bangladesh

1.1. General

1.2. Country Background

1.3. Irrigation Development in Bangladesh – An Overview

1.4. Impact of Irrigation on Poverty, Income and Poverty – An Overview

1.5. Performance of Irrigation Systems: Implications for the Poor

PART 1

Poverty and Irrigation in Bangladesh – An Overview

1.1. GENERAL

Since the 1970s, agriculture in Bangladesh experienced a modest growth around 2.5 percent per year. However, a significant growth that led to self-sufficiency in food/cereal production took place during the second half of the 1990s. One of the reasons for increased output is the rapid expansion of irrigation in Bangladesh, using both surface and groundwater. Expanded irrigation facilities enabled wider adoption of improved varieties, modern inputs, and better cultivation practices. It was estimated during the FAP Study (1991) that out of about 9.03 million ha of total cultivable area, 7.56 million ha (84 percent) was suitable for irrigation.[1] In 1999/00, a total area of about 4 million ha was estimated to be under irrigation, i.e. 53 percent of the total land was suitable for irrigation. Therefore, there is significant potential for expansion of irrigation by exploiting surface and groundwater resources. Compared to around 8 percent in the 1980s, the annual growth rate was 5 percent until the mid-1990s and subsequently declined to 4 percent. The decline was more pronounced in shallow and deep tubewell irrigation. Bangladesh needs to adopt appropriate measures to accelerate irrigation development, as expansion of irrigation is a prerequisite for future agricultural growth.

Expansion of irrigation facilities that led to higher agricultural productivity, should also be linked with poverty alleviation by targeting the small and marginal farmers. Over the years, the land areas operated by rural households declined from 9.3 million ha in 1983/84 to 8.3 million ha in 1996. On the other hand, the number of farm holdings increased from 10.0 million to 11.8 million over the 1984/1996 period, reducing the average size of farm holding from 0.91 ha in 1983/84 to 0.68 ha in 1996. Another important feature of the agricultural sector is the dominance of small and marginal farmers. The number of the landless or functionally landless farmers was 56 percent of the rural households in 1983/84. In 1996, small and marginal farm holdings accounted for 81 percent of the total farms, operating 41 percent of the total land areas. This means that 19 percent of the farms control 59 percent of the operated land in agriculture. While agricultural wage is the major source of income of the poor, the real wage of agricultural labor stagnated in the past. As a result, although agricultural growth matters for poverty reduction, there has been limited impact on poverty. Therefore, improved irrigation, coupled with increased agricultural production, may not necessarily translate into substantial reduction in rural poverty. Other factors such as the land distribution pattern, land tenurial arrangement, demand for agricultural products should also be considered while considering the impact of improved irrigation and increased agriculture production on poverty.

This part reviews literature on the existing irrigation in Bangladesh, with particular reference to poverty alleviation and pro-poor interventions in irrigated agriculture, along with irrigation system performance. After a brief country background, a summary of the detailed review of literature is presented.

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[1] Shahabuddin, Q and R I Rahman 1998. Agricultural Growth and Stagnation in Bangladesh: Dhaka Centre on Integrated Rural Development for Asia and the Pacific.

1.2. COUNTRY BACKGROUND

Bangladesh is the largest delta located in the northeastern part of the South Asian subcontinent. The total area of the country is 147,570 sq. km with an average population density of over 900 per square kilometer. Around 6.7 percent of the total area consists of rivers and inland water-bodies.

According to the Population Census 2001, Bangladesh population as of 2001 is 129.24 million with an annual growth rate of 1.47 percent. On that basis, the population of the country in 2003 is 133.07 million. More than 75 percent of the country's population lives in rural areas. The country has succeeded in significantly reducing the population growth rate over the years. The national goal is to reach a zero population growth status by 2045.

Physiography

On the basis of age of formation, three principal physiographic units are recognized, namely, the tertiary hills, the Pleistocene terrace and the recent alluvial plain. The tertiary hills occupy the southeastern regions of Chittagong and Chittagong Hill Tracts, and to a minor extent, parts of southern Sylhet. The hills comprise the north-south parallel ridges of sedimentary rocks. The average elevation of the hills is around 600 metres. Alluvial terraces of the Pleistocene Age are located in the northwest as the Barind Tract, and in the central part of the country as the Madhupur Tract. These terraces stand slightly above the floodplain level. The Barind is an undulating region of impermeable red clays, while the Madhupur exhibits red-brown laterised soils.

Since the Pleistocene Age, the great rivers of this region have been building the Bengal Basin through a continuous process of sedimentation. More than four-fifthof Bangladesh is occupied by the alluvial plains of the Ganges, Brahmaputra, and Meghna, along with the estuarine and tidal floodplain. Although essentially a lowland, this alluvial plain does show certain relief variations. The extreme northwest is a part of a broad alluvial fan built by the Teesta river in the past. The Meghna depression in Sylhet and Mymensingh regions in the northeast contain a series of low lying permanent lakes or haors. The depression originated partly due to tectonic subsidence, and subsidence in this region may be continuing.

The southwestern region is the deltaic plain of the Ganges and the Brahmaputra. The area to the west of the Gorai River does not currently experience regular inundation and, is therefore, labeled as the moribund delta. On the other hand, the land to the east of the Gorai is experiencing active deltaic sedimentation. In addition, tidal action along the coast is responsible for the formation of the seaward portion of the delta.

Hydrology

The hydrology of Bangladesh has a unique impact on people's livelihoods. In Bangladesh, hydrology includes rainfall, water inflows from upstream and runoff generated from rainfall within the country, transboundary rivers, and other rivers inside the country. The Ganges, the Brahmaputra, and the Meghna river systems are the prime hydrologic sources for Bangladesh. In fact, these river systems constitute the second largest hydrologic region in the world. The total drainage area of the region is about 1.72 million sq. km stretching across five countries including Bangladesh at the tail end to carry the entire load into the Bay of Bengal (Map1). Bangladesh shares all the three river systems. The average annual water flow from these river systems in the region is estimated to be around 1060 billion cubic meters, of which nearly half is discharged by the Brahmaputra.

The rainy season of Bangladesh generally lasts from June to October. Over 80 percent of the annual rainfall occurs between June and October. The annual rainfall ranges from about 1200 mm in the western part to over 5000 mm in the extreme northeast, countrywide average being about 2300 mm.

In an average hydrological year, about one-fifth of the country's total area experiences flooding of varied intensity. High intensity floods (e.g. the ones that occurred in 1988 and 1998) inundate two-thirds of the country's landmass. However, any impact on the hydrology of Bangladesh could have substantial effects on agriculture, fishery, navigation, industrial and domestic water supply, salinity control, and reservoir storage and operation.

Water Resources

The natural surface water resources in Bangladesh are mainly obtainable from the country's dense network of river systems, which include a combination of upstream inflows and runoff generated from rainfall within the country. Preliminary estimates at the inception phase of the National Water Management Plan (Based on the draft National Water Plan of 1991) indicate that the cross-border flows into the country amount to around 1010 billion cubic meters (BCM), and an additional amount of 340 BCM is generated from local rainfall. Of this total quantum of available water (1350 BCM), about 190 BCM of water is lost through evaporation and evapotranspiration, while the balance of 1160 BCM is available for use, or flows into the Bay of Bengal. Eighty percent of this huge flow of water is concentrated in the five-month monsoon period from June to October.

Surface water is an important strategic resource for Bangladesh in the dry season. It is the only resource for some 44 percent of the country (barring some small pockets of groundwater used for domestic and municipal supplies), and can be used to augment all areas where deficits arise. Under the guidelines provided by the National Water Policy, however, more attention is now being given to in-stream demands, and the environmental benefits that will come from healthy river systems.

Water demand varies from season to season. In general, water shortages do not occur during the monsoon, from May to October. In the early part of this season, rainfall can be variable, which is significant to those many farmers who plant *Aman* (a type of rice) at this time of the year. Supplementary irrigation is practiced by few farmers, although there is potential to expand this. Many of the public sector's surface water irrigation schemes were originally designed to promote both early and late monsoon crops, rather than the now popular dry season *Boro* crop.

The main determinant of overall demand for water in Bangladesh in the future is the growth of irrigation. Water supply for urban and rural domestic and commercial use will more than double, but this represents a very small portion of the overall demand. Irrigation demands are expected to increase potentially by at least a quarter, over the next 25 years, depending upon the extent to which future agricultural production requirements are met through improvements in yield and cropping intensity.

Agricultural Practices

Bangladesh is predominantly an agrarian society. Nearly 75 percent of the population is directly or indirectly dependent on agriculture, although this sector now contributes only about 20 percent to the national GDP. Agriculture is still the main user of water, and its share in water demand will further increase concurrently with efforts to attain food security. Land is the most basic resource in Bangladesh, being the main factor in crop production. The country has about 8.6 million hectares of net cultivated area, of which 4.8 million hectares are currently irrigated. Of the net cultivable area, 37 percent is single cropped, 50 percent double cropped, 13 percent triple cropped. About 6 percent of the landmass is under vegetation.

The three cropping seasons: *Kharif I* (pre-monsoon), *Kharif II* (monsoon), *Rabi* (winter or dry). *Aus, Aman,* and *Boro* are the three rice varieties grown, respectively in these three cropping seasons. A notable aspect of the pattern of growth in crop agriculture during the past two decades has been the increasing area covered by dry season High Yielding Variety (HYV)*Boro* rice – a trend that is likely to continue.

The production performance of the agriculture sector in Bangladesh, particularly the crop sector, has considerable bearing upon the level and structure of poverty and malnutrition, the trade balance and the budgetary position of the government, and consequently, upon the rate of growth of the economy of Bangladesh as a whole. Since the 1970s, agriculture in Bangladesh experienced a modest growth and a slow transition: with wide fluctuations, agricultural growth averaged around 2.5 percent per year. A significant acceleration of agricultural growth, however, took place during the second half of the 1990s, primarily led by the growth in the production of food grains, particularly rice. The average annual agricultural growth rate exceeded 5 percent during 1997/2000 compared to about 2 percent during 1991/1996. While all sub-sectors experienced higher growth, crop and horticulture, in particular, grew rapidly at 4.2 percent per year, which was higher compared to any other period in the past. Since the early 1990s, agriculture's share in GDP declined steadily from 30 percent in 1989/90 to about 20 percent currently. Since the 1970s, Bangladesh achieved significant progress in cereal production. The production of rice and wheat increased from around 10 million tons in early 1970s to about 27 million tons by 2001.

Macroeconomic Performance

Bangladesh's economic performance in the 1990s has been relatively strong. The average annual growth rate of GDP increased from less than 4 percent per year during the 1980s, to over 5 percent during the second half of the 1990s. The period witnessed a doubling of annual per capita GDP growth rate to more than 3 percent during the 1990s, both due to increased GDP growth rate, and a falling population growth rate. A near self-sufficiency in food production has been achieved. A major constraint on economic growth is sluggish investment, which for years, has been around 22-23 percent of GDP. The persisting sluggishness is true in respect of both public and private sector investment. The country needs to invest more to create new employment opportunities for absorbing the growing labor force. Savings are not yet adequate to meet the needs for more investment. Hence, the flow of external resources, particularly foreign direct investment (FDI), is critical in at least short and medium terms for financing investment. Maintenance of a stable macroeconomic framework is important, along with measures to increase domestic savings and private investment and ensure prudent use of investment resources. Bangladesh succeeded in keeping inflation at single digit during the 1990s. But the overall budget deficit increased to more than 5 percent of GDP, partly due to high levels of non-productive expenditure. The financing of the deficit through domestic borrowing has increased sharply, while foreign direct investment declined steeply over the past few years.

Poverty Trends

Bangladesh has made notable progress in income-poverty reduction since its independence in 1971. The income-poverty trends since the early 1990s based on Household Income and Expenditure Survey (HIES) data show the following pattern. Between 1991/92 and 2000, the incidence of national poverty declined from 58.8 percent to 49.8 percent, indicating a modest reduction rate of one percent per year. The declining trend is robust in relation to the choice of poverty measures. The results further show that reduction in the head-count index of poverty was better in urban areas. However, rural areas displayed better progress in respect of reduction in the depth and severity of poverty, as captured by trends in poverty gap and squared poverty gap, respectively.

Additional evidence from the Bangladesh poverty literature, based on HIES grouped distribution data maps, indicate progress in poverty reduction since the early 1980s. The results broadly indicate that the progress was faster during the 1990s compared with the 1980s. The faster pace of poverty reduction in the 1990s is attributable to the accelerated growth in consumption expenditure (income). The comparative progress was uneven between rural and urban areas. The pace of rural poverty reduction was slow in the 1980s, but was somewhat faster in the 1990s. The reverse is true for the urban areas.

During the period between 1991/92 and 2000, the level of consumption expenditure inequality increased from 30.7 percent to 36.8 percent in urban areas, and from 24.3 percent to 27.1 percent in rural areas.

In addition to sectoral variation, considerable regional variation in poverty is noticeable. The Dhaka and Khulna (including the study area of G-K project) divisions, have lower incidence of poverty than Rajshahi (including the study area of Pabna Irrigation and Rural Development Project).

Human-poverty trends also show considerable improvement. The human poverty index which stood at 61 percent in the early 1980s declined to 35 percent in the late 1990s. The human poverty index declined by 2.54 percent per year compared to 1.45 percent in the national head-count index for income-poverty over the last two decades.

1.3. IRRIGATION DEVELOPMENT IN BANGLADESH – AN OVERVIEW

In Bangladesh, 84 percent of the cultivable land is suitable for irrigation (Shahabuddin and Rahman 1998). In 1999/00, 47 percent was brought under irrigation, but 53 percent of the total land suitable for irrigation is not yet covered by irrigation. Bangladesh can take pride in attaining self-sufficiency in cereal production, especially rice production despite her alarmingly increasing population. The production of rice and wheat increased from around 10 million tons in early 1970s to nearly 25 million tons by late 1990. Two main factors contributed to the increase in production. First, substitution of local varieties by HYVs and second, increase in area under *Boro* rice which has relatively higher yield compared to other varieties. All these varieties require seasonal irrigation. Over the years, irrigated agriculture expanded rapidly in Bangladesh. The past achievements in crop production rested on irrigation development that enabled wider adoption of improved varieties and modern outputs. The earlier development of minor irrigation depended heavily on the actions and supports of the government. In this backdrop of very slow growth of irrigation under public sector domain, rice production suffered seriously. Since late 1970s, a series of policy reforms have been taken up by the government to liberalize the market for irrigation equipment and to create opportunities for the private sector to play more roles in the development of minor irrigation.

The most significant impact of the market liberalization and privatization policy has been a marked reduction in prices of engines (pumps) and other irrigation equipment, which means that irrigation equipment is now much more widely available and affordable to the farmers. Shallow Tubewell (STW) has propelled the growth of irrigation. In 1999/00 STW pump grew at the rate of 14 percent annually. Low-lift pump and major canal irrigation were moderate, while there has been virtually no growth in DTW irrigation. However, groundwater irrigation technologies as a whole (i.e. STWs, DTWs, and FMTWs) covered about 73 percent of the total irrigated area.

Due to traditional inheritance processes and the parallel process of concentration of agricultural land in fewer and fewer hands, through distress sale of land by small and marginal to existing owners of larger landholdings, the land distribution is highly skewed in Bangladesh. In 1996, 57 percent of all agricultural land was owned by 20 percent of the country's 11.8 million landholders.[2] Small farm holdings (0.02 to 1.00 ha) represented 79.9 percent of all farm holdings, medium farm holdings (1.01 to 3.03 ha) 17.6 percent and large farm holdings (3.04 ha and greater) 2.52 percent. Since the physical capital of rural areas essentially is land, it constitutes the principal determinant of rural income.

Report on Draft Development Strategy: Data Management and Basic Human Needs (prepared within the framework of National Water Management Plan (NWMP), published in August 2000 (reviewed) assessed poverty with reference to food supply and nutrition. It has been suggested that for reduction of stunting, wasting and malnutrition, especially among women and children, the average daily calories demand per capita is 2,500 calories, while the actual consumption level is 2,200 Kcal.

The same report indicates that 53 percent of the total population of Bangladesh (the majority living in rural areas) is poor in terms of the above-mentioned indicators. A large proportion of them continue to suffer from chronic food insecurity, despite increased food production in recent years.

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[2] BBS, GoB, *Census of Agriculture 1996*.

While the majority of households in rural Bangladesh live on an average income of between Tk.1,500 and Tk. 5,000 per month (majority of the rural household earning is approximately Tk. 3,000), the hard-core poor survive on much less. Rural poverty is negatively correlated to land size holdings with the landless comprising the poorest of the poor (HES-1998).

In 1998, the BWDB Systems Rehabilitation Project (SRP) conducted a study on the perceived benefit of 7 out of 38 water control intervention areas. The study indicates that the sample population expected that the projects would bring in benefits ranging from 30 to 50 percent. The population of the sample area also believed that the insecurity in food supply would still exist, ranging from three to six months each year and, in acute cases, it might prolong for more than six months.

The NWMP impact assessment reveals that during seasonal shortage of food grains, low demand for wage laborers compels the low income families to survive on only one meal a day i.e. below the minimum calorie requirement of 2122 calories (i.e. poverty line). In the areas where people can afford to have two meals a day, the consumption level might rise up to 2000 calories per day even during surplus season. There needs to be a concerted effort to boost income and employment in rural areas to overcome the chronic food insecurity.

1.4. IMPACT OF IRRIGATION ON PRODUCTIVITY, INCOMES AND POVERTY: OVERVIEW

Irrigation can play a critical role in Bangladesh through increased crop intensity and yield. Since there is no new land to be brought under cultivation, and the existing agricultural land is declining on account of increased use of land for other purposes, increased food production is critically dependent on increased yield. With expanded irrigation water and supplementary irrigation at other times, two or three crops can be grown and yields of all crops could be increased. Erratic climatic conditions cause a high degree of uncertainty in the agricultural sector. Investment in irrigation can produce a further advantage of reducing this uncertainty.

However, as irrigation coverage expands, more and more unfavorable and difficult lands may be brought under irrigation, meaning that profitability from irrigation and crop production may decline, if on-farm water management is not improved or diversification to high value crops does not take place. Reliable supply of irrigation water is essential in the backdrop of limited land availability in Bangladesh. A higher level of food output can only come through more intensive land use.

As mentioned earlier, the land distribution pattern is extremely skewed in Bangladesh. In 1996, 57 percent of all agricultural land was owned by 20 percent of the country's 11.8 million landholders. Improved irrigation leads to increased cropping intensity, and yield and, hence, food grain production. For example, in the G-K Irrigation and Rehabilitation Project, the cropping intensity increased from 189 percent to 241 percent and net farm income increased from about $500 per ha to $970 per ha per annum. But, benefits of any increase in cropping intensity and production due to irrigation projects are mainly enjoyed by the large landholders as they have more land to operate and can take a disproportionately larger share of the irrigation water.

In many developing countries, there is evidence of increasing concentration of use and control of agricultural land, along with increasing inequality in the ownership of ancillary resources, such as irrigation water, essential for success in the Green Revolution (GR) technology. In such a situation, the rural poor become more dependent on wage employment and how the poor fare depends on the availability of wage employment and real level of wages.

In general, the adoption of the GR technology increases the labor requirement for crop care activities e.g. weeding, fertilizer application, and water control, as well as harvesting and threshing. In Bangladesh also, GR technology increased the use of hired labor, supplied by the poor landless laborers and marginal farmers. In this respect, the technology contributed to social equity. In most cases, however, greater contribution to employment generation has come from its impact on cropping intensity. In particular, in areas where irrigation water is available during the dry season, cropping intensity has increased significantly with favorable employment effects.

Usually the rural poor farmers of Bangladesh cannot reap the benefits of irrigation for two reasons. First, the extreme land fragmentation, with individual cultivators farming in scattered plots results in serious water management and farmer cooperation problems. Second, given uneven rural power structure in Bangladesh, larger and influential farmers tend to dominate in the LLP and DTW cooperatives.

The majority of the irrigation projects failed to address the issue of distribution of additional income among the rural poor generated by the projects. Although the projects usually contribute to an increased GDP, inadequacy in distribution of income generated through the irrigation projects could not address poverty among the landless, small and marginal farmers.

Poverty and Irrigated Agriculture

Despite the absence of baseline studies prior to inception of irrigation projects, it is generally indicated that poverty is reduced due to increased agricultural and related economic activities in the areas under irrigation. Irrigation has a positive employment effect. Irrigation has the potential to absorb more than half a million extra workers each year, which is about half of the number of people entering the job market each year in Bangladesh.

Indeed, the use of surface water using labor-intensive techniques can generate employment in such scale; and this is consistent with the fact that Bangladesh has scarce capital and an abundant supply of labor. However, there is discrimination in government policy support, in that the government-owned low Lift Pumps (LLP) are rented out at subsidized rates to Credit Co-operatives, while indigenous labor intensive methods receive no support. Expansion of LLP irrigation has adversely affected this prospect in different areas, which were previously, or could have been, irrigated by more labor-intensive methods. In addition, it is also possible that this policy has led to a switch of surface water from smaller farmers to larger farmers because it is the small cultivators who use labor-intensive techniques. But the large farmers are the main beneficiaries of LLPs. Nevertheless, it is the relatively capital-intensive irrigation techniques that have received most attention and supported by the public sector.

Despite lack of government support for manual groundwater methods, their use has expanded rapidly since the 1970s. The benefits of manual methods in many situations accrue mainly to the larger farmers because of their ownership of land and capital, and their preferential access to finance and agricultural inputs.

Properly designed irrigation projects can bring a vast fallow land under cultivation or seasonally cultivated land for year around utilization. This in turn generates employment and increases daily wages of the agricultural laborers.

Access to Resource: On the other hand, lack of secure long-term access to land remains a constraint for many poor farmers. This prevents them benefiting fully from the access to irrigation services. A longer-term access to land is crucial for small and marginal farmers to be able to optimize farm profits.

All categories, especially the small farmers and landless, reported a decrease in access to sharecropped land. This was explained by the fact that almost everyone is interested in cultivation because of irrigation and thus competition for land is high.

The marginal farming households are clearly not able to sustain or improve their living conditions. They reported some decrease in quality housing (11%) and wedding presents (17%). The households that reported a decrease in the amount of food available (44%) are all landless, who are not often able to earn enough income to sustain their livelihoods, especially when the number of family members is large. Middle-income farming families show overall stable assets or an increase in assets; they seem to have succeeded in improving their living conditions mostly due to the benefits of irrigated agriculture. (See Eva Jordans and M Zwateveen – reviewed).

Returns to land are far greater than returns to labor and other factors of production in the agricultural sector. Major projects perform poorly in terms of income distribution because the owners of the land get a higher net return per ha; they generally do not pay for irrigation. The STWs perform marginally better than major projects; but even in this case, Gini coefficient has been found to increase from 0.33 to 0.39 and the average share of agricultural income going to the rural poor to decline from 38 percent to 34 percent compared to the pre-project situation. DTWs and LLPs result in a smaller increase in inequality. Manually Operated Shallow Tubewells for Irrigation (MOSTI), under both the labor assumptions used, has a positive and significant impact on equality. It is the only type of irrigation that leads to an improvement in income distribution. The STWs contribute to increased income for all segments of landowners—the increase being between 118 and 198 percent. However, the absolute increase in income is very different. The income of the rural poor households increases by Tk. 3,900 while that of medium farmers jumps by Tk. 9,600 and that of large farmers by Tk. 60,000See Report on the Impact of Water Sector Project on Income Distribution, March 1997).

Pro-poor Interventions in Irrigated Agriculture

Implementation of a set of pro-poor irrigation interventions requires a detailed assessment of the poverty situation of the targeted farmers and an assessment of alternative measures in order to define pragmatic actions to bring about the desired results.

It has emerged from the literature review that the majority of the irrigation projects followed the top-down approach during planning and implementation stages. Pro-poor interests in irrigation management, dimensions of poverty, and poverty indicators to measure the impacts of irrigation on poverty were not integrated at any stage of the irrigation project. Therefore, the principle beneficiaries of the majority of the irrigation projects have been large and medium landholders. The main objectives of the majority of the irrigation projects were to increase production of crops and to attain self-sufficiency in food production. However, the distributional aspect of the increased benefits of irrigation projects was never considered nor was a baseline study undertaken for poor people to be one of the target groups. As a result, the difference between the landowners and the landless became wider. The number of landless people steadily increased while the country attained almost self-sufficiency in food/ cereal production. The marginal, small and landless farmers could enjoy the trickle down effect only. With little purchasing power, self-sufficiency in food production could not change the profile of poverty even in the areas under irrigation.

Another aspect, which was kept out of most of the irrigation projects at the planning stage is that any irrigation project should go hand in hand with flood control projects. The synergies of the two aspects of water management can be more effective than an approach that addresses only one aspect.

One should keep in mind that a broad rural development approach, which conceives irrigation as one critical production input to be combined with credit, agricultural inputs, marketing services and information, can address the poverty issue along with increased production.

In this backdrop, it could be concluded that the irrigation projects of Bangladesh were primarily designed to increase food production and attain self-sufficiency in food. The poor were never considered as a specific target group.

1.5. PERFORMANCE OF IRRIGATION SYSTEMS: IMPLICATIONS FOR THE POOR

The small-scale irrigation technology has played a major part in the expansion of irrigation and the Boro area following the liberalization of the sub-sector during the 1970s. Over the last decade, the area irrigated has more than doubled due to the rapid expansion of shallow tubewells, which have proved to be an affordable and profitable investment for farmers.

A key development issue is the extent to which this strong growth can be maintained in the future. The overall growth in surface water irrigation has been very slow, with gains in Low Lift Pumps (LLP) and large canal systems offsetting reductions in traditional (hand-operated) irrigation systems.

Efficiency of water use for irrigation has been the prime slated economic objective of the irrigation projects. Given the irrigation services delivered by a project in terms of pumping plant for irrigation and drainage, canal system, O&M arrangements, preventive routine, operating arrangement for pumps and gates, along with all other institutional support for the project area and human development, it should be ensured that:

- actual irrigated area is equal to the intended area;
- water is delivered in intended volume; and
- actual water level in canals is at the intended level.

Performance assessment of irrigation systems based on the above mentioned criteria had only been performed in the Command Area Development Project (CADP). In the literature review, very little information was found which could be used as performance indicators for the irrigation projects concerned. This demonstrates the necessity of developing a set of uniform indicators of performance measurement and human capability development, in respect of irrigation projects. More in-depth study should be undertaken in future on performance measurement of irrigation projects, including development of capability resources.

Even the Ganges-Kobadak (G-K) Irrigation and Rehabilitation Project did not go into specific guidelines for irrigation, water management for disadvantaged farmer groups. If adopted, such activities could reduce the poverty gap. The project also failed to incorporate women's role in surface water irrigation management. In addition, it did not address the issues of access to credit for poor farmers, specific guidelines for reinvestment of incremental project benefits, marketing promotion strategy of agricultural products, and the pro-poor specific indicators to measure the impact of irrigation on poverty (Appraisal Report of the Ganges-Kobadak (G-K) Irrigation Rehabilitation Project, ADB-BWDB; November-1983).

It has been found that small farmers in Bangladesh are becoming increasingly productive as a result of enhanced access to irrigation. The literature review also reveals that thousands of informal water user groups have been formed in the minor irrigation sector, to manage the supply of water from shallow and deep tubewells on a seasonal basis. Farmers increasingly pay a cash fee for irrigation services to suppliers, though some continue to pay in kind. Payment in kind is made usually by contributing a proportion of the crop amounting to 25 percent of the yield of the harvest. Local Government Engineering Department (LGED) currently charges a water user fee of Tk. 40 per season from rubber dam schemes, plus a charge ranging from Tk. 300 to Tk. 600 per 40 decimals of irrigated land. Informal water user groups have also been formed around surface water schemes in either Khal excavation or in building a cross bund. It is reckoned that 94 percent of all irrigation is managed in this fashion, with only 6 percent of such schemes being under the public sector management.

During the 1980s, a number of NGOs set up irrigation management programs in which landless groups were responsible for managing shallow tubewells (STWs), deep tubewells (DTWs), and low lift pumps (LLPs) selling the water to farmers. The rationale behind this decentralization was to reduce transaction costs that tend to be high given large number of fragmented holdings scattered in various areas.

The Social Design Study (SDS) in 1994 indicated that the Command Area Development (CAD) has had positive impacts of irrigation in terms of good water supply, better yield/income, increased other opportunities for earning incomes etc. However, due to lack of appropriate water management, these benefits were not extended to all the groups, especially to the disadvantaged groups such as the landless farmers and women.

Women and the landless poor farmers had very little association with the local Water Users Association (WUA) and Water Users Executive Committee (WUEC). It was suggested by the beneficiaries that there should be further improvement in physical structures, operation and maintenance, and improved watersharing procedures (rotation, electricity cost, water tax etc). There has been an important pro-poor proposition that the poor and the disadvantaged groups of the society are to be included in water user groups.

The existing Ganges-Kobadak (G-K) Irrigation and Rehabilitation Project has failed to yield optimum benefits due to heavy sedimentation in the intake channel, an inadequate and undependable power supply, inadequate tertiary canal, field channel network with high operational seepage losses, poor system management, inadequate operation and maintenance (O&M), and unplanned extension services. Lack of access to credit by the poor farmers and unplanned/inadequate water management practices also led to unsatisfactory outcome.

In common with all other BWDB administered surface water irrigation schemes, irrigation service fees in the G-K project have been too low to cover operation and maintenance costs. The fees were set at 3 percent of incremental output from irrigation.

However, later on BWDB decided to levy direct user tax to generate adequate revenue for operations and maintenance and improve water management by farmer groups. In this connection, an irrigation ordinance was approved in 1983 to enable collection of irrigation service fees based on the area irrigated directly by the user.

The review of literature suggests that in irrigation projects, poor water management poised constraints on expansion of irrigation facilities. It has also been found that small and marginal farmers face more problems than the medium and large farmers. Inadequate irrigation management resulted in irregular water supply, incomplete construction of field channels, undependable power supply, and frequent break down of pumps. All these factors led to high cost of irrigation and ultimately restricted access of the marginal and poor farmers to the benefits of the irrigation project.

It is seen from NWMP that economic returns per cubic meter of irrigation water from ground and surface sources are respectively expressed in terms of gross water use (the amount pumped) and the net water use (the net amount taken from the water resource, after allowance for return flows from deep percolation and other non-consumptive losses). It is also mentioned that most farmers would want a rate of return, well above 12 percent to allow for risk. The study also reveals that economic returns from groundwater use are less, due to higher cost of pumping.

Indeed, efficient irrigation project management has a very important role to play, not only to increase income generation through increased agricultural production, but also to reduce poverty.

The literature survey also reveals that there are no uniform policy guidelines for management of irrigation projects. The past studies were conducted on a piecemeal basis, depending on the existing situation and design of the project. Therefore, it is warranted that broad policy guidelines for irrigation management should be developed, which would allow a proper impact assessment. The policy guidelines should also include issues concerning impact of irrigation on poverty.

In short, based on the review of literature, the main problems influencing the performance of irrigation systems (especially those under study) include: inadequate power supply; inadequate number of tertiary channels; high operational and seepage losses from the canal system; poor operation and maintenance; lack of adequate extension services, non-availability and less access of credit, inadequate farm input supply; failure to protect on-farm water management; top down approach and lack of community participation; and little or no concern in the designing and implementation of irrigation projects about dimensions of poverty and poverty indicators to measure impacts of irrigation on poverty.

A two- pronged approach is required to improve irrigation system performance:

- Improve social aspects towards pro-poor growth that will increase demand for laborers, accompanied by policies and programs to mitigate inequalities and facilitate income and employment generation for the poor, especially women and other traditionally disadvantaged groups.
- Address technical aspects of the irrigation projects for smooth and efficient irrigation and optimum use of water resources at minimum costs.

The following recommendations have been generated mostly by Mid-Term Evaluation of the G-K Project:

- Improving efficiency of the intake channels through dredging at the entrance of the intake channel of the West Bank. This will reduce the flow velocities and sediment load at the entrance
- Improving process of organizing Tertiary Water Users Association (TWUA)
- The TWUAs should be adequately informed and prepared prior to remodeling of the territories
- Loan provisions by the Krishi Bank to the TWUAs should be organized by BWDB, prior to remodeling of tertiary canals
- Extension staff should be retained in the G.K project and should be provided with adequate transport for better performance
- Irrigation fees should be collected on time
- Irrigation fees should be fixed at such a level that will cover the full operation and maintenance expenses of the project facilities
- Bangladesh Agriculture Development Corporation should sell LLPs to the Krishak Samabai Samity (KSS)/ water users groups in the project area whenever required

Part — 2

Institutional Arrangements for Irrigation Management in Bangladesh

PART 2

Institutional Arrangements for Irrigation Management in Bangladesh

2.1. INTRODUCTION

Prior to 1947, there had been no national-scale government-led water sector. During this time, public investment in water resources was mainly concentrated around construction of local infrastructure such as small reservoirs to reduce the adverse effects of flood and to ensure irrigation during dry seasons. Following the devastating flood of 1954, a United Nations Mission (the Krug Mission) recommended the creation of East Pakistan Water and Power Development Authority (EPWAPDA). EPWAPDA was established in 1959 with the objective of planning design, operation and management of all water development schemes.

In 1964, a 20-year Master Water Plan was developed by EPWAPDA with US assistance. This plan highly recommended the construction of embankments and polders for flood control (Rogers et al., 1994). However, this master plan failed to bring in increased production, which was one of the objectives, and the systems declined rapidly in terms of operation and maintenance (Datta (ed), 1999).

EPWAPDA was restructured in 1972 after the independence of Bangladesh. EPWAPDA was divided into two separate organisations, dealing with water and power separately. The Bangladesh Water Development Board was entrusted with water resources management under the Bangladesh Water and Power Development Boards order, 1972 (P. O No 59 of 1972) as a fully autonomous organisation. BWDB was entrusted with Planning and management of water resources of Bangladesh. In the same year, the Joint Rivers Commission was established to jointly manage all the international rivers flowing through India and Bangladesh.

BWDB gained support from several agencies including International Bank for Reconstruction and Development (IBRD) in 1972. The IBRD mission recommended a strategy for " small, low-cost, quick generation Flood Control and Drainage projects" (MPO, 1991, p. 1). This study marked a turning point in water management in Bangladesh calling for small-scale incremental development, primarily through irrigated dry-season cultivation using low- lift pumps and groundwater (Rogers et al., 1994). These recommendations placed great importance on private sector and were endorsed by the government. It resulted in significant increase in the area of cultivated land. However, the large-scale water control projects were also retained for constructing 1,963 km of embankments with 8,000 hydraulic structures and 1000 river closures in 1980 (Hughes et al., WSIP 2000). At this juncture, the main emphasis was primarily on achieving increased agricultural production. To achieve the goal of increased agricultural production, the main focus of water management was on flood control. Improved drainage and irrigation took a back seat.

In 1974, another devastating flood hit Bangladesh, and this renewed interest in flood control and protection. Several new initiatives were implemented with the assistance by various organizations, of which Early Implementation Project (EIP) was undertaken in collaboration with the Government of the Netherlands (GoN).

The National Water Council (NWC) was established as an inter-ministerial body in 1983. In the same year the Master Plan Organisation was created to draft the first National Water Plan (NWP). Due to the lengthy process of collecting the baseline information, the first National Water Plan (NWP, phase-1) was completed in 1986. The phase-II of the NWP was completed in 1991. During this phase the country was divided (initially) into 173 catchments. These were grouped into 60 planning areas, and further aggregated into five regions (Northeast, Northwest, Southeast, Southwest and South Central).

Development of management of water sector initially, was strictly sectored with very little inter-sectoral communication. The MPO was restructured to recast the NWP within the appropriate inter-sectoral focus. The MPO was restructured as the Water Resources Planning Organisation (WARPO) in 1991 with the mandate to "evolve national policies and strategies for utilisation and conservation of water by all" (GoB, 1999, p.15).

In 1989, the World Bank and the Government of Bangladesh (GoB) recommended an integrated approach for flood mitigation, based on the concept of ‘controlled flooding' to be implemented over the next 20-30 years. As a result, in the same year, representatives of the Government of Bangladesh and the donors endorsed the plan for the Flood Action Plan (FAP). The FAP was seen as a five year rolling plan that would be reviewed every two years. Various plans of actions were put forward by various donor countries ranging from improved flood forecasting and warning systems to high cost embankment schemes aimed at changing the entire hydrological regime of the country. In 1992, the FAP consisted of 30 separate components (Adnan et al., 1992). These regional and supporting studies were to be managed by a newly established Flood Planning Co-ordination Organisation (FPCO). However, since the formulation stage of FAP, it encountered criticisms by NGOs, civil society, etc., for being non-consultative and continuation of planning in the traditional modus operandi of the BWDB on a much grander scale.

The combination of the poor results of FAP project evaluation studies and pressure from donors and NGOs led to the realisation of the need for a participatory approach to water development. At the second conference of FAP in 1992, FPCO produced a set of guidelines for participation in management of projects. It was agreed after much discussion, that guidelines should be established and the local people would be considered as partners of professionals in water management (Hanchett, 1997 pp 286).

FAP final report was published in 1995. In the meantime, Bangladesh Water and Flood Management Strategy (BWFMS) was also approved by the GoB. Following the recommendation of the BWFMS, the institutional arrangements for planning of water resources were reviewed leading to the merger of FPCO into an expanded Water Resources Planning organisation (WARPO) in 1996.

Another program of BWDB was Systems Rehabilitation Project (SRP), for rehabilitation of some 80 BWDB partially dysfunctional projects. The project started in 1992 and was largely unsuccessful (Soussan and Datta, 1997). However, in this component also, people's participation was gaining momentum. After a review, in 1994, the World Bank introduced participatory elements to the work. The adopted approach was on formation of Water User Organisations (WUOs). This approach was also criticised as not being representative enough. It was claimed that most of the WUOs consisted only of farmers rather than all water users.

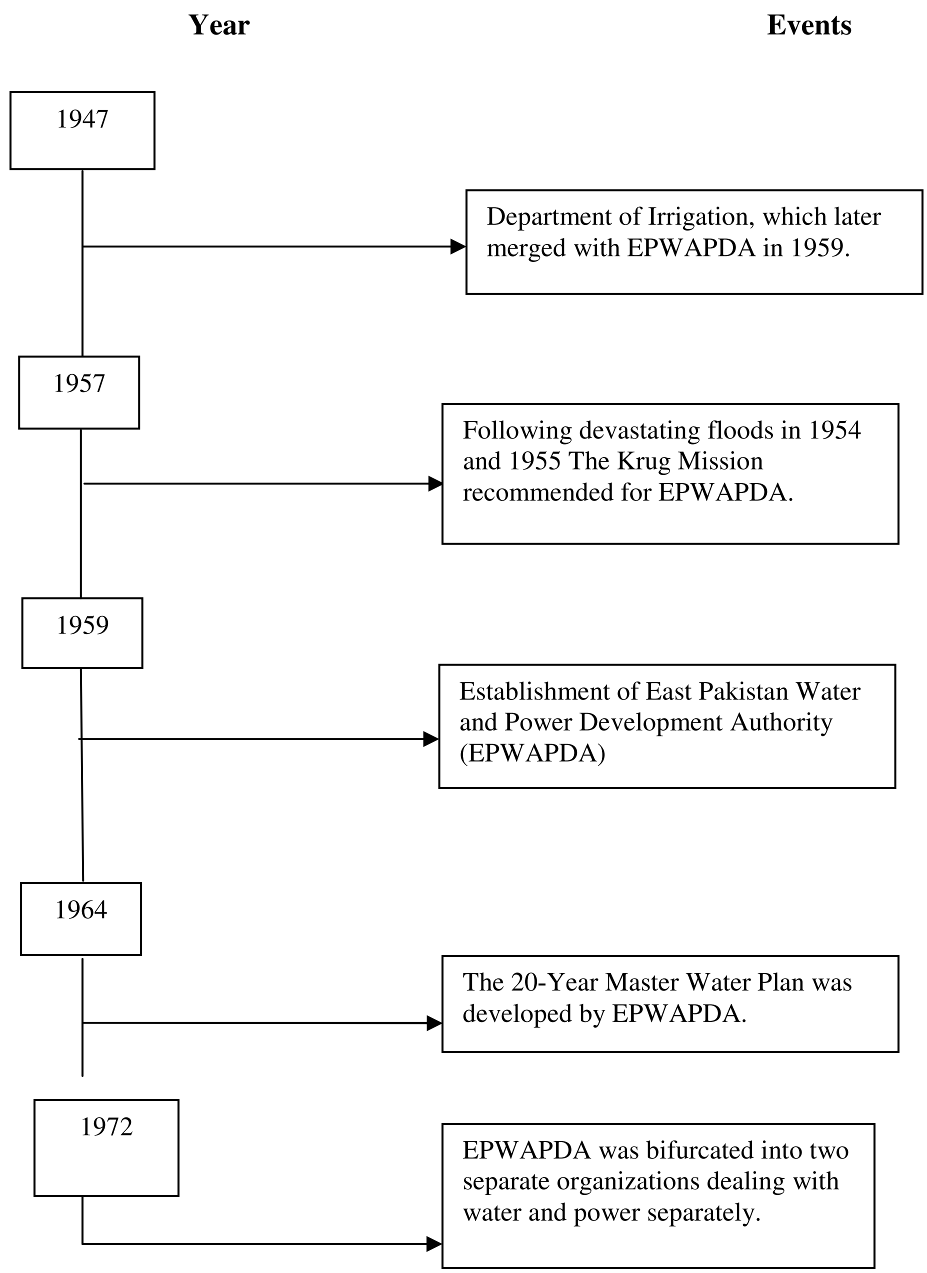
In 1992, the National Minor Irrigation Development Project (NMIDP) was launched by the Ministry of Agriculture with the principal objective of consolidating the transition of minor irrigation from a supply driven public sector to a demand-driven private sector. There has been widespread growth of minor irrigation throughout Bangladesh, in part through the promotion by NMIDP, but arguably more as a result of the obvious benefits of the technology and through the reduction in government taxes on equipment.

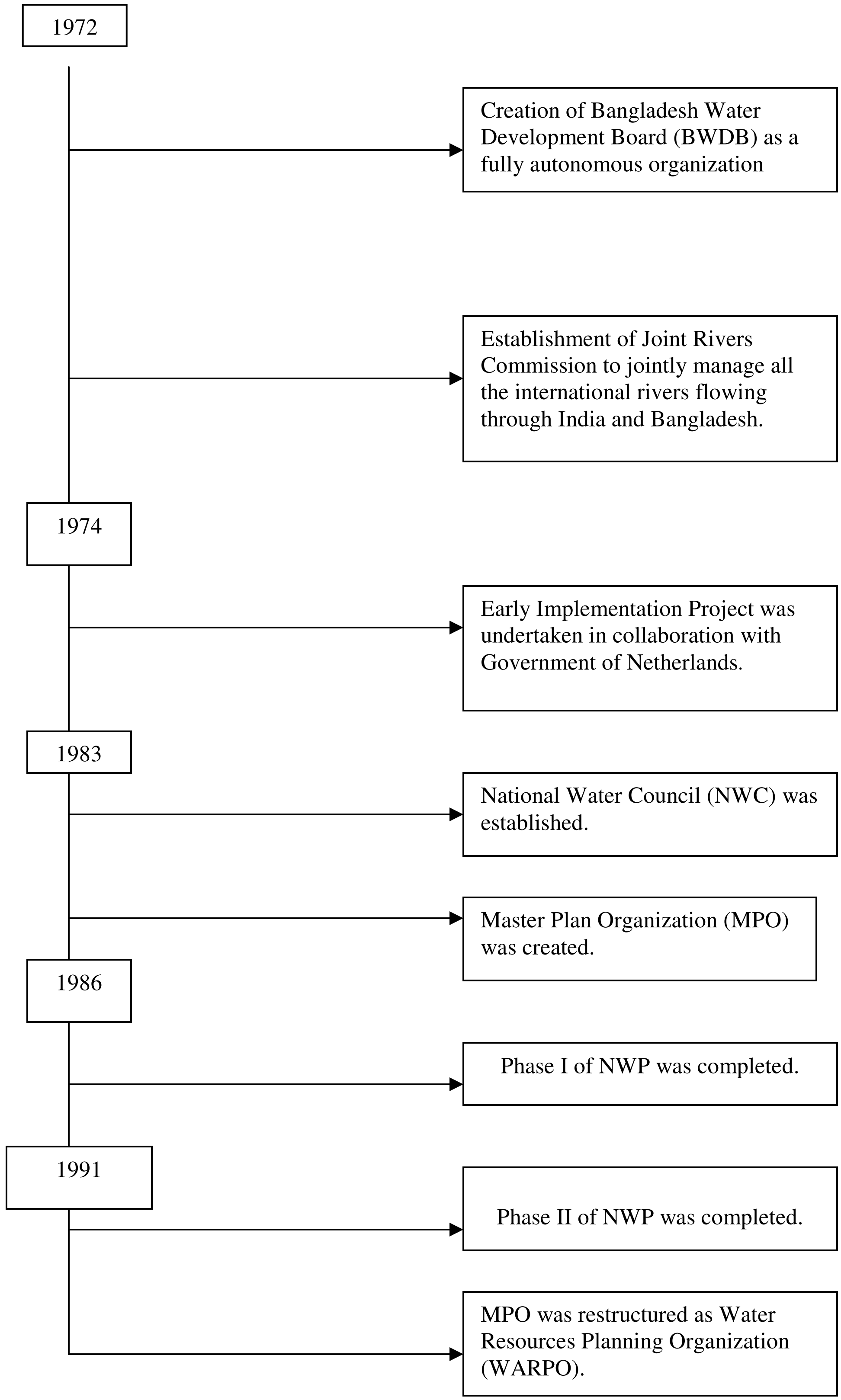
The need for restructuring the water sector has grown over the period of time. The GoB responded through the Bangladesh Water and Flood Management Strategy that included formulation of a national water management plan and the institutional strengthening of water sector organisations. However, it is generally acknowledged that floods receive more emphasis than the dry season.

Period guidelines for people's participation in project assessment and environmental impact assessment (EIA) were developed by FPCO. The local Government and Engineering Department (LGED) also prepared guidelines on how to involve local people in water management projects. SRP and CPP also developed Guidelines for People's Participation (GPP). Upazila Parishad Act 1998, schedule 2 specifically deals with the water resources sector development with special reference to planning and management of small-scale water resources scheme below 1000 hectares.

The GoB drafted the National Water Management Plan (NWMP) and National Water Policy (NWPo). This process also led to establishment of the National Water Resources Council (NWRC). The NWRC and NWPo led to the first National Water Policy in January 1999. The goal of NWPo is "to ensure progress towards fulfilling national goals of economic development poverty alleviation, food security, public health and safety a decent standard of living for the people and protection of the natural environment." (GoB, 1999).

Flow Chart: Evolution of Major Institutions and Events in Water Management in Bangladesh




1972
Creation of Bangladesh Water Development Board (BWDB) as a fully autonomous organization
Establishment of Joint Rivers Commission to jointly manage all the international rivers flowing through India and Bangladesh.
1974
Early Implementation Project was undertaken in collaboration with Government of Netherlands.
1983
National Water Council (NWC) was established.
Master Plan Organization (MPO) was created.
1986
Phase I of NWP was completed.
1991
Phase II of NWP was completed.
MPO was restructured as Water Resources Planning Organization (WARPO).

2.2. INSTITUTIONAL ARRANGEMENTS FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT

National Water Resources Council (NWRC)

The National Water Resources Council (NWRC) is the highest national body for the formulation of water policy, including inter-agency coordination, and is charged with making recommendations to the Cabinet on all water policy issues. The NWRC has 48 members, with the Prime Minister as the Chair. In January 1999, the National Water Policy (NWPo) was published for the first time. This was a major achievement of NWRC. The NWPo determines a clear strategic role for NWRC to co-ordinate all water resources management activities in the country. Key areas of future activity are expected to include adoption and oversight of the National Water Management Plan and updates, resolution of inter-agency conflicts, and adoption of common standards for the water sector.

The Executive Committee of NWRC (ECNWRC)

To support the NWRC, a 15 member Executive Committee of the NWRC (ECNWRC), headed by the Minister of Water Resources was constituted in 1997 by an order of the Government. In carrying out its responsibilities to the ECNWRC, WARPO is to provide a high caliber Secretariat and to ensure that routine matters are addressed without delay. It will also address the issues requiring the attention of the full council and will ensure that issues are properly presented, recorded and executed.

Ministry of Water Resources

Formerly designated as the Ministry of Irrigation, Water Development and Flood Control, the Ministry of Water Resources (MoWR) was established in 1994. MoWR is the executive body responsible for all aspects of the water sector including expansion of irrigated areas, water conservation, surface and groundwater use, and river management. In addition to the Minister and State Minister, the MoWR consists of the Secretary, an administrative group of sixteen Class I officers and a small Planning Cell.

The NWPo entrusted MoWR with formulating a framework for institutional reforms to guide all water sector related activities. It is required to review periodically the mandates of all water sector institutions and redefine their respective roles, to ensure efficient and effective institutions commensurate with changing needs and priorities.

Water Resources Management Policy

The National Water Policy (NWPo) published in January 1999 has the following broad aims and objectives:

"The water policy of the government aims to provide direction to all line agencies working with the water sector, and institutions that relate to the water sector in one form or another, for achieving specified objectives. These objectives are broadly:

- To address issues related to the harnessing and development of all forms of water and groundwater and management of these resources in an efficient and equitable manner.

- To ensure the availability of water to all elements of society including the poor and the underprivileged, and to take into account the particular needs of women and children.
- To accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing.
- To bring institutional changes that will help decentralise the management of water resources and enhance the role of women in water management.
- To develop a legal and regulatory environment that will help the process of decentralisation, and sound environmental management, and will improve the investment climate for the private sector in water development and management.
- To develop a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice and environmental awareness, to facilitate achievement of the water management objectives through broad public participation" (GoB, 1999).

It is acknowledged in the new NWPo that the existing legislation on water management requires supplementing in a number of key areas (GoB, 1999). It is the intention of the Government that the policy will be given effect through a National Water Code (NWC), which will outline and specify provisions of the water policy required to facilitate implementation. The views of government are to enact this NWC by revising and consolidating the laws governing ownership, development, appropriation, utilisation, conservation and protection of water resources.

The NWRC is also responsible for the continued development of water resources institutions and for providing policy directives for co-ordination across sectors. However, it is the responsibility of WARPO to determine the means by which the broad policy aims in the NWPo are to be implemented. Policy itself implies the framework within which this is to be achieved through the National Water Management Plan.

The policy states that "standards of effluent disposal in common water courses are being set by WARPO." However, WARPO as yet, has no powers to act as a regulator. Currently, the greatest concern is the fact that the policy is yet to be endorsed by the Parliament or backed by an Executive Order. As a result, no agency including BWDB, LGED or the Ministries of Fisheries and Livestock and Roads and Highways are at present obliged to submit their plans and projects to WARPO.

Inter-Sectoral Policy Linkages

A number of policies are related, and have implications for water management in Bangladesh.

National Policy for Safe Water and Sanitation (1998)

The above policy, published by the Local Government Division of the Ministry of Local government and Rural Development and Co-operatives aims to ensure that all people have access to safe drinking water and sanitation services at an affordable cost. Since the NWPo places the highest priority on the provision of domestic water supplies and sanitation during times of water shortage, the policy is clearly important. There appears to be no real contradiction in the policy that could restrict the policy in achieving its aims and objectives.

National Fisheries Policy (1998)

The fisheries sector accounts for roughly 3.5 percent of the GDP, 11 percent of export earnings and over 2 million people in the various stages of the production process. Fishes provide most households with the majority of their animal protein. Fishing for domestic consumption is an important part of rural life in Bangladesh. Most of the water bodies in the country are owned and administered by the Ministry of Land (MoL), through the Deputy Commissioners or Collectors of the districts. Water resources in Bangladesh are under the Ministry of Land (MoL) from a fisheries management point of view, defined as open (rivers and streams) or closed water bodies (beels, haors and baors). The basic mechanism for managing fisheries in the inland open waters of Bangladesh has been based on the allocation of fishery rights through periodic leasing. However, the management and control of *jalmahals* (closed water bodies) still remained in the hands of the local elite. In 1995, the Prime Minister, abolished the leasing of flowing water bodies (MOFL, 1997).

National Agricultural Policy (1999)

The main objective of the policy is to maintain food self-sufficiency. As highlighted by Halcrow et al., 2000, this has implications for the NWPo and may be inconsistent with the aims of the NWPo particularly during times of water scarcity. A related feature is the fact that the NAPs drive to self-sufficiency has implications for agro-chemical usage and discharge. Any such increases are in contradiction of the policy's objective to maintain an ecological balance, conserve biodiversity and ensure public health, and the NWPos stated goal of protection of the environment.

National Environmental Policy (1992)

The National Environmental Policy was adopted in 1992. The GoB has since gone on to establish acts by which the policy can be administered. This included the enactment of the Environmental Conservation Act in February 1995. The law was enacted for conservation, improvement of quality standards, and control and mitigation of pollution of the environment. Following the Act of 1995, The Environmental Conservation Rules 1997 was lodged.

Water Resources Planning Institutions

Regulatory and Planning Agencies

Regulatory and Planning Agencies are required to frame and periodically revise the rules, procedures, and guidelines for combining water use and land use planning. In planning public water investments, government agencies with assistance from service and information providers will develop multipurpose projects with an integrated multi-disciplinary approach. The following are the Planning and Regulatory Agencies in the urban and rural sector:

- *Rajdhani Unnayan Kartripakha (RAJUK)*

  RAJUK is the Development Authority for Dhaka. RAJUK has direct control over urban expansion plans and planning consents. It also has direct influence over issues relating to management and the sustenance of urban water bodies. There are similar organizations in Chittagong, Khulna, and Rajshahi namely Chittagong Development Authority (CDA), Khulna Development Authority (KDA), and Rajshahi Development Authority (RDA) , respectively.

- *Joint Rivers Commission (JRC)*

  JRC was established in 1972. The JRC is responsible for 57 identified border rivers, 54 with India and three with Myanmar (minor rivers with no treaty agreement). All staff members are on secondment from the Water Investigations Directorate of BWDB. It also acts as the "home" for:

  1. International Commission on Irrigation and Drainage (ICID)
  2. International Hydrological Program (IHP) and
  2. Inter-Islamic Network on Water Resources Development and Management (INWRDAM).

- *Department of Environment (DoE)*

The Department was established in 1989 at the end of an Asian Development Bank Project. The National Environment Policy was published in 1992, followed by the Environment Conservation Act in 1995, the Environment Conservation Rules and EIA Guidelines for Industry in 1997,

Under the 1995 Act, DoE has unilateral powers to set and enforce environmental standards throughout all sectors of activity in the country. All water sector projects need to conform to their rules and guidelines as a legal requirement.

- *Ministry of Industry (MoI)*

The Government formulated an Industrial Policy in 1982 outlining the strategies for environment-friendly industrialisation. The policy was revised in 1999 to disperse the industries that without mitigating measures could have adverse impacts on the quality of water bodies receiving industrial effluent.

- *Ministry of Land (MoL)*

All Government land comes under the jurisdiction of the Ministry of Land, which manages all land in the country through a system of lease settlement, sale, and acquisition. MOL has recently formulated the first draft of a land-use policy for efficient management and for resolving conflicts. Flood control and drainage structures, which have altered land and water use patterns, will also receive careful attention in the policy guideline.

Water Resources Planning Organization (WARPO)

The Water Resources Planning Organization (WARPO) was created by the GoB as the organization responsible for the overall water sector planning for the nation. WARPO's task is to initiate and develop national policies and plans for water resources, ensuring optimum utilization among various users such as agriculture, fisheries, navigation, public health, and industry. WARPO is also entrusted with collating data collected by the various water sector agencies. However, it is widely acknowledged that though WARPO has put forth every effort and fulfilled its sectoral planning and co-ordination role to a great extent, unfortunately, the individual line ministries tend to rely on their own planning departments, and tend to work in isolation.

The mandate for WARPO was gazetted in December 1991, but it no longer reflects the organization's new vision and responsibilities. Consequently a new mandate is under preparation but, unlike the NWPo, has not yet been finalised. Nevertheless, WARPO's responsibilities as stated in NWPo are as follows:

- Delineating the hydrological regions of the country based on appropriate natural features for planning their water resources.
- Providing administrative, technical and legal support to the ECNWRC.
- Advising the ECNWRC on policy, planning and regulatory matters of water resources, and related land and environmental management.
- Preparing and periodically updating the National Water Management Plan for NWRC approval
- Setting out and updating the National Water Resources Database (NWRD) and Information Management System.
- Acting as a "clearing house" for all water sector projects identified by different agencies and reporting to the ECNWRC on their conformity with the NWMP.
- Undertaking special studies, required by the ECNWRC, to fulfil the objectives and programmes envisaged in the NWPo and the Bangladesh Water and Flood Management Strategy.
- Performing any other function as may be assigned to it from time to time by the Government.

The NWPo further implies that WARPO will be responsible for delineating water-stress areas, based on land characteristics and assessing water availability for managing dry season demand.

The mandate, policy and administration of WARPO have been presented in a schematic diagram below.

Water Resources Planning Organization

Mandate

- Prepare environmentally compatible water master plan.
- Develop national policy and strategies for appropriate use and conservation of water resources.
- Advise and assist other water- related organizations.
- Act as a "clearing house" for all water sector projects.

Policy

- Provide a comprehensive framework for the development of WARPO as an institution.
- Specify clearly WARPO's main functions and the ways in which it should carry them out in an inter-institutional context.

Administration

- Designed to be highly professional and capable of working in collaboration with the private sector and the NGOs.
- Headed by a Director General who is assisted by two Directors. At real working level are the Chief Scientific Officers who are in charge of the technical sections overseeing the work of other professionals.

Sub-regional Planning

Planning for the eight NWMP regions is a project obligation, but sub-regional, or in practice, project planning is carried out by the various water sector agencies. Many central government agencies are represented at the District level with the District Administration having a dominant co-ordinating role. Agencies such as LGED and DAE are at the District level, but BWDB and BIWTA, for example, work on different sub-divisions. To some extent, the District Co-ordinating Committee composed of officials and chaired by the Deputy Commissioner has some planning functions, but hardly represents the decentralised approach required in NWPo.

Elected District Councils were dissolved in 1991 and are now being resurrected as elected bodies. Ways must be found to institutionalize the planning process at the District and certainly at the local level, with an appropriate mechanism for beneficiary consultation and decision making.

District Level Inter-sector Project Evaluation Committee (DLIPEC)

The DLIPEC was established by the Planning Ministry in 1999, in anticipation of inter-sectoral conflicts between LGED and BWDB, both of which are entrusted to construct FCDI schemes up to 1000 ha, but the BWDB is responsible for all other schemes. The directive establishes a conflict resolution formula as follows:

- Committees are constituted by the lead agency of the proposed project comprising a chairman, plus eight members including representatives from the District Administration, Department of Agricultural Extension(DAE), **Local Government and Engineering Department (**LGED), BWDB etc.
- There are no representatives of the intended beneficiaries or of the concerned Local Government Institutions (LGIs) on the Committee.
- The committee is empowered to prepare and submit PCPs. However, this is unlikely to happen in the near future.
- If the Committee cannot reach a consensus on any project proposal, the matter would be referred to the BWDB Zonal Chief Engineer for resolution.
- As a last resort, there is provision for a Central Co-ordination Cell to take the final decision. The Cell comprises seven members, including the Director General WARPO as the Chairman.

Currently, very few new water sector projects are being implemented. There is a probability that DLIPECs will only be convened by LGED in order to clear Small-Scale Water Resources Development Sector (SSWRDS) projects.

Local Level Planning

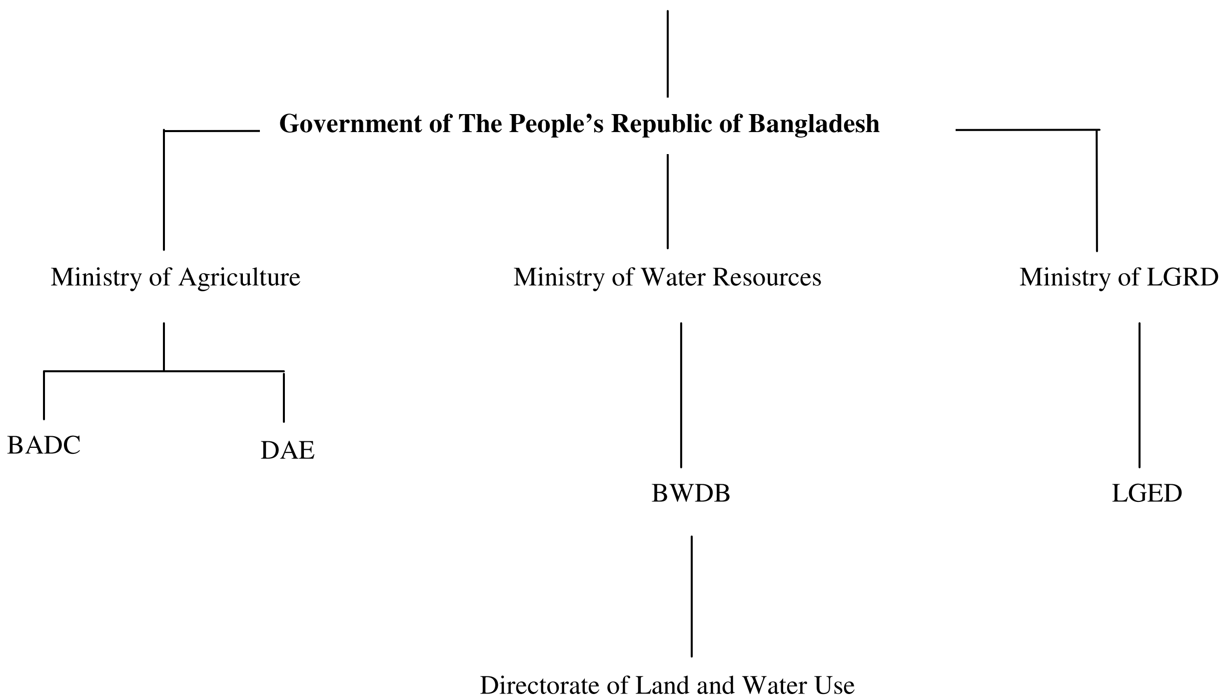
The local level planning has been pioneered by LGED and some water resources planning is taking place at the Upazila/Union levels. SSWRDSP is an example of local level planning. Phase I of SSWRDSP has been completed and now it has entered into Phase II of the project. The steps adopted at the local level planning are following:

- The Chairman of the Union puts forward a proposal to the LGED Upazila Engineer to prepare a Performa outlining concepts.
- The project is cleared by Upazila Development Co-ordinating Committee (UDCC) and is entered in the Upazila Plan Book.
- It is then forwarded to the District LGED Executive Engineer for review.
- Subsequently it is forwarded to the head office.
- The initial shortlisting of the proposed project by LGED reduces the number of total proposed projects by approximately 40 percent.
- Through field visits, the total number is further reduced by 30-40 percent.
- Approved projects are sent back to field for basic data collection by the existing staff members.
- RRA of the proposed/approved project is carried out by a pre-selected NGO.

- A local consulting firm performs the feasibility study of the project.
- If the project is deemed to be feasible by the head office, the consulting firm performs a detailed project implementation design.
- The project is then presented to DLIPEC.
- The final step is to sign an agreement with the beneficiaries. However, to date only 12 schemes have been handed over, following the above-mentioned procedure.

Implementing Agencies

The chart below shows major implementing agencies in the irrigation sector.

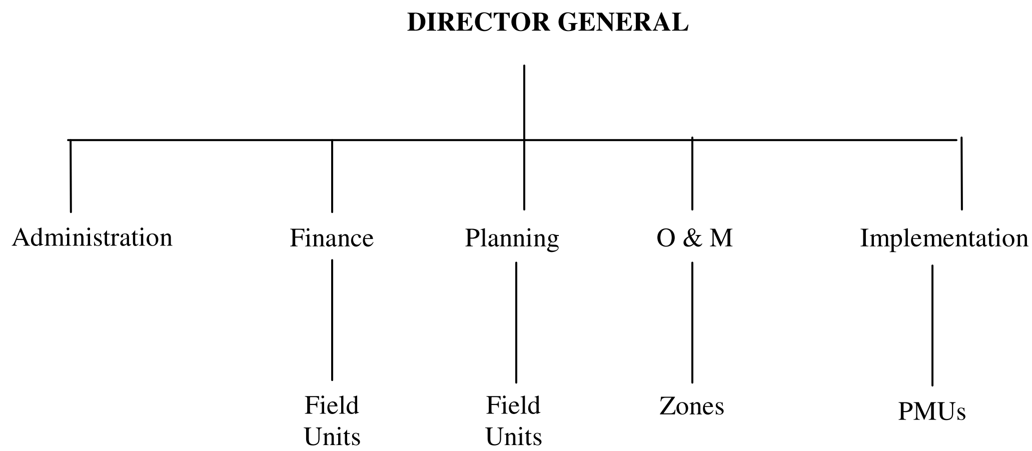


Bangladesh Water Development Board

Originally established in 1959 as the Water Wing of the East Pakistan Water and Power Development Board (EPWAPDA), the organization was restructured in 1972 as BWDB and its mandate limited to water resource development by the Bangladesh Water and Power Development Boards Ordinance. EPWAPDA was restructured in 1972 after the independence of Bangladesh. EPWAPDA was divided into two separate organizations, dealing with water and power separately. The Bangladesh Water Development Board was entrusted with water resources management under the Bangladesh Water and Power Development Board order, 1972 (P. O No 59 of 1972) as a fully autonomous organization. BWDB was entrusted with the responsibilities for the planning and execution of over 400 projects throughout the country including flood control, drainage, irrigation, town/coastal protection and erosion control. BWDB shares an interest in groundwater irrigation and also in minor surface irrigation with BRDB, BADC and

LGED. It has five main operating directorates for: Implementation of Major Projects; Operation and Maintenance; Planning; Finance; and Administration.

Organization Chart of the BWDB



The BWDB is an autonomous body under the MoWR. Under recent reforms, policy functions now vest in an outside Governing Council (GC) consisting of thirteen government and non-government Members with the Minister in charge of the MoWR as its chairman. The BWDB's activities are now confined to executive and operational functions only.

The operations of BWDB are divided into five broad areas or wings. The Director General (DG) is the chief executive of the organization and is assisted by five Additional Director Generals (ADG), who look after the five wings. The DG's office and the five wings form the core of the headquarters of the BWDB. Among the five wings, non-engineering staff man the administration and finance, whereas in the other wings, engineering staff dominate.

BWDB is basically a field-oriented organization, to the extent that all its activities lay outside Dhaka. Except for the administration wing, all other wings have their field outfits extending deep inside the rural areas.

- The basic work of the organization is carried out by the O&M wing that manages the largest number of professionals in the field.
- The implementation wing carries out large civil engineering works and on completion, hands them over to the O&M wing. Implementation units in the field are, therefore temporary, whereas the O&M set up is permanent.
- The field outfits of Planning and Finance wings provide necessary support to the O&M and Implementation wings in carrying out their work smoothly. As mentioned earlier that WARPO has become the exclusive government institution for macro-level planning, sector agencies of the government and local bodies will prepare and implement sub-regional and local water management plans in conformance with the National Water Management Plan (NWMP) and approved government

project appraisal guidelines. Similarly, the BWDB will not undertake any physical modelling or materials testing and these will be done by the RRI.

National Water Policy

National Water Policy has already been introduced in the mandate of the BWDB. In the Policy, there are some specific policy guidelines for BWDB relating to the coastal area along with some other general guidelines applicable to the entire country. The overall thrust of water policy is "to ensure continued progress towards fulfilling the national goals of economic development, poverty alleviation, food security, public health, decent standard of living for the people and protection of the natural environment."

The Policy has finally directed the BWDB to carry out further investigations for appropriate policy development on these following two subjects:

- The efficacy of coastal polders and the sociology of public cut of embankment and the motives and conflicts of interest; the sociology behind them.
- Experience of joint execution of Projects

Since the 1980s, the BWDB has tried to participate in all its project activities. These were pursued in three forms and the initiatives can be reviewed accordingly. These components are:

- Changing the character of BWDB itself
- Developing linkages with other water-related agencies and the NGOs
- Beneficiary participation
- Reforming BWDB

Assumption by the lead executing agency that the relevant agency will automatically take over the responsibilities: This assumption that field units of national agencies will automatically take over functions within the mandate, most of the time, does not come true. Lack of funds and absence of a proper field outfit dissuade them from assumption of their otherwise mandated responsibilities. Similarly, for a large number of FCD and FCDI projects, the assumption that the DAE would automatically take up the extension activities after the physical infrastructure were built, also did not come true in most cases.

Induced participation through Memorandum of Understanding between a lead agency and a partner organization: Another approach to inter-agency co-operation is built around signing a Memorandum of Understanding (MoU) between a lead agency and a service delivery organization. The MoUs worked out the respective duties and obligations of each signatory. However, for a number of reasons, this approach did not bear much fruit.

Bringing in other relevant agencies as Joint Executing Agencies: This approach has two variations — the first variation uses only one Project Performa (PP) under a national Project Director to retain central control on flow and use of project funds. In the second variation, each agency is allowed to process PP for its own component thereby ensuring financial autonomy for the particular agency.

- Working with the NGOs
- Beneficiaries' participation such as Landless Contracting Society (LCS) comprised members from amongst the destitute labourers, facilitated by an NGO.

Another innovation applied for the first time in the Delta Project was the introduction of the Embankment Maintenance Group (EMG). An EMG is comprised of a group of female labourers, organized by an NGO. Only destitute women who own less than 0.5 acre of land and whose main source of income is manual labour are eligible for membership in an EMG. EMG is also organized by NGOs. These could be termed as a major pro- poverty intervention in the FCDI projects by BWDB.

Innovative Approaches to Management:

Budget crunch and wide-ranging criticism of its inefficient operation and maintenance of completed projects, of late have awakened the BWDB to consider some innovative approaches to management. One such item is outsourcing. For such activities as mobilisation of beneficiary's group formation, and resettlement, the BWDB is involving the NGOs; similarly, it is using the national agencies for works that were previously done by the BWDB itself. Inducting the DAE for extension in BWDB project areas is one such example of this approach.

Restructuring of BWDB

There was a study on BWDB in 1997 and the study recommended re-organization. One of the main recommendations was to privatise the Mechanical/Engineering Workshops and to reduce staff numbers to less than 9000 by 2001 through progressive retirement.

The Board consisted of a Chairman and a minimum of five members. By conscious design, both policy and executive functions were assigned to the Board. Framers of the BWDB mandate at that time thought that combining these functions will bring about efficiency and speed in the disposal of business of the Board and thereby accelerate the water resources development in the country. The Board's principal responsibility would be flood control, drainage and irrigation through executing flood control and drainage (FCD) and flood control, drainage and irrigation (FCDI).

BWDB was reconstituted in July 2000 under a new Act that repositions the organization and aligns its responsibilities to those set out in the NWPO. A key element of the new act is to create a Board of Directors that would be responsible for setting policies and strategies governing BWDB activities, as well as overall management. The new Board is headed by the Minister for Water Resources and comprises of four Secretaries, Director General WARPO, Director General BWDB and four appointed members outside the Government. The former Chairman of BWDB has been designated as the new Director General and the former five Members as Deputy DG's. This change separates policy from day-to-day operation, and distances the new BWDB from the Ministry of Water Resources. These will serve to increase the accountability of the organisation and should streamline decision taking.

The Act removes any overlap between BWDB and WARPO with regard to planning responsibilities. WARPO is entrusted with preparing national and regional level policy planning. It is envisaged that BWDB and others would then develop projects that would fulfil the requirements of the plans. BWDB is also a major collector of water resources information and as such will be an important partner to WARPO in sustaining the NWRD.

Mandate: The BWDB Act of 2000 has somewhat reduced the scope of work of the organization but what remains is more rational, manageable, people-oriented and focused. Within the reduced scope, the main functions of the BWDB as enumerated in the Act are as follows:

Subject to fulfillment of conditions under the Act and guidelines provided by the National Water Policy and the National Water Management Plan, the BWDB shall perform the following activities and towards that end shall carry out all activities relating to preparation of needed projects, their implementation, operation, maintenance and evaluation:

- Construction of dams, barrages, reservoirs, embankments, regulators or other structures for development of rivers, flood control, drainage, surface irrigation and drought prevention;
- Dredging, re-excavation and de-siltation of water channels and removal of obstacles from river mouths for improvement of water flows or diversion of water for assisting fisheries, navigation, forestry, wildlife preservation and upgrading environment;
- Works for preservation, land accretion, land reclamation and estuary control;
- Training and river bank protection for the protection of towns, bazaars, and places of historical and public importance from the hazards of land erosion;
- Construction and maintenance of coastal embankment;
- Prevention of salinity intrusion and desertification;
- Harvesting rainwater for irrigation, environmental protection and supply of drinking water;
- Flood and drought forecasting and warning;
- Hydrological survey and investigation;
- Development of forestry and fisheries on the land available around BWDB's infrastructure, in conjunction with relevant government agencies, for the preservation and improvement of the environment as well as for poverty alleviation;
- Basic and applied research on water management; and
- Development of water user's association and other water user/stakeholder's organisations, their training and participation in project planning, implementation, operation and maintenance and project cost recovery for long-term sustainability of benefits to the beneficiaries of completed projects.

The mandate, policy and structure of BWDB have been presented in the schematic diagram below.

The Bangladesh Water Development Board

Mandate

- According to the BWDB Act 2000, the scope of the organization remains rational, manageable, people-oriented and focused.
- Construction of dams, barrages, reservoirs, embankments, regulators or other structures for development of rivers, flood control, drainage, surface irrigation, and drought prevention.
- Dredging, re-excavation, and de-siltation of water channels and removal of obstacles from river mouths..
- Construction and maintenance of coastal embankment.
- Harvesting rainwater for irrigation, environmental protection and supply of drinking water.
- Development of water users' associations.

Policy

- Harnessing and development of water in an efficient and equitable manner.
- Ensuring availability of water to all elements of the society including the poor and the underprivileged.
- Accelerating the development of sustainable public and private delivery systems of water.
- Bringing about institutional changes to help decentralize the management of water resources.

Structure

- BWDB is an autonomous body under the MOWR.
- Its activities are now confined to executive and operational functions only.
- Its operations are divided into five broad areas namely administration, finance, O & M, planning, and implementation.
- Director General is the chief executive of the organization and is assisted by five Additional Director Generals looking after the five wings.
- Administration and finance wings are manned by non-engineering staff whereas in the other wings, engineering staff dominate.

Local Government and Engineering Department (LGED)

LGED grew from a rural works programme started in the early 1960s and a Works Programme Wing was created in 1982 under the Local Government Division of MLGRD&C. Thereafter, it expanded rapidly to become the Local Government Engineering Bureau in 1982 and a Department in 1992, headed by a Chief Engineer. In 1998, LGED was responsible for 26 Rural Development projects. It places a heavy emphasis on local participation, with representation on Upazila Co-ordination Committees. In the water sector, the Small Scale Water Resources Development Sector Project (SSWRDSP) is located in the western half of the country, but with plans to expand countrywide. The Department also constructs and maintains rural roads, and in this regard, also has responsibilities in the same way as the R&H Department.

LGED has its own GIS and databases and has been co-operating with WARPO in developing in NWRD. These linkages need to be strengthened in the future.

Mandate: In regard to water sector projects, LGED draws its mandate from Upazila Parishad Act (24 of 1998) Second Schedule, Clause 23 items 4, 11 and 17:

- Ensure the best possible use of surface water, for adoption and implementation of minor irrigation projects in line with government directives
- Implement programmes in the development of Agriculture, Livestock, Fisheries and forest resources
- Prepare programmes for protecting the environment and promotion of social forestry
- Provide technical support to the rural local government institutions (LGIs)
- Provide technical support to the urban LGIs
- Planning, implementation, maintenance and monitoring of infrastructure development projects in the rural and urban areas
- Prepare plan books, maps, database, design manuals, technical standards and specifications
- Impart training to the LGED officials and LGI representatives[3]

Sector Policy

The current program of activities of the LGED has been developed on the basis of policies approved for the sub-sector under the Fifth five-year Plan. The objectives of the policy are the following:

- Reduction of poverty in the rural areas
- Productive employment generation in the rural areas
- Self-employment creation for the rural poor
- Development of rural infrastructure
- Development of basic infrastructure and services at zila, thana, union and village level
- Development of small and landless farmers

The objectives referred to above, are sought to be achieved through the following strategies:

[3] Government of the People's Republic of Bangladesh, *Report of martial law committee on organisational set up. Vol. X. Part. I.* Dhaka: May 1982.

- Development of rural infrastructure such as growth centres and roads, bridges and culverts connecting such centres
- Provision of small irrigation and flood control related infrastructure
- Preventing destitution through rural maintenance program[4]

According to the stipulations in the policy, all small-scale flood control, drainage and irrigation schemes having a command of 1000 ha or less shall henceforth be executed by the local government institutions. Similarly, all such projects executed by the BWDB will gradually be transferred to the local government, beginning with the ones that are being satisfactorily managed and operated by the beneficiaries/community organisation.[5]

LGED is headed by a Chief Engineer and is assisted by three Additional Chief Engineers and other support staff at the HQ. The Department is basically a field-oriented organisation and it presence is visible even in the villages. Besides the HQ staff, there is permanent standard set-up for each of the 64 districts and 463 thanas. The cost of this permanent establishment is borne by the GoB through its revenue budget. For each district, there is a sanctioned strength of 11 persons while for each Thana the number is 13. For the coastal districts, the pattern is the same and there is no special set-up.

LGED is a government department and its management is bound by government rules and regulations. Despite its ability to deliver outputs in a satisfactory manner, it is surprising that the LGED does not have a job description as yet. It does not also have a formal delegation of administrative and financial powers. Consequently, the financial management and accounting system in LGED is considerably weak and fragmented.

Experience with Joint Execution of Projects:

LGED has already worked with the BWDB in completing two components under two projects. Currently it is implementing its components under seven infrastructure development projects being executed by different agencies under the Ministry of Agriculture.

Community Participation

LGED has been working with local communities in the development of rural infrastructure for many years. In the Second Small-Scale Water Resources Development Sector Project, the Joint Appraisal Mission had developed a Beneficiary Participation Plan for involving all the stakeholders in a project cycle process.[6]

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[4] Planning Commission, Ministry of Planning, Government of the People's Republic of Bangladesh, *Op Cit.* Pp 279-280 and 403.
[5] Ministry of Water Resources, *National Water Policy.* Op Cit p 9.
[6] Asian Development Bank, "Aide Memoir of the Joint Appraisal Mission for the proposed Small-Scale Water Resources Development Project" April 1995. Appendix 5.

Innovative Approach to Management

Since the early 1980s, in addition to contractors and the Project Implementation Committees (PICs), Labour Contracting Societies (LCSs) are being used by the LGED as a new and innovative mode of construction activities. The main objectives for using the LCSs for infrastructure development are to:

- Directly involve and provide employment opportunities to the landless / destitute groups
- Involve women in infrastructure construction and maintenance
- Eliminate intermediaries in construction activities
- Ensure fair wages to labourers

Encouraged by the positive results of this experiment on poverty alleviation and income generation, the NWP has enjoined that at least twenty-five percent of all earthworks done by any agency should be executed through the LCSs.

Bangladesh Agricultural Development Corporation (BADC)

BADC was established by Ordinance in 1961 as the East Pakistan Agricultural Development Corporation to bring about a technical transformation of agriculture through the distribution of inputs and related technical support services. The Chief Executive is the Chairman with six functional wings: Seed; Irrigation; Distribution; Planning; and Member Directors, except for Administration (including Establishments), which is headed by the Secretary.

BADC pioneered the introduction of mechanised minor irrigation (LLPs, STWs and DTWs) from the 1960, and laid the foundations for the rapid expansion that has since occurred. Activities have been progressively privatised and in 1993 the Cabinet decided that all the remaining operative functions related to irrigation, distribution of pumps, and most of the repair and maintenance functions should cease. The fertiliser and biocide supply function has also been privatised, leaving a large proportion of BADC staff without work.

The original establishment consisted of about 19,000 of whom 68 percent were engaged in the irrigation wing. The policy of downsizing through privatisation has meant that some 8000 staff members have taken early retirement, although the organisational structure of BADC has remained unchanged in the absence of an agreed restructuring plan.

Mandate: The Corporation drew its original mandate from the BADC Ordinance of 1961, subsequently amended in 1972. The Ordinance covered responsibilities for procurement, storage, and distribution of seed, fertilisers, pesticides, agricultural machinery, irrigation equipment etc. Many of these services have now been phased out and a draft document "Activities of the Irrigation Wing" is at present being discussed between BADC and the Ministry of Agriculture.

The draft defines irrigation-related activities as

- Assisting the Government in policy planning and implementation of minor irrigation
- Development of water resources related to minor irrigation and
- Implementation of on-farm water management

The document does not have clauses comparable to those of NWPo on local government or beneficiaries. It may therefore be prudent to revise the document in the light of NWPo.

Department of Agricultural Extension (DAE)

In 1982, the Government of Bangladesh created the Department of Agricultural Extension (DAE) as the core of an institutional reform of extension activities. DAE's overall responsibility is to equip the farmers with modern technical know-how and improved methods of farming to increase agricultural productivity and farm income level.

The Department is headed by a Director General who is assisted by five Directors and two Additional Directors. The functions of the DAE have been divided into seven broad areas and are allocated to the seven wings namely, Food Crops Wing, Cash Crops Wing, Field Services Wing, Training Wing, Water Management and Agricultural Engineering Wing, Administration and Personnel Wing, and Planning and Evaluation Wing.

The creation of the DAE and the intensification of extension activities formed the first round of reforms in the country's extension system. However, with the passage of time, it became clear that another round of reforms was necessary to further consolidate the gains already made. It was against this background that the New Agricultural Extension Policy (NAEP) was adopted for implementation in 1996. The declaration of the new policy was followed by *A strategy for Implementing the New Agricultural Extension Policy (NAEP)* in January 1997. The execution of the NAEP is further assisted by the formulation of a Strategic Plan (1999/2000) now under implementation by the DAE. The DAE through its Strategic Plan has been establishing linkages with other entities like the NGOs, research institutes, other government organizations and relevant educational institutions.

National Level Government Agencies Responsible for Irrigation

National Level Government Agencies Responsible for Irrigation

Responsibilities at a Glance

BWDB:

- Data collection
- Program planning and coordination
- Standard monitoring
- Major river maintenance and erosion control
- Barrage and transfers
- Managements of medium and large FCDI projects
- Large irrigation projects
- Regulate river maintenance and irrigation control
- Maintenance of local drainage and irrigation control
- Management of small FCDI projects
- Flood protection

BADC:

- Data collection
- Minor irrigation
- Maintenance of local drainage

DAE:

- Data collection
- Minor irrigation
- Education awareness raising (rural and local level)

LGED:

- Data collection
- Local area development planning
- Maintenance of local drainage
- Flood proofing
- Management of small FCDI projects
- Flood protection
- Small-scale irrigation

Irrigation-related Statutes and Their Inter-linkages

Irrigation Law

Existing documents include the myriad Acts that have bearing on the water sector. Especially important among these are:

- The Irrigation Act of 1987; The State Acquisition and Tenancy Act of 1950; the Embankment and Drainage Act of 1952; the Acquisition and Requisition of Immovable Property Ordinance of 1982; the Irrigation Water Rate Ordinance of 1983; the Groundwater Management Ordinance of 1985;
- Linkages: Support to preparation of new ordinances; linkages to programs (Water Resources Legislation-Preparation of Supporting Ordinances), Project Preparation Procedures – Guidelines and Manuals, Regulatory and Economic Instruments, Field testing and Finalization of the Guideline for Participatory Water Management.[7] The local-level patterns of management of water resources, and the context within which they take place, interact with and are influenced by the external legal, policy and institutional context that determine many aspects of local change and development. This includes the functioning and impact of markets as well as laws, government policies and the actions of government agencies.
- There has been no effort so far for conflict resolution among the different agencies managing water related areas.
- Public participation has been identified as the key area for sustainable development in the water sector.

[7] National Water Management Plan Project: WARPO: July 2001.

2.3. INFORMAL INSTITUTIONS IN THE WATER SECTOR

Non Government Organizations (NGOs) and the Water Sector

Origins and Involvement of NGOs: Expansion of NGO activities gained momentum since 1970, as an aftermath of the devastating cyclone and the liberation war in 1971. Recently, the vacuum created by the inability of the Government, Local Government Institutions of the market to deliver goods and services have been filled by the NGOs.

Many NGOs have an interest in water supply and sanitation with installation charges varying form nil to full recovery. In contrast to water supply, NGOs have generally had unhappy experiences with the management and operation of DTWs, but much more success with STW and low lift pumps (LLPs).

Review of literature shows ample evidence that local efforts were not always organized by local government bodies like, Union/Thana Parishads, but also by spontaneous self-help private groups. Involvement of NGOs in water development is a relatively recent phenomenon that started vigorously with formation of the Labour Contracting Society (LCS), under Early Implementation Project (EIP) and later on stretched to Embankment Maintenance Group (EMG), Canal Maintenance Group (CMG) under Systems Rehabilitation Project (SRP) and Command Area Development (CAD) projects of the Asian Development Bank (ADB). Various studies show, however, that the expertise of the NGOs is limited to formation of groups and working as their voice, contrary to the claim of championing in totality the cause of the people and their participation from the grassroots. Apparently, the NGO involvement was more of a donor requirement rather than demand driven.

Four NGOs, Proshika, Grameen Krishi Foundation, BRAC and Gono Kalyan Trust, signed a joint agreement for the transfer of DTWs from BADC/BWDB in 1988 as follows:

- Proshika contracted 200 DTWs and initiated operations of 41, but currently only 9 are fully operational.
- Grameen Krishi Foundation originally obtained 800 DTWs (565 from BADC and 235 from BWDB). 350 of BADC pumps are currently operating primarily with the sharecroppers. However, cost recovery of BWDB's pumps was not satisfactory. Therefore, the pumps leased from BWDB were returned in 1991.[8]
- BRAC initiated its operation with 800 DTWs but due to heavy financial loses closed down the operation in 1996.
- Gono Kalyan Trust is still continuing its DTW operation with very small number of pumps.
- Proshika provided credit and support services for the purchase of 3000 STWs and 1000 LLPs in 46 Upazilas. Loan repayment had been excellent (capital to be paid off over two years and O&M loans over six months). Proshika will continue to provide credit to groups demonstrating a need for STWs and LLPs.

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[8] Though the Government decision was to hand over 959 DTWs to Grameen Bank, at their First attempt in 1989 they took only 231DTWs. But as their system of water rate collection was not accepted by the beneficiaries who have been getting Irrigation Water Free or with minor charges, on public demand in 1992 Government decided on taking back 726 DTWs. Two were returned to BRDB and the rest were handed back to BWDB for operation and maintenance. Since then BWDB is operating 986 DTWs (726 new+259 old +1 experimental): "Proceedings of the National Seminar on Implementation of Pilot Cost Recovery Programme in KIP (Ichamati Unit)"

Other NGOs and CBAs demonstrated little interest in irrigation water management, especially in the project areas. Despite running successful micro credit programs, NGOs, CBOs and other private organizations limited their program to certain categories only, which did not include management of irrigation water and the components of water management. Community participation in this respect was also not very encouraging, though the communities benefited by the irrigation projects stated that with proper technical assistance, training, and assistance in group formation, the community was ready to take over Irrigation Management Transfer (IMT). However, there had been no substantial growth as well as development in the private sector for management of this sector despite existence of a strong demand for irrigation water.[9]

NGOs' relations with WARPO

Learning from the experience of FAP, WARPO has actively sought co-operation with the NGO community. With full support of the Association of Development Agencies of Bangladesh (ADAB) and the Coalition of Environmental NGOs, WARPO has engaged 13 NGOs to play an active part in developing and implementing a People's Participation and Consultation Process (PPCP) to support national level planning of water resources management. NGOs have indicated that this is a welcome development in the planning process.

Co-operatives and the Water Sector

The Co-operative Movement

The Bangladesh Rural Development Board (BRDB) provides support to the national co-operative movement of 63,000 farmer societies (KSS) which are grouped at Upazila level into Upazila Central Co-operative Associations (UCCAs).

BRDB consists of a DG and Additional DG and six Directorates responsible for the following services: Field Services; Planning; Administration; Finance; and Training. The co-operatives are involved in a range of services of importance to farmers as well as irrigation services.

Irrigation and Water Supply

The Government decided to transfer DTWs, STWs and LLPs installed by BADC to farmer's co-operatives as follows:

- Sonali Bank (a nationalised commercial bank) buys the TWs from BADC and sells them on to the Upazila Central Co-operative Association (UCCA);
- UCCA passes wells on to KSS who undertake to repay UCCA;
- KSS repays the UCCA which in turn repays Sonali Bank;

[9] "The water users' organization consists of water users themselves, who have direct interest in water management activities. The water users will put in best efforts to reap meaningful benefits out of the system built for them and try to sustain it in their own interest. Therefore, the apprehension of forming CBA in such socio-economic project hardly exists if development takes place through process on longer term. Close monitoring on the development of users organization should be made to avoid exploiting the situation by any vested group. The organization to grow needs time." Proceedings of the national seminar on implementation of pilot cost recovery programme in KIP (Ichamati Unit): 1994, Dhaka.

- BRDB stands as guarantor for all transactions.

Repayment of the loans has been very poor except for the hand-operated pumps (38 percent of the loan on DTWs and 23 percent of STW loans have been repaid). The main reason for poor repayment appears to be the past tendency of politicians to forgive KSS debts. This provides a clear signal to the whole co-operative movement—if repayments are delayed, Government will cancel the debts in due course. A culture of default pervades the irrigation sector and it will take much to restore lender confidence.

Out of the total tubewells supplied, 8.7 percent of DTW and 7.2 percent of STW have fully been paid. Of the total invested amount, 38 percent has been repaid. Despite discouraging experiences, the Japanese aid is apparently planning to support a further DTW program through the co-operative movement.

Possible Alternatives to Cooperatives

There is an increasing need to explore alternatives to co-operatives as the recipient organisation with the increased emphasis on ownership and management of water by the communities. Currently, co-operatives are the community-based organisations that are recognised by law and authorised to take over publicly financed infrastructure and securing lines of credit. Possible alternatives to co-operatives should be explored. It could be either community organisations of private companies for developing, operating and/ or maintaining local water resources to the surrounding communities.

Private Sector

Private sector activities in modern irrigation date back to the late 1970s when private operation and sales of mechanised irrigation equipment were first allowed. Successive actions by GoB, including withdrawal of BADC from commercial activities in 1993, fuelled rapid expansion of the private irrigation market. By 1995-96, over 500,000 wells had been installed and annual turnover of the minor irrigation market had reached over Tk.1500 million (US $26 million).

The private sector is closely involved in all aspects of water resources development and management such as consultants involved in survey, planning, design and supervision of works; contractors in construction and in some cases, financing of works; equipment importers and suppliers; distribution and sales organisation; service providers, including maintenance of equipment and training and credit agencies. Each play a part in the sector as a whole and during the last 20 years expanded significantly, which resulted in a major shift away from centrally run public institutions. This trend is also supported by the Government policy.

Minor Irrigation

Private sector activities in minor irrigation started in 1970s with the liberalisation of STW and LLP equipment sales. Successive actions by the GoB and withdrawal of BADC from all commercial activities in minor irrigation in 1993 created added incentives for the private sector, which led to rapid growth especially in STW.

The massive response of the private sector is commendable but one should also keep in mind that this sector comprised of small businesses working independently of each other and providing simple and low quality products. Credit services from the formal sector are widely recognised as having been ineffective in meeting private sector needs, a gap that is yet to be filled. While at village level there is some degree of co-operation between dealers/suppliers, and mechanics etc, there is a lack of distribution network such as a wholesale dealer dealing with the central market. Usually, the suppliers have very little technical knowledge of the equipment and irrigation in general. Two main manufacturing centres of irrigation pumps are Dhaka and Bogra.

Manufacturing of Irrigation Pumps

STWs and LLPs in Bangladesh are usually produced in a multitude of small foundries. The products are usually of low quality. Imported motors and engines poorly match the pumps and pumping requirements. However, due to overall high profitability, poor quality of the equipment has not deterred the users, and the growth rate of manufacturing was high. As irrigation and rural water supplies continue to expand, there will be increased demand for new and improved products.

Interaction between Public and Private Sectors

The Private sector was dominated by a relatively small number of importers, suppliers, contractors etc., when BADC played a predominant role in minor irrigation. Since liberalisation though, the number of importers remained small, but the numbers of suppliers and contractors have increased significantly.

Importance of maintaining contact with the private sector and exchange of information is given due importance in the New Agricultural Extension Policy (NAEP). This new policy has recognised the importance of representation of the private sector at national, regional, District and Upazila level on its DAE extension committees.

Very few trade organisations are active in the water sector and that makes it difficult for WARPO to interact with the private sector at a central level.

With the growth of the market and improved awareness, recently, several changes could be noticed. Various products (e.g. plastic pipes, pumps etc) are being manufactured now locally by larger producers. These large producers are setting up sales networks. Interest in manufacturing submersible pumps, by the large producers is also growing with the expansion of rural electrification.

2.4. WATER DISTRIBUTION

The major components of irrigation network of the project areas are main canals, secondary canals, tertiary canals, field canals, plot channels, (all irrigation canals), minor drains, main drains and collector drains.

The Main Canals

In both the study areas, main canals started at the pump house and ended to start another main canal and so on. The main canals and pump houses are still operated and maintained by BWDB. Peoples' participation in operation and maintenance in this phase are still not being considered. Questions such as, which canal should receive priority over other main canals on getting water, how much water and during which period of the year, for how long etc., are decided in consultation and mutual understanding with the members of the Water Management Organization (WMO) and the implementing agency (in this case BWDB). This system is fully operational in the study areas. The field findings reflect a good understanding and rapport with the WMO and the officials of BWDB.

Secondary Canals

Secondary canals branched off from the main canals, e.g. the Ganges Canal supplies water to twelve secondary canals with lengths varying from 1- 4 miles.[10] In general, the conditions of these canals are poorer towards the end in the study areas. The most likely reason for poorer condition at the tail end could be due to frequent water shortages. This leads to more weed growth at the tail end of the secondary canals.

Tertiary Canals

Tertiary canals were originally meant to be the last canals under control of BWDB for conveying water to field channels, constructed by the farmers themselves. They usually take off from secondary canals but in the study area, a large number of tertiary canals take off directly from the main canal, especially in the G-K Project area. The tertiary canals normally cover 300-800 acres, and if a larger area cannot be avoided it should be subdivided into smaller units, each commanded by a branch of the tertiary which can be closed or opened separately in view of rotation and proper water allotment.

Field Channels

Field channels convey the water to the farmer's plots. They originate at tertiary canals, quite often at secondary canals. The channels are very simple ones, apparently made without strict criteria and generally follow the actual plot borders.

Drains

The drainage system of the study area functions well. Flooding only occurs in limited areas. Damage to crops caused by lack of drainage is, under the present conditions, reportedly small.

[10] Report of an Irrigation Advisory Team: Ganges Kobodak Project (Kushtia Unit). 1980.

2.5. ENFORCEMENT MECHANISMS IN FORMAL AND INFORMAL IRRIGATION SECTORS

Within the government organisational structure relevant to the water sector, at the highest level is the National Water Council, with representatives from all water-related ministries. This body approves the policy prior to presentation before the Cabinet. WARPO was created by the GoB as the organisation responsible for overall water sector planning for the nation. As the individual line ministries tend to rely on their own planning departments, which tend to work in isolation, WARPO had to struggle for its sectoral planning and the role of co-ordination.. The problem has been identified and has been acknowledged by the government. NWMP is trying to identify the needs and priorities for water resources management, the institutional structure through which water resources should be managed and the process through which both institutional reform and priority interventions can be realised.

Currently, major investments in the water sector are made by the Ministry of Water through BWDB and by the Ministry of Local Government Regional Development and Co-operation through its Local Government Engineering Department (LGED). However, other water-related ministries have their own investment programs. Each of these agencies has, in the past, attracted donor support for the projects in a manner that has little co-ordination and much duplication.

The BWDB, which falls within the Ministry of Water Resources (MoWR) but is operationally independent was and still is predominantly an engineering, construction-oriented agency. It has a centralised structure and is less appropriate for any management functions with significant devolution of responsibilities and the capacity to respond to local conditions and events.

A robust process through which meaningful participation could be achieved has not yet emerged. Some FAP projects had participation as central dimensions to their implementation; the core process was the development of "Guidelines for People's Participation (GPP)" (Table 2.1) by the BWDB through Systems Rehabilitation Project (SRP).

On paper, the scale of WMG formation grew rapidly, particularly during 1995-96. Targets for spread of WMG formation were set, the tiers above the Water Management Groups(WMGs) identified (with a hierarchy of committees for each sub-project of Water Management Committees), Water Management Associations (WMAs) and a Project Council (PC) and group formation was rapidly expanded. However, as the whole process became target-oriented, the effectiveness and functionality of groups after formation became lost, characteristics found in many similar projects.

Field surveys were undertaken during the evaluation of SRP. The livelihood survey demonstrated total ignorance of the respondents regarding WMOs. It was clear that the WMG/O formation process has had little success in initiating a community based management of the operation and maintenance of the water control structures. However, the field surveys showed that a high proportion of people from all walks of life was interested to be consulted on key decisions concerning the structures. An effective participatory process is time consuming, requires substantial external inputs and local initiatives. The purpose of participation should be clear and useful for the local people.

The old GPP was the root of many of the problems in the informal sector of water management. After a long review a new GPP has been developed in early 2000. Following are some of the flaws in the old GPP, which made it ineffective:

- The GPP was based on logic and was prescribed on an organisational structure of BWDB, with an assumption that water management can be separated from other aspects of livelihood systems, and the appropriate spatial structure for organising community participation is hydrological.
- The definition of the two key concepts of water users (exclusively farmers) and integrated water management (surface water for crop production) are both inadequate and exclude key groups of stakeholders (such as fishermen, landless and boatmen) and key aspects of water resource management (such as groundwater utilisation, domestic water supply, fishing resources and navigation). This categorisation does not reflect the realities of rural life in Bangladesh.
- The development of participatory organisations around water resource management requires recognition of, and co-ordination with many other local-level participatory groups and organisations, both informal and formal. This will avoid duplication and will make the group formation easier and quicker.
- Local level BWDB staffs are squeezed between the emerging need for local accountability and joint decision making and their accountability to the Centre. They also lack full local decision-making authority.
- Lack of devolution of the decision-making authority to the lowest appropriate level within BWDB. This devolution of decision making to the appropriate level to allow real participation in negotiations and decisions is one of the most essential steps warranted for widespread participation in the water sector.

2.6. USERS PARTICIPATION IN IRRIGATION MANAGEMENT

Irrigation Management Transfer (IMT) to the Community

The irrigation network built and maintained by the BWDB is still being managed by the BWDB. However, people's participation in irrigation water management has come into the lime light, as communities are progressively being made aware of the responsibilities of managing the projects which benefit them, belong to them and should be managed by them. The colonial attitude that "any property built/developed by the government is not people/community's property but property of the government" has also contributed to lack of community ownership and awareness. The common attitude of the community is that management, maintenance and operation of those projects are supposed to be performed by the government. The community does not feel any responsibility in operation, maintenance and management of any project developed/implemented by the government. Therefore, the sense of community belonging is still at a formative stage. However, Focus Group Discussion (FGD) with the various stakeholders (Table 2.2) revealed that the people, especially farmers and landowners are already motivated to take responsibility for managing irrigation projects, and are also ready to take over full responsibility for managing and maintaining the irrigation projects.

On the other hand, highly centralised management system of the Government of Bangladesh (GoB), contributed to the bottlenecks of efficient management of the projects by the community users/ beneficiaries. The net result is that neither the community nor the officials concerned are very effective in an irrigation water management that satisfies the communities' needs and demands. The community does not view any such project as their own asset, and bears no responsibility for operation and management.

In the study area (Pabna Irrigation Project), there are 365 WMG of which only two have been registered with the government. However, it was disclosed that the rate for use of water has not yet been fixed. Methods of charging fees for irrigation water currently is area based, i.e. the fee is based on total area under irrigation. Although no official water user fee has as yet been determined, unofficially the farmers are paying Tk. 540 per ha to the WMG. The charges are still collected by the BWDB extension overseers.

The representatives of WMG/WMAs suggested that the role of BWDB should be limited to technical aspects only, meaning smooth operation of the irrigation channels up to secondary levels. The decision of priority channels receiving irrigation water should be left with the WMG/WMAs.

NGOs/Community Level Self-help Groups

The NGOs/Community level self-help groups available at the local level are playing the role of facilitating /supporting role for beneficiary mobilization concerning participatory water management. The NGOs are already rendering assistance in respect of assessment of negative impact to PAP and identifying mitigation measures (Pabna Irrigation Project).

The NGO/community level elf-help Groups workers are carrying out social mobilization activities, either on contract or as per their interest, to ensure appropriate involvement and capacity development of the local stakeholders. They are also involved in the group formation for LCS, EMG and CMG.

Other Public Sector Agencies

The activities of a number of other public sector agencies have an impact on or are supplementary to the agencies directly involved in the water resource development activities. The main agencies are the Department of Agricultural Extension (DAE), Department of Fisheries (DOF), Forest Department (FD), Department of Environment (DOE), Department of co-operatives (DOC), Bangladesh Rural Development Board (BRDB), Department of Livestock services (DLS) and Ministry of Land (MOL) etc. The role of these agencies in relation to water sector interventions is to deliver services in their respective fields of activity within the participatory framework set out in these guidelines. These may include assisting WMOs, i.e. WMGs, WMAs and WMFs, in identifying problems and providing potential solutions.

The concerned implementing agency for the water resource development project will take the initiative to ensure necessary co-ordination and co-operation with the above public sector agencies.

For Sub-Project/Scheme up to 1000 ha

In such project/ sub-project/ scheme, there may be one or two WMOs as indicated below:

- WMG at the lowest level for each smallest hydrological unit or social unit (Para/Village)
- WMA at the apex level of the project/ sub-project/ scheme

For Project/Subproject/Scheme above 1000 ha and below 5000 ha.

The WMO for such project/ sub-project/ scheme may consist of two or three following levels:

- WMG at the lowest level for each smallest hydrological unit or social unit (Para/Village)
- WMA either at the mid-level for each sub-system of the project/ sub-project/ scheme or at the apex level for the project/ sub-project/ scheme

If necessary, WMF at the apex level of the project/ sub-project/ scheme in case WMA is formed at the mid-level for each sub-system.

For Project/ Sub-project/ scheme above 5000 ha

There will be the following three tiers of WMO:

- WMG at the lowest level for each smallest hydrological unit or social unit (Para/village)
- WMA at the mid level for each sub-system of the project/ sub-project/ scheme
- WMF at the apex level of the project/ sub-project/ scheme

Table 2.6.1. Guidelines for Participatory Water Management.

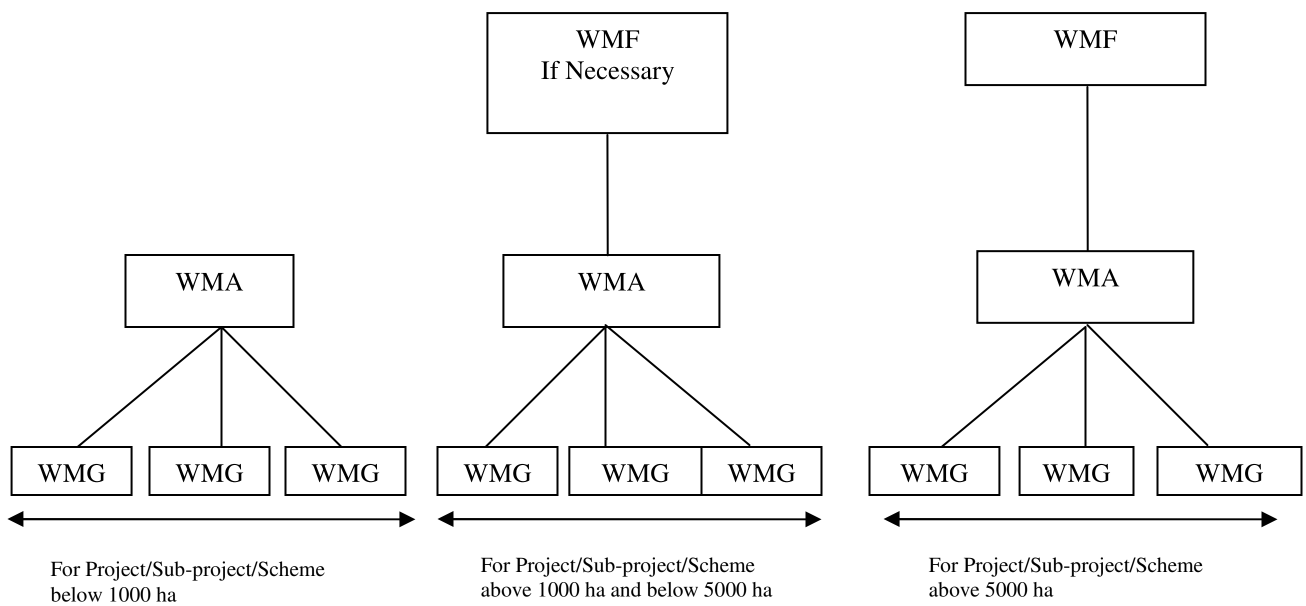

Table 2.2. Focus group discussion on Irrigation Management Transfer (IMT).

Categories of beneficiaries/ farmers	Number	Response
Large Farmers	15	Significant majority for IMT
Marginal/small farmers	11	Majority for IMT
Landless	10	Majority for IMT
Female Headed Households	7	Could not comprehend the concept of IMT

Focus Group Discussion with the Stakeholders at G-K Project.
*Not*e: Significant majority refers to 66 % and above of the responses.

2.7. PRO-POOR INTERVENTIONS IN IRRIGATION

Labour contracting societies (LCS), Embankment Maintenance Group (EMG), and Channel Maintenance Group (CMG) are the direct pro-poor interventions in the irrigated area/water management projects. The groups of various local NGOs and CBOs are eligible for registration as the third class contractors with the BWDB in any earthwork. Thirty percent of the earthwork is reserved for these groups.

Labour Contracting Society (LCS)

Labour Contracting Society (LCS), known as Landless Contracting Society under EIP, initially was formed in the EIP project areas. The main objectives of LCS activities are to provide employment and income-generating opportunities to the rural people, both men and women, ensure fair wage and achieve high quality of construction work.

At least 25 percent of the earthwork of any public water project/ sub-project/ scheme is supposed to be reserved for the LCS. The work would be offered to WMOs, which would carry out the actual work through the LCS. An agreement is usually signed between the implementing agency and the WMO and another agreement would be signed between WMO and the LCS. The landless male and female groups of BRDB and such groups formed by the NGOs would be included as LCS members. At least, 30 percent of LCS groups or 30 percent of LCS members are required to be women. LCS is supposed to be used in the earthwork and construction process. Due to the heavy nature of work, it was found physically not suitable for women. However, LCS does not exist in the study area (G-K and PIRDEP project). Both the study areas are old and there are no new constructions.

Preventive Maintenance of Water Management Structure

Preventive maintenance of embankments is an integrated component of O&M and aims at maintaining their crests and slopes in optimal physical condition. Preventive maintenance is executed through Embankment Maintenance Group (EMG) throughout the year. Preventive maintenance also includes Canal Maintenance Group (CMG).

Embankment Maintenance Group (EMG)

Under preventive management, EMG includes following activities: repair of holes, rain cuts; other damages caused by cattle and humans; filling of rodent holes; cambering, clearing of bushes, trees, weeds and other aquatic and non-aquatic vegetation; and fine dressing and turfing. Preventive maintenance also includes daily vigilance. EMG members are paid for working days only, i.e. 6 days per week. They are not paid for public holidays during which they do not work.

BWDB is responsible for the selection of an embankment reach to be assigned to an EMG for preventive maintenance. The activities involved are suitable to female labourers, and therefore, the implementation of preventive maintenance provides an opportunity for women belonging to the poorest of the rural poor. Therefore, while the main objective of EMGs is to ensure preventive maintenance, it also needs to be appreciated as a strategy to support poor women's socio-economic development.

BWDB is responsible for assessing the size of the EMG required for ensuring preventive maintenance of a specific site. The size of EMG is usually defined by the following rules:[11]

Type of embankment	Preventive Maintenance Capacity of one EMG Member (in Metre/ year)
A. Sea facing embankment	650
B. Major embankment	700
C. Normal embankment	750
D. Marginal embankment	1,150
E. Minor embankment	1,600

BWDB is responsible for appointing one of its staff members for monitoring the non-technical aspects of the EMG program. BWDB is responsible to identify a suitable Affiliated Agency (AA: BRDB or NGO) for supporting the implementation of the EMG program.

Channel Maintenance Group (CMG)

CMG also follows the similar guidelines as EMG. A certain portion of main and secondary canals would be maintained by a women's group facilitated through an AA.

The AA is in charge of the recruitment of female labourers willing and capable of engaging themselves in an EMG/CMG for a period not shorter than six months. Priority would be given to Female Headed Households (FHH). The EMG candidates would be selected in conformity with the guidelines.

In Pabna Irrigation Project, Channel Maintenance Groups (CMG), a pro-poor intervention of irrigation and water management project, are in place. In the G-K Project,Embankment Maintenance Group (EMG) mainly formed by women, is in place. Both the groups are working successfully with the assistance of local NGOs (AA). EMG is the most successful pro-poor intervention in other water management projects as well. In both study areas, the majority members of both EMG and CMG are vulnerable women. Women are using the slopes of the canals and the embankments to harvest vegetables and thereby adding extra income.

In terms of increased production through increased irrigated area, the project can be termed as very successful. In Pabna Irrgation Project alone, approximately 9000 ha of land have been brought under irrigation in place of 1000 ha prior to the irrigation project..

Access to credit for agricultural inputs are the Krishi Bank and the Krishak Samabaya Samity (KSS). Only large farmers have access to the Bank as they are able to offer collateral but the small and marginal farmers can have access only to KSS. Ironically, often loan defaulters from the bank are exempted but the defaulters of KSS are not exempted if the marginal and small farmers are unable to pay off their debts.

In more matured irrigation projects such as G-K Irrigation Project, the beneficiaries are more aware and more active than the new projects. The FGD with the President, Secretary and Treasurer of the WUA revealed that the unofficial price of irrigation water is much more cost-effective than the operation of DTW or STW. Due to increased fuel price, the cost of irrigation per ha of land with STW is

[11] Guidelines for the Implementation of Preventive Maintenance through Embankment Maintenance Groups: March 1995: BWDB Systems Rehabilitation Project (SRP).

Tk. 750.00, which is much higher than the unofficial rate of Tk. 540.00 per ha. Due to increased cost of production, it becomes difficult for the farmers to market the products profitably. Therefore, lack of irrigation water by the surface channel affects not only the volume of agricultural production but also the existing poverty situation. So far, irrigation projects constructed by BWDB are still considered to be more cost effective for the farmers and agricultural production.

Participatory Irrigation Management (PIM)

Community participation in irrigation management is very important to ensure the community ownership of any irrigation project. O&M, tax collection, training etc. are not possible without Participatory Irrigation Management by the community. Although there is always a danger of domination by those locally influential in irrigation water management, still community's involvement in management of the project that is targeted for their benefits will make O&M more sustainable at the grass root level. The FGD with the various stakeholders reflects that the beneficiaries would prefer to manage irrigation channels instead of any public implementing agency. The FGD with the local influential (Table 2.7.1) clearly demonstrates that if the irrigation channels are handed over to the beneficiaries (WMG) in perfect running condition, the community is capable of decision making on irrigation water. Participatory Irrigation Management (PIM) will require assistance of the law enforcement agencies in case of any defaulters. They would prefer collection of taxes not by the extension overseers of BWDB but by the designated members of the WMGs. It will create a fund to maintain the irrigation components and that in turn will result in better management and to some extend support to poor. The existing Chasi Club is not functional any more. For PIM, the stakeholders suggested that the following support is required: (a) Water tax should be collected by the WMG/WMA; (b) Assistance of law enforcement agencies; (c) O&M training by the officials of BWDB; (d) More grassroot government workers, such as extension overseers are required for smooth transition of management; (e) More demonstration and knowledge about Crop Diversification by the workers of the Directorate of Agricultural Extension (DAE) for increased and varieties of crop production; and (f) Ownership of the irrigation channels should be handed over to the community representatives.

Table 2.7.1. FGD with the Local Elite and Office Bearers of the WMG/WMA.

Questions	Number of Respondents	Response
Water tax should be collected by the WMG/WMA	15	Significant majority
Role of Law Enforcement Agency in collection of water tax should be integrated	20	Significant majority
Training need on O&M to the community member	20	Significant majority
Ownership of the irrigation channels should be with community	15	Simple majority
Irrigation has benefited the landless/marginal farmer and other disadvantaged groups	12	50:50
Future role of BWDB should be only of technical Assistance not managerial	12	Significant majority
What is the capacity of marginal and small farmers To pay water taxes	15	Majority believe that the marginal and small farmers are capable of paying water taxes.

Source: Focus Group Discussion with the Stakeholders at G-K Project.
Note: Significant majority refers to 66 % or above of the responses.

2.8. COST RECOVERY

No detailed cost recovery procedure has yet been finalised under the two sample project areas. However, a recommendation is appended for further discussion and improvement in the project areas.

For example, if the cost of the irrigation pump in the previous year during irrigation season in PIRDEP project was Tk. 4,300,000.00 and the irrigated area was 10,500 ha, the FWMA suggested an irrigation fee for 100 percent cost recovery.

• Water fee	80%
• Service fee WMG	15%
• Service fee Joint. Committee	3%
• Service fee WMA	1.5%
• Service fee FWMA	0.5%
Total Irrigation Fee	100%[12]

[12] Operation and Maintenance Procedure for Pabna Irrigation and Rural Development Project by the Ministry of Water Resources and the Asian Development Bank, April 1999.

2.9. CONCLUSION AND RECOMMENDATIONS

Over the years, irrigated agriculture expanded rapidly in Bangladesh. The past achievements in crop production rested on irrigation development. Poverty reduction efforts in Bangladesh emphasized raising productivity and incomes of the rural population. In these efforts, rapid improvements in agricultural production—food grain production in particular through expanded irrigation and water management played a crucial role.

The water management institutions in Bangladesh, covering both rural and urban, irrigation and flood control, along with urban water management system did play an important role in the Green Revolution in Bangladesh. However, the top tier in water management policy (WARPO) is yet to eliminate the overlapping roles of the water management institutions. In view of scarce resources, roles, responsibilities and functions of water management institutions should be well coordinated and optimal use of resources should be ensured.

Another important aspect should be kept in mind i.e. water management related policies, planning of projects etc. should prioritize poverty alleviation as one of the major objectives. Community and people participation in water management should take up the front seat in the process of planning, implementation and operation and maintenance. More decentralization and more coordinated intersectoral linkages of various water management institutions, will not only reduce the income gap, but will also address poverty alleviation.

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Part — 3

Poverty in Irrigation Systems - An Analysis for Strategic Interventions

PART 3

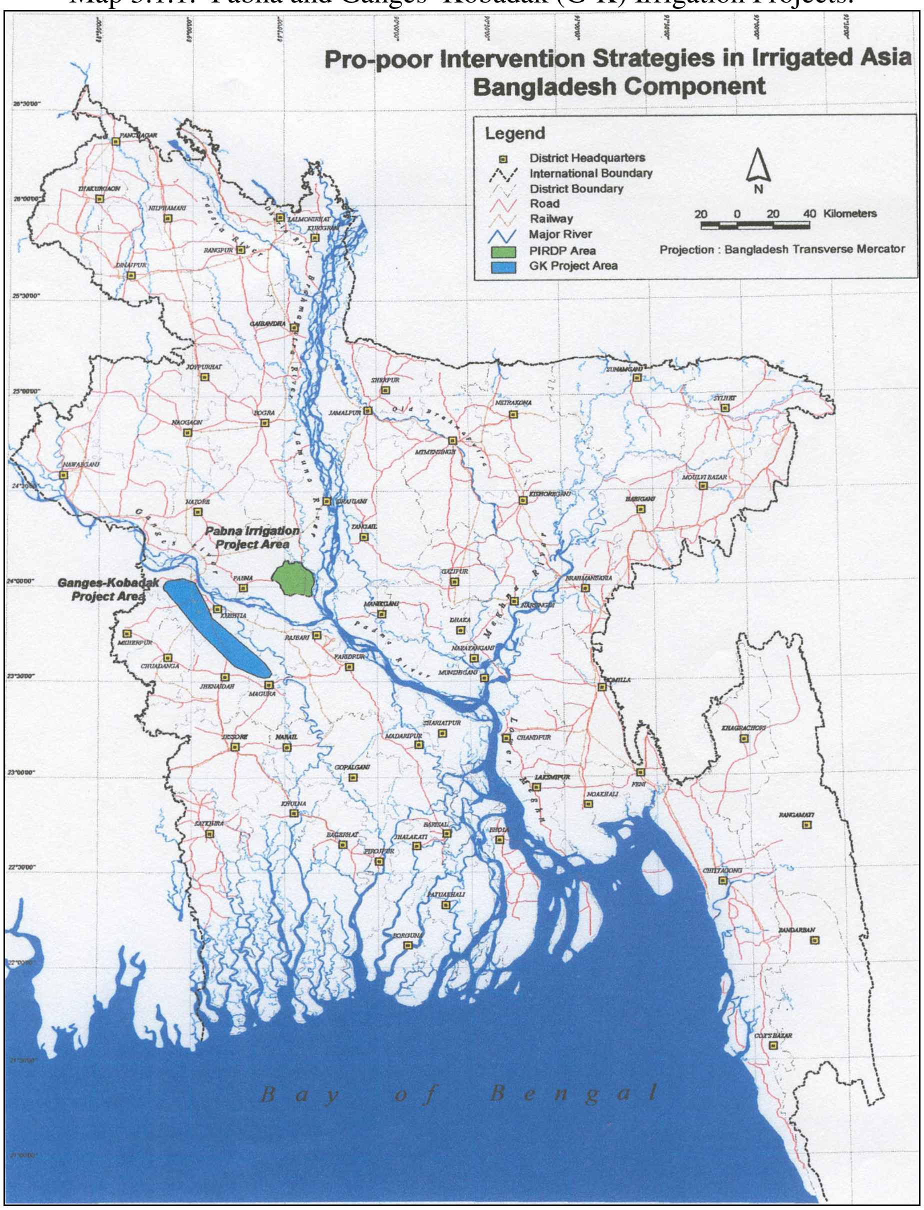
3.1. STUDY SETTINGS AND DATA

3.1.1. Description of the Study Areas

Introduction

Two projects namely (i) Ganges–Kobadak (G-K) Irrigation Project and (ii) Pabna Irrigation and Rural Development Project (PIRDP) were selected for the study (Map 3.1.1). A brief description of each project is given below.

Map 3.1.1. Pabna and Ganges–Kobadak (G-K) Irrigation Projects.



The G-K project was conceived in the early fifties and it was the first major step in the country to provide flood control facilities and supplementary irrigation to the traditional paddy varieties grown in the area. Built on the river Ganges it is the largest lift-cum gravity irrigation project in Bangladesh. The construction work of the project was started in 1955/56. The first and second phases of the project were completed in 1969 and 1984, respectively. Initial plan was to build a pumping plant consisting of three large pumps, each having a capacity of 36.8 cumec. But as the major pump house construction was delayed, a supplementary pumping plant consisting of 12 pumps each having a capacity of 3.54 cumec was constructed and limited irrigation was started in 1962 with these 12 pumps. The construction of the main pumping plant was completed in 1969. In addition to the pump houses, physical work of the project included approximately 1600 km of canals to distribute water through 2,184 hydraulic structures to the field outlets. Water is distributed through three main canals, more than 49 secondary canals and 444 tertiary canals. Although the entire command area of 125,000 ha can be brought under irrigation during the Kharif–II season (Monsoon), only 25,000 ha is presently irrigated during the dry season (Kharif-I). The farmers of the project area are now eager to grow irrigated HYV paddy both in Rabi and Kharif-I seasons. But due to shortage of water in the Ganges river and very low water level in the intake channel, all the main pumps cannot be operated. The system is shut down from November to March for annual maintenance. Presently farmers are installing shallow tube-wells for irrigation during the dry months, and switching to surface water as and when it is made available. In many places, there are occasional tubewell irrigation practices.

The Pabna Irrigation and Rural Development Project (PIRDP) was planned in late 1960s and was originally intended to provide flood control and drainage (FCD) facilities. Before implementation of the project, the area used to be flooded by the water flows from the Hurrasagar and Brahmaputra Rivers resulting in frequent crop damage. As the area was deeply flooded, only low yielding local variety of Broadcast Aus and long stem Aman paddy were the major crops. The BWDB initiated the PIRDP as early as 1968/1970. The Feasibility Report proposed to provide flood protection and drainage for 184,000 ha and irrigation facilities for 145,300 ha by:

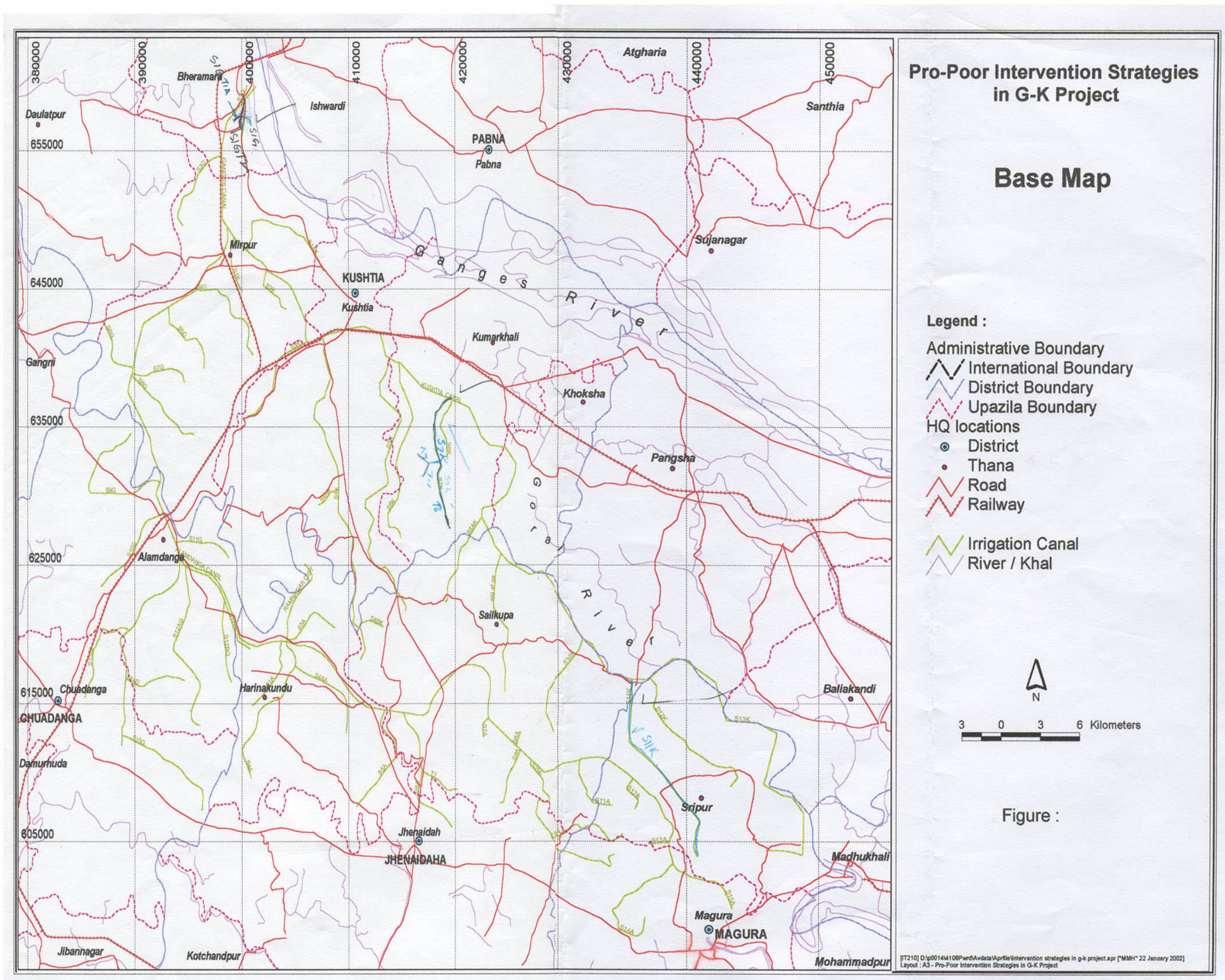
a. constructing 153 km of flood control embankments, with necessary outlet structures, excavation of 209.3 km of drainage channels with regulating structures
b. construction of 209.3 km of major irrigation channels with necessary central structures
c. construction of four large primary pumping stations

The phase–I of the project was started during 1970/71 and completed in 1992 to provide FCD facilities to the entire planned area, but only 21.862 ha were brought under irrigation. At present, command area development of the project is in progress under a separate loan from the Asian Development Bank (ADB).

Location

G-K. The G-K irrigation project (phase-I and phase-II) is located at the South Western part of Bangladesh in four districts, viz. Kushtia, Chuadanga, Jhenaidah and Magura (Map 3.1.2). It is situated between latitude $23^0$27' to $24^0$03' and longitude $88^0$47' and $89^0$30' and covers an area of 197,500 ha with population of two million. At present, the irrigated area is 142,000 ha (Table 3.1).

Map 3.1.2. Ganges–Kobadak (G-K) Irrigation Project.

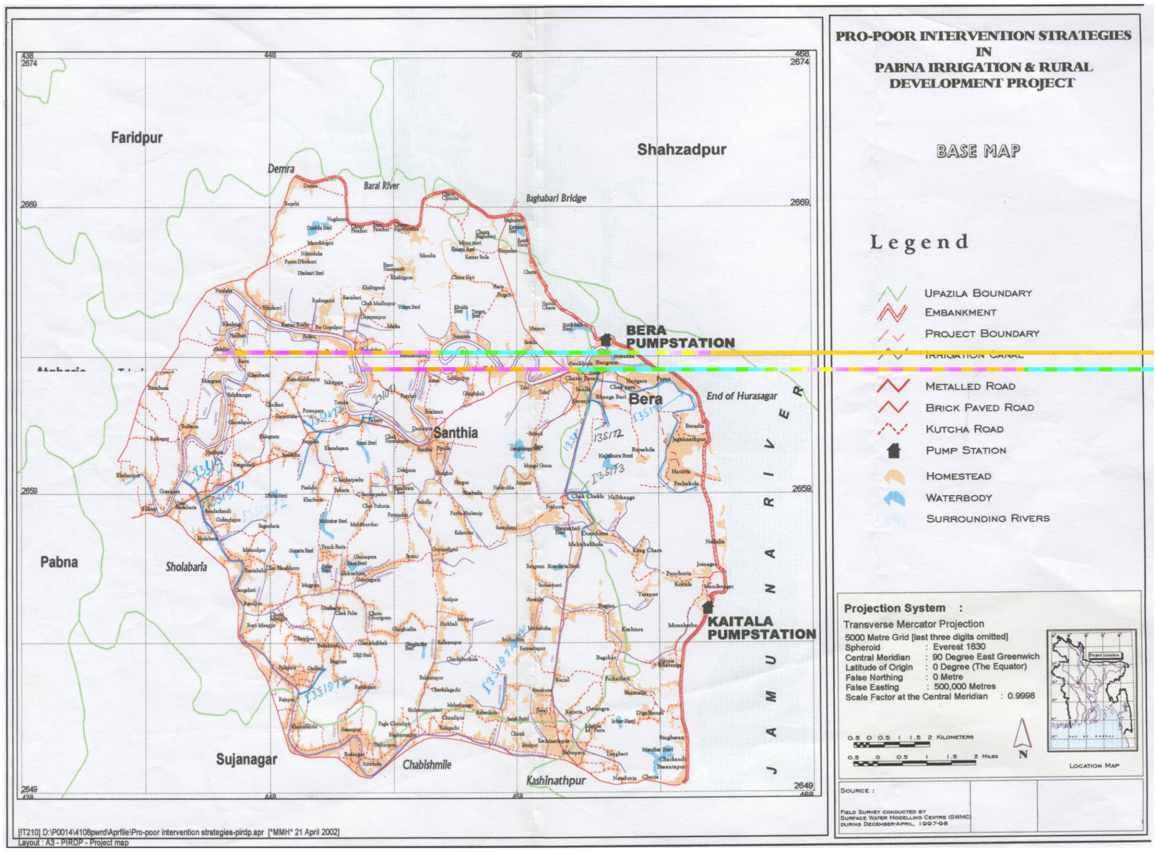


The G-K derives its water from the Ganges river. The project includes two major pumping plants, flood and drainage facilities and an irrigation distribution network comprising main, secondary and tertiary canals. Irrigation water is pumped from the Ganges river by a main pumping plant having three pumps of 35.8 cumec capacities and also by a subsidiary pumping plant having 12 pumps of 3.54 cumec capacity each. The main canals are about 193 km, secondary canals about 467 km and tertiary canals about 995 km in length.

Water from the river is pumped into the main canals. From the main canals water runs into secondary canals and from secondary into teriary canals from where farmers get water onto their land through field channels. The command area of a teriary canal is called a tertiary unit and receives water from a tertiary off-take. A tertiary unit is sub-divided into quaternary units called chaks, which vary in size from 25 to 40 ha. Chaks receive water from the tertiary canals through the outlet.

PIRDP. Located in the west-central part of the country, the project was originally planned to include Pabna, Serajgonj and Natore districts of Rajshahi Division. The phase-I included in this study is located in the Sauthia, Bera and Sujanagar upzilas of Pabna district near the confluence of the Ganges and Brahmaputra rivers (Map 3.1.3). The project area is situated between latitude 23^{0}57' to 24^{0}08' 30" and longitude 890^{0}25' to 89^{0}40' and covers an area of 186,000 ha with a population of 2.3 million. Currently, the irrigated area is 145,300 ha (Table 3.1).

Map 3.1.3. The Pabna Irrigation Project.



PIRDP derives its water from the Brahmaputra river through a pumping station at Bera. Water from the river is pumped into the main canal, which acts as a storage/reservoir canal. From the main canal water runs into the secondary canals and from secondary into tertiary canals from where farmers take water to their land through farm turnouts covering about 40 ha blocks.

Topography

G-K. The project area lies within the flood plain of the Ganges river. Prior to the implementation of the project, the low land used to be flooded by the Ganges. After the implementation of the project, the area has become flood free as a result of the embankment constructed on the north west corner and on the right bank of the Gorai river. The land elevation near Bheramara (where the main pumping plant is located) is 12.0m above MSL and slopes down to about 5.5m near Magura. Two other main rivers, namely, Kaliganga and Dakua flow from North to South near the center of the area. The Kuma river bifurcates the project area and the river Nabaganga is the southern peripheral river.

PIRDP. The project area lies within the floodplain of the Brahmaputra and Hurasagar rivers. Prior to the implementation of the project, most of the project area used to be flooded by flows of the Brahmaputra and Hurasagar. Now the project area is almost flood free due to an embankment on the southeast side on the bank of the river Brahmaputra and on the north and the west on the bank of the rivers Hurasagar and Baral. The land elevation varies from 12.0m above MSL near Sholabari and Tebaria on the west side of the project area and slopes down towards southwest to the low-lying areas where it is about 5m. The land elevation at Bera pump house is about 8m while at the Kaitula pump house it varies from 8m to 9m near the bank of the river Jamuna. The main river bordering the northwest boundary of the project is the Hurasagar. The other rivers are Ichamati and Kaitula.

Climate and Hydrology

G-K. A typical monsoon climate prevails in both the project areas. Average annual rainfall in the G-K project area is about 1500 mm, of which about 70 percent occurs during mid-June through mid October. The period from November to March is largely dry. Maximum temperatures vary from about 28^0C to 36^0C with the highest temperature experienced during the period March to June. There is a significant diurnal fluctuation with minimum temperatures ranging from about 10^0C to 23^0C. Relative humidity is high throughout the year with an average of more than 70 percent. Potential evapotranspiration ranges from about 2.55 mm/day in December to about 5.5 mm/day during pre-monsoon month in May.

PIRDP. Average annual rainfall in the PIRDP is about 1470 mm, of which about 77 percent occurs during mid-June through mid October. Just as in G-K, the period from November to March is largely dry. Maximum temperatures vary from about 33.4^0C to 36.3^0C with the highest temperature experienced during March-June. There is a significant diurnal fluctuation with minimum temperatures ranging from about 11.5^0C to 26.2^0C. Potential evapotranspiration ranges from about 2.63 mm/day in December to about 5.85 mm/day during the pre-monsoon month of May.

Agricultural Practices

G-K. Paddy is the dominant crop occupying about 70 percent of the total cropped area. Pulses, oil seeds, tobacco, jute, sugarcane, onion and wheat are other important crops. In irrigated areas, mostly high yielding varieties (HYV) of paddy are grown. At present, about 93,000 ha benefits from supplemental irrigation during Kharif-II season (mid July to mid November) against a targeted area of 125,000 ha, while about 25,000 ha are irrigated during the Kharif-I season (March to June) due to scarcity of water at the source (the Ganges river). The average paddy yield ranges from 3.2 metric ton/ha to 4.0 metric ton/ha for transplanted HYV. The yield for transplanted local varieties is about 2.5 mt.

PIRDP. Paddy is also the dominant crop in PIRDP occupying about 64 percent of the total cropped area. Pulses, potato, vegetables and oil seeds, jute, sugarcane, onion and wheat are other important crops. In irrigated areas, mostly high yielding varieties (HYV) of paddy are grown. At present, about 10,182 ha benefit from irrigation during Rabi Season (November to May) against a targeted area of 10,382 ha while about 26,015 ha are irrigated during the Kharif-II season (July to October).

Water Management and Water Allocation System

G-K. Overall management of irrigation including delivery of water to the main canal system is the responsibility of the Bangladesh Water Development Board (BWDB). Management of water at the field level is the responsibility of water management organizations, viz. water management groups (WMGs) at the chak level and water management associations (WMAs) at tertiary level. As the G-K system is deficient in water in relation to the total needs of the farmers within its command area, a ten-day rotation (with 5 days of flow, followed by 5 days off) is being followed throughout the system. For this, the whole system has been divided into two sections. Farmers serviced by a tertiary canal fix up their own rotation in respect of their outlets for a flow period of 5 days.

PIRDP. As in G-K, BWDB is responsible for the overall water management at the system level, including delivery of water at the system level. The amount of water to be pumped is according to the demand placed by the project water management officials of BWDB on the basis of the field requirement. The water level in the main canal is to be maintained according to the design level by different water structures such as regulator, siphon, aqueduct and drop structures. But in practice, often this does not happen.

WMGs at the farm turnout level and WMAs at the tertiary level play key management roles at the field level. As the main canal is of reservoir type, full supply level is maintained throughout the canal length and, unlike G-K, the rotational system of irrigation is not required in PIRDP.

Table 3.1.1. Main Features of G-K and PIRDP.

Main features	G-K	PIRDP
Project area (ha)	197,500	186,000
Population (million)	2	2.3
Irrigable area (ha)	142,000	145,300
Pump house (nos)	2	2
Pumping capacity (cumec)	153	107.7 cumec
No. of main canals (km)	3	1
Length of main canals (km)	193	42.28
No. of secondary canals	49	19
Length of secondary canals (km)	467	90.89
No. of tertiary canals	444	65
Length of tertiary canals (km)	995	84.22
Total no. of outlet	3,500	524
Length of drainage canals (km)	971	104.24
Length of flood control embankment (km)	39	157.55
WMA (nos.)	324	6

Source: Bangladesh Water Development Board (BWDB).

3.1.2. Study Approach and Methodology

The main research focus is at the irrigation system and household levels. But the relevant macro aspects and procedural issues are also considered. The study seeks to analyze poverty and assess irrigation performance, constraints and opportunities, and institutional interventions.

The study is based on both primary and secondary data and information. Five main sources have been tapped for necessary data and information. These are:

- Participatory rural appraisals (PRAs)
- Key stakeholder interviews/consultations
- Household surveys
- Primary measurements, for example, water productivity measurements
- Secondary sources, including government publications, research studies, and project reports and documents

Selection of the Canals, Villages, Households in G-K and PIRDP

Selection of Canals

G-K. Three secondary canals (S_1G, S_7K and $S_{11}K$) were selected according to the location of the canals at head, middle and tail reaches of the G-K system. Three tertiary canals for each selected secondary canal were picked according to the three stratified locations of the tertiaries of each secondary as follows:

For S_1G: T_1A, T_2, T_3A at head, middle and tail, respectively
For S_7K: T_1, T_3, T_6 at head, middle and tail, respectively, and
For $S_{11}K$: T_1, T_6, T_{10} at head, middle and tail , respectively

PIRDP. Three secondary canals (I_3S_1, I_3S_{10}, I_3S_{19}) were selected according to the location of the canals at head, middle and tail reaches of the Pabna project system.

Three tertiary canals for each selected secondary canal were included according to the three stratified locations of the tertiaries of each secondary as follows:

For I_3S_1: T_1, T_2, T_3 at head, middle and tail, respectively
For I_3S_{10}: T_1, T_2, T_3 at head, middle and tail, respectively, and
For I_3S_{19}: T_1, T_7, $T_{14}M_1$ at head, middle and tail, respectively

The cropping patterns, access to water and irrigation infrastructure are almost similar in both the systems. chawkbandi maps and schedules were excellent sources of necessary information and were helpful in the selection of sample households.

Villages under the Selected Canals

G-K. A total of 41 villages were identified at head, middle, and tail reaches of the selected canals. More specifically, at the head of the selected secondary canal (S_1G), 21 villages were identified and the survey households were randomly picked from those villages. Similarly, under secondary canals at the middle (S_7K) and the tail ($S_{11}K$), 14 and 6 villages were identified, respectively for household level surveys.

Name of tertiary	Names of villages/mouzas of households surveyed
<u>Head</u>	
$S_1G\ T_1A$	[Sholadag], [Bheramara], Farakpur, Chardamukdia, {Ramkrishnapur}, Shahebnagar, {Baramail}, Collegepara
$S_1G\ T_2$	Baradag, [Sholadag], Pakuria, Ruppur, [Bheramara], {Nawdapara}, {Chandgram}, {Baramail}, {West Bahirchar}, {Chandipur}, Khadimpur, {Baradi}, {Kharara}
$S_1G\ T_3A$	[Bheramara], {Nawdapara}, [Sholadag], {Chandgram}, Damukdia, {Chandipur}, Charkapur, {West Bahirchar}, {Ramkrishnapur}, Majhpara, {Kharara}, {Baradi}
<u>Middle</u>	
$S_7K\ T_1$	Dharmapara, Bharra, Durgapur, Chapra, Madhupur, Bawlat
$S_7K\ T_3$	Sheikhpara, Natiria
$S_7K\ T_6$	Khagrabaria, Gobra, Ramchandrapur, Anandanagar, Brittidevirajnagar, Kacherkona
<u>Tail</u>	
$S_{11}K\ T_1$ $S_{11}K\ T_6$ $S_{11}K\ T_{10}$	[Chandrapara], [Sreepur], [Hogoldanga], [Madanpur], [Bkhna], [Sonaikandi]

[ ] indicates that the village is under all three tertiaries
{ } indicates that the village is under two tertiaries

PIRDP. 29 villages were identified at the head, middle, and tail reaches of the selected canals. More specifically, at the head of the selected secondary canal (I_3S_1), 9 villages were identified and the survey households were randomly selected from those villages. Similarly, under secondary canals at the middle (I_3S_{10}) and tail (I_3S_{19}), 10 villages in each location were identified for household level surveys.

Name of tertiary	Names of villages/mouzas surveyed
<u>Head</u>	
$I_3S_1T_1$	{Bangabari}, Hatigara, Painateghri, Teghrishanonda, Haturia, {Boroshila}, Shalpaboroshila
$I_3S_1T_2$	Jordha, {Bangabari}, {Boroshila}
$I_3S_1T_3$	Chakchakla
<u>Middle</u>	
$I_3S_{10}T_1$	Nandanpur, Krishnapur, Shibrampur, Devgram
$I_3S_{10}T_2$	Tetulia, Darmuda, {Shandaha}, Ramchandrapur, {Joragacha}
$I_3S_{10}T_3$	{Joragacha}, {Shandaha}, Piadaha

Name of tertiary	Names of villages/mouzas surveyed
Tail	
$I_3S_{19}T_1$	Hatbaria, Gobindapur, Sundarkandi, Khapur
$I_3S_{19}T_7$	Gadhuli, Hasanpur, Khetupara, Bishnupur
$I_3S_{19}T_{14}M_1$	Kabarikhola, Chatokborat

{ } indicates that the village is under two tertiaries

A comprehensive household level survey questionnaire was used to obtain field data on irrigation, productivity, poverty and other related issues, from both G-K and PIRDP projects. The questionnaire is divided into four modules that include a basic information module, an agricultural module, an income and expenditure module, and a credit module. The questionnaire was administered to randomly selected 450 sample households in the aforesaid locations, following a single stage random sampling method. Since the area under each part of the system (head/middle/tail) was not large, the single stage stratified sampling method was used to select the sample households for conducting household level surveys in both the project areas.

Selection of Households

There are households in the irrigated areas which own land and there are others who are landless. Landowning households are divided into small (owning 0.2 ha to 1 ha or 0.5 acre to 2.49 acre), medium (1 ha to 3 ha or 2.49 acres to 7.49 acres), and large (3 ha+ or 7.50 acres+) farmers. A landless household is defined to include those households owning up to 0.2 ha or 0.5 acre. All these categories of households in the irrigated areas are included in the sample in predetermined numbers. From the rain-fed areas, however, only landowning households of a predetermined number have been included.

The following steps were undertaken to prepare the sample frame.

- Maps of the chawkbandi areas under all the selected tertiaries were collected
- Mouza maps with reference to the chawkbandi, and the related list of villages which include most recent household numbers and population were selected
- Up-to-date list of heads of households for each chawkbandi collected from the project offices
- Total number of households in each of the tertiary was divided by 50 (arbitrarily chosen) to obtain a fixed interval for selecting households. If the head of a selected household is either absent or does not fit the landholding status, the survey team moved on to the next household to be included for substitution. Following this procedure, households were picked from each tertiary in required numbers in each category, as indicated below.
- 450 (9x50) sample households in G-K as also in PIRDP were surveyed in the three selected tertiaries in each project area, including households from the selected rain-fed areas. The broad distribution of households in the command area of each tertiary is as follows.

Landowning households in the secondary system	:	106-108
Landless household in the secondary system	:	21-22
Landowning households in the rain-fed areas	:	21-22
Total	**:**	**150**

Participatory Rural Appraisal (PRA)

Among various tools of Participatory Rural Appraisal (PRA), three were used for conducting the PRAs. The tools are (i) open meetings (ii) focus group discussions (FGD) and (iii) stakeholders interviews. These three tools were used in each location on three different days. In G-K, the selected areas under three secondary canals—viz. S_1GT_2 at head, S_7KT_3 at middle, $S_{11}KT_6$ at tail—were the West Bahirchar, Bharra and Sreepur villages, respectively. For PIRDP, the selected areas under the three secondary canals— viz. $I_3S_1T_1$ at head, $I_3S_{10}T_2$ at middle, $I_3S_{19}T_{14}M_1$ at tail—were Hatigara, Tetulia and Kabarikhola, respectively.

Open meetings, arranged in advance, were conducted, which were participated by local people including farmers, non-farm operators, poor, distressed women, journalists, teachers, members of the Union Parishad, and others concerned. Each session was conducted by PRA facilitators in the presence of the chairperson of the WMA under the secondary canal.

The focus group discussions (FGD) were conducted through semi-structured interviews with the participation of both male and female local elites, small and medium entrepreneurs, local *upazila parisad* representatives, local *tahshilders*, *patwaries*/water rate collectors.

Stakeholders were interviewed using semi-structured questionnaires. The interviews were conducted with the owners of Shallow Tubewell (STW) & Deep Tubewell (DTW), public representatives such as *upazila parishad* chairmen and presidents of WMAs.

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3.2. POVERTY IN IRRIGATED AGRICULTURE: SPATIAL DIMENSIONS

Two approaches were used to define poverty and the poor households in the study areas: (a) Income approach: This defines a poverty line in terms of income. If the income of a family is below that level, it is officially regarded as living in poverty; (b) Entitlement approach: This defines poverty as non-availability of services and facilities required for secure and sustainable livelihoods of a family.

These approaches have relevance to the agricultural economy in seeking to understand the poverty situation in the sector, given the recent trends in the expansion of irrigation, adoption of modern varieties, etc., according to the farm-size brackets (particularly for marginal and small farm-households). In view of the design of the research, poverty as a result of lack of access to equitable distribution of irrigation water in a public and large-scale surface water irrigation project can be functionally linked with the income level, entitlements to public services and facilities, and land-ownership status.

It may be relevant here to mention that the earlier prognosis that modern technology would bypass small and marginal farmers (Griffin, 1974; Pears, 1980) has not been established by recent empirical studies (Mandal, 1980; Hossain et al., 2002). The benefits of irrigated agriculture employing modern technologies have been found to actually involve those small farm size-groups more than the larger farm size-groups. The intensity of irrigation (particularly of minor irrigation) and the rate of adoption of HYV rice have been greater for the small and marginal farmers.

The farm households are divided into the following categories:

Table 3.2.1. Farm Size Classification.

Size of land-ownership (ha)	Categories of farm households
Less than 0.20	Landless
0.20 – 0.50	Marginal
0.50 – 1.00	Small
1.01 – 3.00	Medium
3.01 and above	Large

Poverty in Rain-fed and Irrigated Areas

Landownership and Landlessness

Household surveys conducted in the two project areas reveal patterns of landownership and landlessness as reported in Table 1.2. In the rain-fed area, 10 percent of the large landowning households own about 63 percent of the total land in G-K, and in PIRDP, 12 percent hold 50 percent of the total land. The situation is different for irrigated areas both in G-K and PIRDP. Only 4 percent of the large landowning households own 43 percent of the total land in G-K, and 10 percent of the large holders own 25 percent of the land in PIRDP. One feature of land ownership is common to both rain-fed and irrigated areas of G-K: the largest land holding group has the largest share of the total land area. In PIRDP, the largest land area belongs to the small landowning group in the rain-fed area and to the medium landowning group in the irrigated area.

The asymmetry in the distribution of land among various size-groups is represented by Lorenz Curves in Figures 3.2.1 and 3.2.2. for G-K, and in Figures 3.2.3. and 3.2.4. for PIRDP. Skewed land ownership is common everywhere: rain-fed and irrigated in G-K and PIRDP. The relative degree of skewness is more in the rain-fed area than in the irrigated area. It implies that the distribution of land among various holding size groups has improved due to the intervention of the irrigation project in both the areas. Investment in irrigation has been an important means of enabling small and marginal farmers to resist vulnerability and sale of land in distress. Land transfer from relatively poorer households to richer ones has not occurred much in the areas under the two irrigation projects.

Data collected also show that about 81 percent of the landless households are non-farming in the PIRDP and about 100 percent in the G-K project areas. About 14 percent of the landless households (owning less than 0.20 ha.) in PIRDP own 8 percent of the total irrigated land, while in G-K, 16 percent representing the category own 4 percent of the total irrigated land (Tables 3.2.2 and 3.2.3)

Table 3.2.2. G-K System: Distribution of Land-ownership, Irrigated and Rain-fed Areas.

Size of landownership (ha)	% of households		Share of land owned (%)	
	In the rain-fed area	In the irrigated area	In the rain-fed area	In the irrigated area
Less than 0.20	14	16	2	4
0.20 – 0.50	46	28	17	11
0.50 – 1.00	30	27	18	10
1.01 – 3.00	9	27	25	32
3.01 and above	1	2	38	43
Total	100	100	100	100

Table 3.2.3. PIRDP System: Distribution of Land-ownership, Irrigated and Rain-fed Areas.

Size of landownership (ha)	% of households		Share of land owned (%)	
	In the rain-fed area	In the irrigated area	In the rain-fed area	In the irrigated area
Less than 0.20	23	14	2	8
0.20 – 0.50	30	22	8	12
0.50 – 1.00	35	42	40	25
1.01 – 3.00	10	16	38	30
3.01 and above	2	6	12	25
Total	100	100	100	100

Figure 3.2.1. G-K: Lorenz Curve Showing Distribution of Land in Rain-fed Areas.

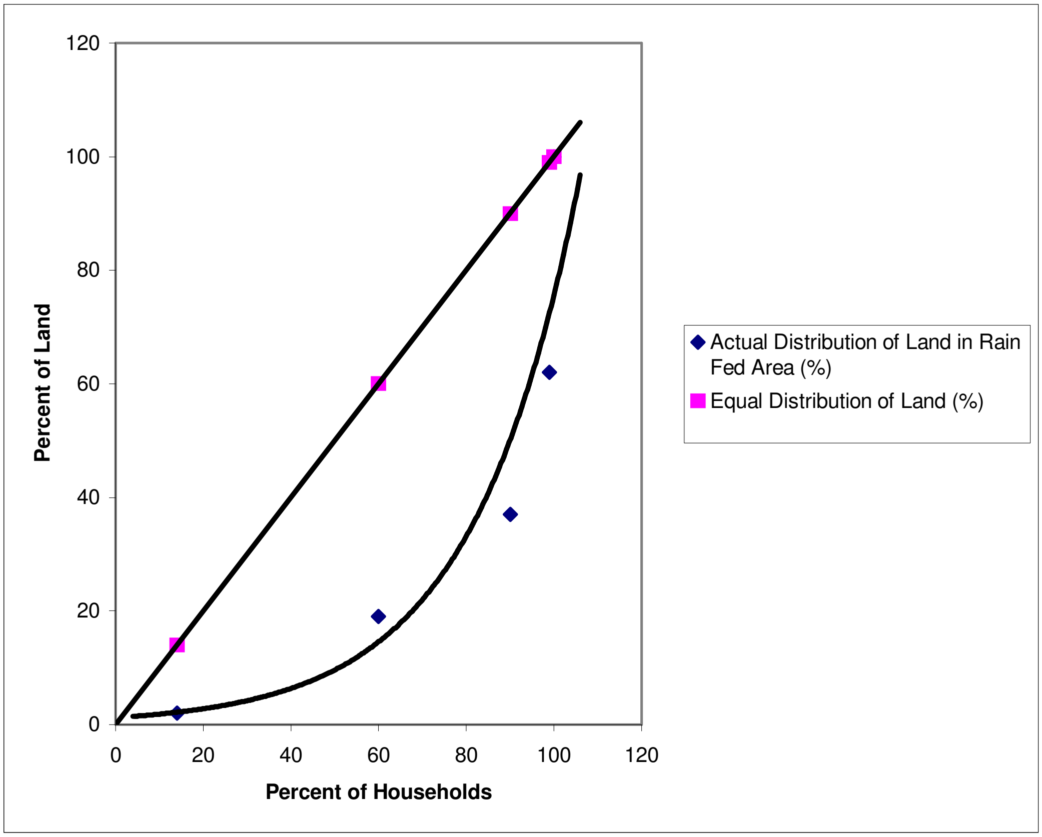


Figure 3.2.2. G-K Lorenz Curve Showing Distribution of Land in Irrigated Areas.

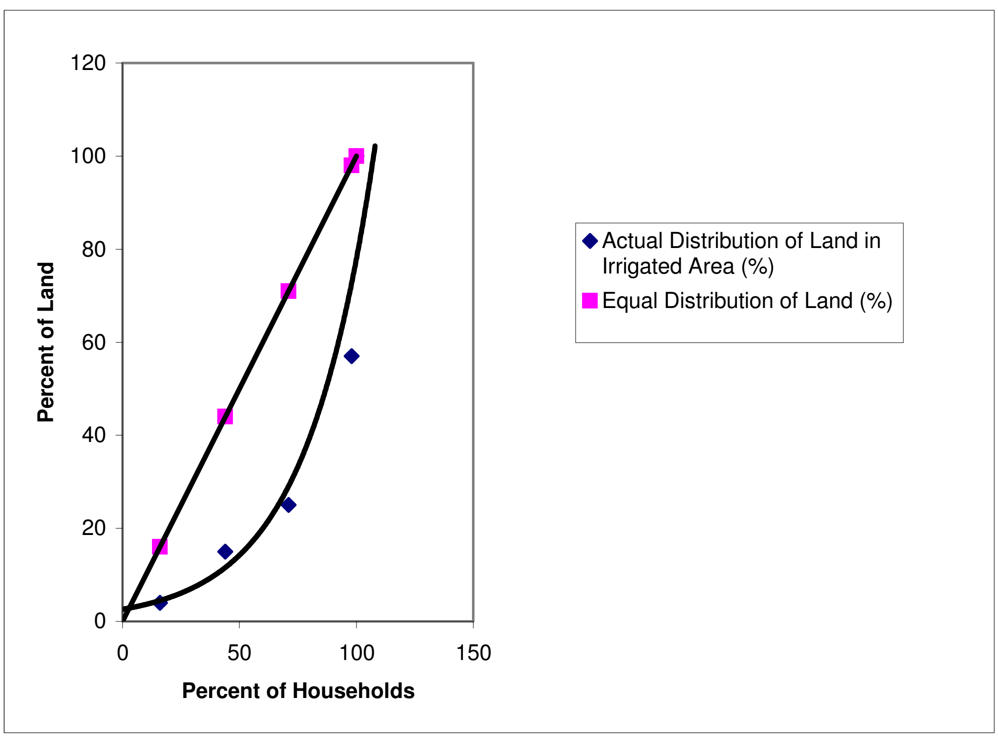


Figure 3.2.3. PIRDP: Lorenz Curve Showing Distribution of Land in Rain-fed Areas.

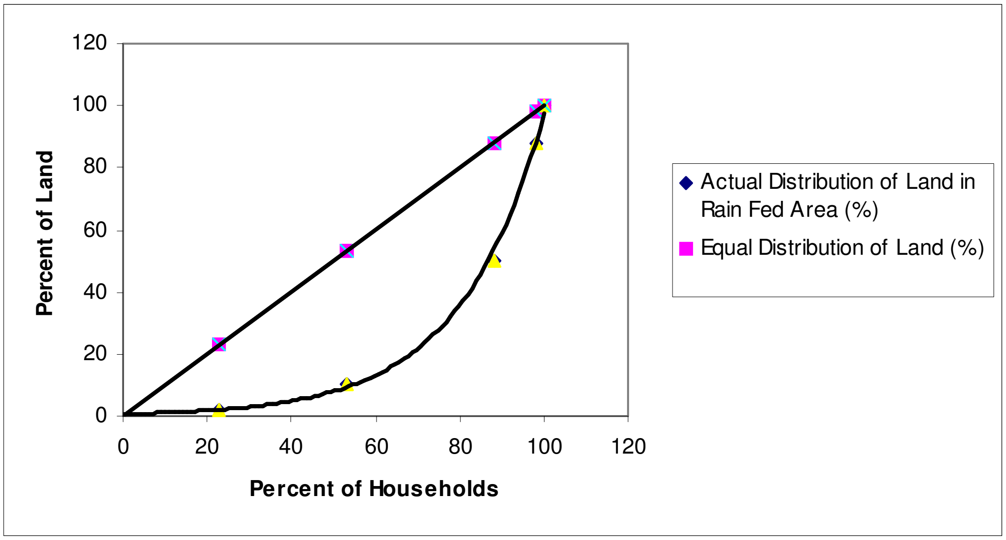
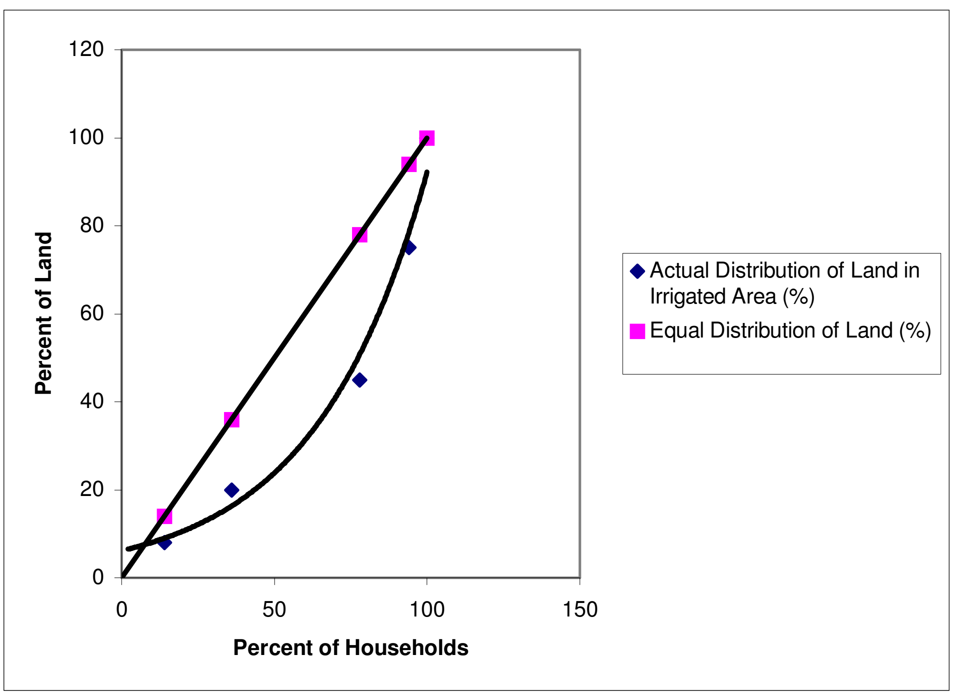


Figure 3.2.4. PIRDP: Lorenz Curve Showing Distribution of Land in the Irrigated Areas.



Major Occupational Distribution of Households

Information obtained from the survey on the primary occupation of households in the study areas is presented in Table 3.2.4. In 2000/2001, about 85 percent of the households were found to be farming households and about 15 percent non-farming in PIRDP. In G-K, the percentages are about 82 and 18, respectively. In the rain-fed areas, the situation is different. Almost 100 percent of the households are farming in G-K and about 68 percent in PIRDP. It is learnt, from focus group discussions, that the people in PIRDP, who were initially employed as agricultural wage laborers, are increasingly seeking employment in local areas and elsewhere in the rural service sector including transport operation and repairing services, which exhibit very low productivity.

Table 3.2.4. Occupational Distribution of Landowning Households by Major Type.

Project	Irrigated					Rain-fed				
	Total	Farmer		Non-farmer		Total	Farmer		Non-farmer	
		No.	%	No.	%		No.	%	No.	%
G-K	384	316	82	68	18	66	66	100.00	-	-
PIRDP	418	356	85	62	15	34	23	68	5	15

Housing Condition

Household survey data on housing conditions in the irrigated and rain-fed areas under G-K and PIRDP are presented in Tables 3.2.5 and 3.2.6, respectively. Households with pucca houses are very few in both the irrigated areas (only 1.5 percent and 2.1 percent of the total households in G-K and PIRDP, respectively); and in the rain-fed areas, pucca houses are absent. Overall, the housing patterns in both PIRDP and G-K are similar in terms of housing materials used.

As for ownership, all large farm households and most small and medium farm households own their houses. The number of medium farm households who do not own their houses is very small (4 percent in G-K for S_1 canal and 14 percent and 5 percent in PIRDP for S_1 and S_{19} canals). In PIRDP, 5-10 percent of small farm households live in others' places; and in G-K, all small farm households own their houses.

In S_1 canal of G-K, about 27 percent of the landless households do not own their houses, but in other areas, all landless people have their own houses. In all the three canals (S_1, S_{10} and S_{19}) of PIRDP, 14 percent, 5 percent and 4 percent of the landless households do not own houses. It can be concluded that (a) Pucca houses are found only in the irrigated areas; (b) in G-K, kutcha houses are less prevalent in the irrigated areas than in the rain-fed areas, while kutcha/pucca houses are more prevalent in the irrigated areas than in the rain-fed areas; and (c) in PIRDP, the situation is the reverse. The percentage of households with kutcha houses is higher in the irrigated areas than in the rain-fed areas, while households living in kutcha/pucca houses are more prevalent in the rain-fed areas than in the irrigated areas. Thus, the impact of irrigation intervention on housing condition cannot be discerned clearly from the available data.

Table 3.2.5. Distribution of Households by Holding Size in the Irrigated Areas.

Project	Household size	Irrigated areas						
		Total household	Kutcha		Pucca		Kutcha/pucca	
			No	%	No	%	No	%
G-K	Large	37	3	8.1	4	10.81	30	81.1
	Medium	71	21	29.6	1	1.41	49	69.0
	Small	213	139	65.3		0.00	74	34.7
	Landless	63	59	93.7		0.00	4	6.4
	Total	384	222	58.0	5	1.5	157	40.5
PIRDP	Large	30	7	23.3	4	13.3	19	63.3
	Medium	50	24	48.0	2	4.0	24	48.0
	Small	280	172	61.4	2	0.7	106	37.9
	Landless	58	42	72.4	1	1.7	15	25.9
	Total	418	245	58.6	9	2.1	164	36.4

Table 3.2.6. Distribution of Households by Holding Size in the Rain-fed Areas.

Project	Household Type	Rain-fed areas						
		Total household	Kutcha		Pucca		Kutcha/pucca	
			No	%	No	%	No	%
G-K	Large	1					1	100
	Medium	6	3	50.0			3	50.0
	Small	50	38	76.0			12	24.0
	Landless	9	5	55.6	None		4	44.5
	Total	66	46	69.7			20	30.3
PIRDP	Large	2	2	100.0				
	Medium	1	1	100.0				
	Small	21	9	40.0			12	60.0
	Landless	10	2	20.0			8	80.0
	Total	34	14	41.2			20	58.8

Educational Status of Heads of Sample Households

The human capital content of the households, in terms of number of years of education of the heads of households, as revealed by survey data, is shown in Table 3.2.7.

Table 3.2.7. Educational Status of Heads of Sample Households in the Study Areas.

Project	Number of households	Years of education completed by heads of HHs (in %)				
		0	1-5	6-10	11 – 12	>12
G-K	450	29.3	30.0	31.0	6.4	3.1
PIRDP	452	44.7	24.1	21.7	7.7	2.9

Overall, the duration of schooling is somewhat better in G-K than in PIRDP. The G-K, being the oldest irrigation project in the country, the irrigation activities relating to irrigation groups, and associations and other institutions have been continuing for about 40 years. These activities have direct influence on farm families in terms of training in irrigation and other village development programs. Irrigation intervention is seen to have played a role in improving the educational level of the concerned households.

Disaggregated data show that educational levels achieved by the land-rich are relatively higher compared to the land-poor and the landless. The percentage of people completing longer years in schools is larger among large and medium farm households than that among the small-farm and the landless categories. Agrarian studies (e.g. Hossain et al., 2002) for Bangladesh have reported that the average years of schooling of heads of farm households and landless households increased from 1.8 to 2.2 for the landless and marginal landowners during 1988 and 2000. The figures for the same period are from 3.7 to 4.4 for small landowners and from 5.2 to 6.8 for medium and large landowners.

In view of this general improvement in schooling years, the net impact of irrigation in the two projects on years of schooling of household heads is positive, more so in the case of G-K.

Living Conditions

Household surveys have generated detailed information on a number of indicators that are generally used for defining livelihood conditions of the households. The major parameters considered are: ownership of dwelling houses, source of drinking water, types of latrine used, access to electricity as a source of energy and quality of fuel used for cooking.

Dwelling House: Housing conditions in the two study areas have been discussed earlier. A few comments are in order here. Almost all families own their dwelling houses. The practice of living in rented houses is practically non-existent. The four households in PIRDP, as recorded to have been living in houses on payment (Table 3.2.9), do not really rent houses on a monthly basis as the typical dwellers in urban areas do. The category “others” recorded in PIRDP represents a very low proportion. This category includes households living mostly in relatives’ houses or in temporary houses built on public lands.

Besides ownership, the materials used for construction of houses are also an important element for assessing levels of poverty. Most of the pucca households are found to have used brick and corrugated tin-sheets as materials, with concrete floor, but no concrete roof (Tables 3.2.5 and 3.2.6). Houses with concrete roof account for only 2.1 percent of all houses. But kutcha houses abound both in irrigated (58 percent) and rain-fed areas (60 percent).

It emerges from the above analysis that there is no clear relationship between house ownership and irrigation interventions. However, on the whole, the quality of houses is better in the irrigated areas than in the rain-fed areas.

Source of Drinking Water: Open well and hand tube-wells are the two major identifiable sources of drinking water in the rural areas of Bangladesh. Other sources include river or pond, deep or shallow tube-wells, rain, irrigation canals, khals, beels, baors, etc. It is found that hand tube-wells are the most popular sources, irrespective of irrigated or rain-fed areas. Other publicly owned open water bodies or private irrigation water sources stand second as the source of drinking water. Water from irrigation pumps is very limited and sometimes priced and, hence, often inaccessible to the poor households.

Finally, open wells are on the verge of extinction in rural Bangladesh. Information collected in this regard from the two project areas may be found in Tables 3.2.8 and 3.2.9.

Table 3.2.8. G-K: Livelihood Situation by Size of Holding; Access to Major Facilities.

Livelihood parameters	% of small farm HHs enjoying		% of medium farm HHs enjoying		% of large farm HHs enjoying		% of landless HHs enjoying	
	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated
Ownership of dwelling house:								
Owned	100.0	100.0	100.0	96.0	100.0	100.0	100.0	73.0
Rented	0	0	0	0	0	0	0	0
Others	0	0	0	4.0	0	0	0	27.0
Source of drinking water:								
Open well	0.2	0.1	0	0.1	0	0.1	45.0	3.0
Hand-pump	85.0	76.0	80.0	84.5	80.0	94.6	35.0	27.7
Others	15.0	24.86	20.0	12.3	20.0	4.7	20.0	69.2
Types of latrines:								
Open	10.0	16.5	15.0	1.4	12.0	0	8.0	43.1
Sanitary	60.0	77.0	65.0	97.2	75.0	97.3	80.0	15.4
Flushing	0	0.4	0	0	0	0	0	0
Others	30.0	6.0	12.0	1.0	13.0	2.0	12.0	38.5
Energy sources:								
Electricity	15.0	25.6	22.0	33.8	27.0	32.4	11.0	4.6
Fuel wood	23.0	58.2	39.0	56.3	55.0	59.5	60.0	56.9
Cow dung	40.0	6.6	30.0	5.6	8.0	5.4	20.0	18.0
Others	12.0	9.0	9.0	5.0	10.0	4.0	9.0	12.0

Table 3.2.9. PIRDP: Livelihood Situation by Size of Holding; Access to Major Facilities.

Livelihood parameters	% of small farm HHs enjoying		% of medium farm HHs enjoying		% of large farm HHs enjoying		% of landless HHs enjoying	
	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated
Ownership of dwelling house:								
Owned	82	92	90	94	92	100	80	89
Rented	0	0	0	0	0	0	0	4
Others	18	8	10	6	8	0	20	7
Source of drinking water:								
Open Well	4	3	0	8	0	7	0	0
Hand-pump	47	72	48	64	50	87	70	62
Others	49	25	52	28	50	6	30	38
Types of latrines:								
Open	3	17	2	18	3	0	1	14
Sanitary	6	38	8	24	8	40	3	28
Flushing	0	8	0	22	0	47	0	5
Others	91	37	90	36	89	13	96	53
Energy sources:								
Electricity	20	39	21	50	32	57	20	47
Fuel wood	56	88	62	92	58	100	70	90
Cow dung	24	10	15	4	10	0	10	10
Others	20	2	23	4	0	0	0	0

Sanitation. Use of sanitary latrines was recorded during the survey for each household. Four types of latrines were found: open, sanitary (ring, slab, septic tank), flushing, and others (including temporary, bore-hole, kutcha). Sanitary and 'others' constitute the major types of latrine used by the households. Large and medium households in the irrigated areas mostly use sanitary latrines. A difference between the landless and the small holders in using sanitary latrines is seen: small farmers use such latrines more than the landless. In the course of discussions it was revealed that lack of adequate space for constructing sanitary latrines, and the inability to meet its construction costs, were the bottlenecks faced by the landless community. Finally, it was learnt from the group discussions that the use of open space is generally getting unpopular across the different farm-size groups, given the expansion of adult literacy programs in rural areas.

Access to Energy. Electricity is available in both the project areas for domestic and commercial use. But its accessibility is limited by the distance of households from the distribution point on the one hand, and by its cost (both installation and running) on the other. It has been found that a large size of land holding and irrigation intervention do not ensure access to electricity, nor do a small size of holding and/or absence of irrigation facility preclude the households from accessing electricity. As reported during group discussions, other factors responsible for accessing it are ownership of non-land assets, education, relationship with power groups etc. As for fuel use, fuel wood is used mostly by the irrigated area households. Cow-dung is mostly used by the rain-fed area households (Tables 3.2.8 and 3.2.9).

Summing up. Safe drinking water, access to sanitary latrines, use of electricity for domestic purposes have been found to be more prevalent in the irrigated areas, compared to the rain-fed areas. Economic gain from irrigation is not the only reason behind greater use of these amenities by households in the irrigated areas; but because it is perceived as an important issue.. No difference has been found in respect of ownership of houses as between different areas or categories of households in general; however, richer households have relatively better quality houses.

Cropping Pattern and Farm Income

Access to irrigation has directly improved the cropping patterns from a dominance of local variety of main cereals (paddy and wheat) to a general practice of taking up their HYV substitutes. In G-K, the major change in the cropping pattern is a 55 percent increase in HYV Aman and 44 percent increase in HYV Aus areas. Sugarcane area has been replaced to the extent of 50 percent by other more profitable crops like vegetables. Farm income per ha in G-K ranges from Tk. 29,000 to 46,000 while in PIRDP it ranges from Tk. 28,000 to Tk. 29,000. In PIRDP, the major change in the pattern is a 223 percent increase in Aus (local variety) and 106 percent increase in T. Aus (HYV) for Kharif-1. Another major change is a 424 percent increase in the Boro area in winter, due to the irrigation facility created by the project.

The net increase in cropping intensity (difference between cropping intensities in irrigated and rain-fed conditions) is 34 percent in G-K and 51 percent in PIRDP.

Economic and Financial Farm Budget

The farm budgets for a 1-ha farm (economic and financial) have been analyzed with the help of FARMOD software. Market prices (collected during field surveys) have been used for financial analysis, and accounting prices (Shahabuddin, 2000) have been used for economic analysis. Crops other than cereals are also produced during the year. But, in drawing economic and financial farm budget for the irrigated area farmer, a partial farm budget covering cereals only has been computed to show the impact of irrigation on the cereal yield and income. Other crops are not produced under irrigated conditions. Results are presented in Table 3.2.10 to show the linkage of access to irrigation to production and employment.

Table 3.2.10. Summary of Production and Employment Benefits of Irrigation.

Location	Incremental values due to irrigation per ha.											
	Production (Ton)	Employment labour days			Net Return (in '000Tk)							
	Rain-fed	Irrigated	Increase	Rain-fed	Irrigated	Increase	Economic			Financial		
							Rain-fed	Irrigated	Increase	Rain-fed	Irrigated	Increase
G-K S_{11}												
Head	2.8	5.7	2.9	171	251	80	8.6	24.7	16.1	22.9	46.3	23.4
Middle	2.5	5.1	2.6	171	251	80	5.5	19.7	14.7	19.7	41.4	21.7
Tail	2.6	5.1	2.5	171	251	80	6.3	19.3	13.0	14.4	29.4	15.0
PIRDP S_{19}												
Head	1.1	4.0	3.0	109	225	116	0.7	17.0	16.3	6.0	28.0	22.0
Middle	1.6	4.1	2.5	109	225	116	4.7	18.6	13.9	10.0	29.0	19.0
Tail	1.1	4.0	2.9	109	225	116	4.7	17.9	13.2	9.9	28.0	18.1

Note: Differences in labour days per ha between G-K and PIRDP are mainly due to differences in cropping intensity.

In analyzing production and employment benefits of irrigation, out of the three selected canals each in G-K and PIRDP, S_{11} of G-K and S_{19} of PIRDP, which are situated at the tail end areas of the two systems, respectively, have been chosen for comparison with the rain-feed areas. The results are shown in Table 3.2.11, which demonstrate the following:

- Net increase in the production of cereal food crop due to irrigation is 2.5 to 3 tons/ha.
- Net increase in employment in irrigated agriculture for the poor households is 80-116 labor days per ha/annum.
- Net increase in financial return from cereals to a farm family with 1.0 ha is between Tk 15,000.00 and Tk 23,000.00 in G-K and between Tk. 18,000 and Tk. 22,000 in PIRDP. The range of net economic return is Tk. 13,000 to Tk. 16,000 in both G-K and PIRDP for a 1-ha farm.
- Production, employment and net return in the irrigated areas are larger compared to rain-fed areas in all sections head, middle and tail of the two canals.

Without irrigation intervention in the two areas, poor households would face multiple vulnerabilities as follows:

- Net family income (financial) from cereals would fall short by an average of about Tk 20,000/ha in G-K and Tk. 19,700 in PIRDP.
- Increase of 80-116 labour days per ha/annum due to irrigation implies increased demand for wage labour in agriculture. Since small, marginal and landless families mostly depend on wages for their livelihood, the direct beneficiaries are these poor groups.
- Poor farm and landless households (71 percent of total households in G-K and 78 percent in PIRDP) would lose additional wage income from irrigated agriculture to the extent of Tk 5000 per ha in G-K and Tk 7000 per ha in PIRDP (an average daily wage rate of Tk. 60 has been assumed).
- Given an average family size of 6 members, the living status of the poor households would fall much below poverty line (below 2218 Kcal intake per day) without the incremental production of food and agricultural wage income.
- As a result of increased cereals production and wage income, the poor households have been enabled to cope with food crisis, which may otherwise compel them to sell their cropland. In both the projects, distribution of irrigated land across the rich and poor households has been less skewed (Figures 3.2.2 and 3.2.4) compared to that in the rain-feed areas (Figures 3.2.1 and 3.2.3).

Income and Expenditure Patterns

Data on income and expenditure of the households for the year 2001-02 have been obtained through household surveys. Incomes from major sources like crops, wages, and remittances have been recorded. Consumption expenditures have also been estimated. It is found that the incomes of small landowners and landless households enable them just to meet the minimum consumption expenses. Rain-fed households have a lower income for all farm-sizes in both the projects. On average, the per capita annual income across the farm-size groups ranges from Tk. 12,000 to Tk. 14,000 in the irrigated areas and from Tk. 9,000 to Tk. 10,000 in the rain-fed areas. The annual expenditure ranges from Tk. 12,000 to Tk. 12,250 in the irrigated areas and from Tk. 9,600 to Tk. 10,000 in the rain-fed areas.

Table 3.2.11. Per Capita Income/Expenditure of Sample Households.

Farm holding size	Total annual income per capita (Tk. in thousand)		Total annual expenditure/ per capita (Tk. In thousand)	
	Rain-fed	Irrigated	Rain-fed	Irrigated
G-K				
Large	*	20,000	*	17,000
Medium	11,000	14,000	10,000	12,000
Small	10,000	12,000	10,000	11,000
Landless	8,000	8,000	7,000	8,000
PIRDP				
Large	13,000	19,000	12,000	18,000
Medium	12,000	13,000	12,500	12,000
Small	10,000	10,000	9,000	10,000
Landless	7,000	9,000	7,000	8,000

* Not available.

Incidence and Depth of Poverty

The household survey has obtained income and expenditure data from the sample households in both G-K and PIRDP systems. Incidence of poverty and poverty gap analyses have been carried out on the basis of those data. The results of poverty analyses are shown in Table 3.2.12. Headcount indices have been computed to show the incidence of poverty in irrigated and rain-fed areas while poverty gap analyses have been carried out to indicate the depth of poverty.[13]

Table 3.2.12. Results of Poverty Analyses in G-K and PIRDP, 2002.

Project area	Headcount index (%)	Poverty gap index (%)	Poverty line (Tk/family of 6/ year)
G-K			
Irrigated area	35	10	60,000
Rain-fed area	55	22	60,000
PIRDP			
Irrigated area	58	26	60,000
Rain-fed area	77	34	60,000

[13] The Headcount Index is given by the percentage of population living in households with a consumption per capita that is lower than the poverty line consumption. This is interpreted as a measure of the incidence of poverty. In the Bangladesh context, the poverty line refers to 2112 calories per person per day. The approach is based on the costing of a given food bundle containing the said calories. Thus the poverty line corresponds to an income around Tk 850/month/person for the year 2001-02. With an average household size of 6 persons, the annual poverty line income is Tk 60,000 (rounded).

Poverty Gap is the mean distance below the poverty line as a proportion of the poverty line again. The mean is computed over the entire concerned population, with the non-poor having no or zero poverty gap. Here, the same poverty line income for a family of 6 (Tk 60,000) is used to derive the poverty gap.

Both the above indicators show less spread and depth of poverty in the irrigated areas than those in the rain-fed areas. That is, growth in household income as a result of irrigation in G-K and PIRDP has not been accompanied by sharp inequalities of income. While national rural headcount index (2000) is 53 percent (GoB, 2002), the headcount indices are 58 percent and 35 percent, respectively in the irrigated areas of PIRDP and G-K, and 77 percent and 51 percent in the corresponding rain-fed areas. Incidence of poverty in PIRDP is more than the national level, but in G-K, it is much less than the national average. The poverty gap indices are 26 percent and 10 percent for the irrigated areas of PIRDP and G-K against 34 percent and 22 percent for the rain-fed areas in the project areas, respectively.

The differences in the values of the indicators between irrigated and rain-fed areas are thus substantial, showing that both the incidence and the depth of poverty are lower in areas where irrigation interventions have been made, compared to non-irrigated areas.

3.3. DETERMINANTS OF POVERTY IN IRRIGATED AGRICULTURE

In order to estimate the influence of selected (for which data are available) independent variables on household agricultural income, gross value of agricultural product per hectare, and poverty (defined with reference to a threshold per capita annual income of Tk. 10,200), several regression models were estimated. The results of three such regression runs, apparently more useful, are given in Tables 3.3.1 to 3.3.3.

It is seen from the results of regression model 1 that total annual agricultural household income (AgriIncome) is significantly influenced by the technology used (represented by the value of agricultural tools employed – AgriTools). Agricultural income is also influenced prominently by membership of WMG (WMGMem), the amount of credit taken (CREDIT), and locational advantage (Dummy DM). But, R^s is only 0.13 implying that only a small proportion of the total variation in dependent variable is explained by the explanatory variables used.

Regression Model 2 results show that the gross value of agricultural output per hectare (GVP) is influenced importantly by cropping intensity (CI) followed by irrigation (Irri). The coefficients of no other variable are statistically significant. Moreover, R^2 is very low.

From the results of Regression Model 3 it is seen that the coefficients of all explanatory variables, except DT, are significant, indicating that households with larger family size, high dependency ratio, low education of household heads, and in land-poverty are more likely to be poorer than otherwise. These findings should be interpreted cautiously, given the low value of R^s found (0.12).

These findings are generally in conformity with poverty related analyses presented elsewhere in this and other components of this study.

Regression Model 1

In order to estimate how far annual household agricultural income in the project areas is influenced by various selected independent variables, the following regression model was estimated.

AgriIncome= β1 + β2 * NetLand + β3 * ADMALE + β4 * ADFEMALE + β5 * CREDIT + β6* AgriTools + β7 * WMGMem + β8 * Irrig + β9 * DH + β10 * DM *+ β11 * Loc + e

AgriIncome	= Total annual agricultural income of selected households in Tk.
NetLand	= Net household landholdings in hectares
ADMALE	= No. of adult males (age > 16) in selected households
ADFEMALE	= No. of adult females (Age>16) in selected households
CREDIT	= Total amount of credit taken from various sources by selected households in Tk.
AgriTool	= Total value of agricultural tools owned by selected households in Tk.
WMGMem	= If member of WMG then 1 otherwise 0
Irrig	= If household has irrigated land then 1 otherwise 0
DH	= If household is at head location of the canal then 1 otherwise 0
DM	= If household is at middle location of the canal then 1 otherwise 0
Loc	= If household is in G-K project then 1 otherwise, i.e. if in PIRDP, 0
β1	= Constant
β2- β11	= Coefficients to be estimated
e	= Error term

The estimated regression coefficients, their t-values and significance levels, and the values of R^2 and F statistics are given below.

Table 3.3.1. Regression Results; AgriIncome is the Dependent Variable.

Independent variables	Coefficients	Std. Error	t-value	Sig.
Constant	17751.716	13806.189	1.286	0.199
NetLand (ha)	126.215	105.776	1.193	0.233
ADMALE (no.)	635.116	2359.942	0.269	0.788
ADFEM (no.)	871.426	2634.577	0.331	0.741
CREDIT (Tk.)	0.056	0.044	1.263	0.207
AgriTools (Value, Tk.)	1.642	0.204	8.066	0.000
WMGMem	19742.985	10086.900	1.957	0.051
Irrig	9315.139	12511.272	0.745	0.457
DH	13660.209	8567.766	1.594	0.111
DM	7833.884	8336.597	0.940	0.348
Loc	-7176.337	8750.144	-0.820	0.412

N = 638, R^2 = 0.132, Adjusted R^2 or Ra^2 = 0.119, F = 9.577 Significant at .000**

Regression Model 2

Gross value of output per hectare is an important variable to be influenced towards improving agricultural performance. It is intended to identify through regression analysis important independent variables that influence this dependent variable. The following regression equation has been run for the purpose.

GVP= β1 + β2 *+ CI + β3 * ADMALE + β4 * ADFEMALE + β5 * CREDIT + β6 * AgriTools + β7 * WMGMem + β8 * Irrig + β9 * DH + β10 * DM *+ β11 * Loc + e

TVAP = Total value of agricultural output in Tk.
NetLand = Net household landholdings in hectares
GVP = Gross value of agricultural output per hectare (TVAP÷NetLand) in Tk.
CI = Cropping intensity (total cultivated area÷NetLand)
ADMALE = No. of adult males (age > 16)
ADFEMALE = No. of adult females (Age>16)
CREDIT = Total amount credit taken from various sources by selected households in Tk.
AgriTool = Total value of agriculture tools owned by selected households in Tk.
WMGMem = If member of WMG then 1 otherwise 0
Irrig = if household has irrigated land then 1 otherwise 0
DH = if household is at head location of the canal then 1 otherwise 0

DM = if household is at middle location of the canal then 1 otherwise 0
Loc = if household is in G-K project then 1 otherwise, i.e. if in PIRDP, 0
β1 = Constant
β2- β11 = Coefficients to be estimated
e = Error term

Regression results are given below.

Table 3.3.2. Regression Results; GVP is the Dependent Variable.

Independent Variables	Coefficients	Std. Error	t-value	Sig.
Constant	64547.564	20841.612	3.097	0.002
CI	1274.360	239.593	5.319	0.000
ADMALE	-3881.699	3561.011	-1.090	0.276
ADFEM	1913.588	3979.486	0.481	0.631
CREDIT	-0.055	0.067	-0.827	0.408
AgriTools	-0.387	0.308	-1.257	0.209
WMGMem	29.540	15271.396	0.002	0.998
Irrig	31406.610	18914.799	1.660	0.097
DH	-3421.521	12973.302	-0.264	0.792
DM	-11082.855	12599.284	-0.880	0.379
Loc	-24884.785	13260.969	-1.877	0.061

N = 638, R^2 = 0.063, Ra^2 = 0.048, F = 4.247 Significant at 0.000**

Regression Model 3

In order to explain poverty of households, the following regression model has been used.

POVERTY = β1 + β2* FAMSIZE + β3* DR + β4* RESPEDU + β5* NetLand + β6* LOC + β7* DM + β8* DT + e

POVERTY = Per capita annum income <= Tk. 10,200 (i.e. poor) then 1 otherwise 0
PCI = Per capita income
FAMSIZE = Family size
DR = Dependency ratio
RESPEDU = Education of household heads in years
NetLand = Net household landholdings in hectares
Loc = If household is in G-K project then 1 otherwise 0 (i.e. if in Pabna) 0
DM = If household is at middle location of the canal then 1 otherwise 0
DT = if household is in tail location of the canal then 1 otherwise 0
β1 = Constant
β2- β8 = Coefficients to be estimated
e = Error term

The regression results are presented below.

Table 3.3.3. Regression Results; Poverty Dummy is the Dependent Variable.

Independent Variables	Coefficients	Std. Error	t-value	Sig.
Constant	0.450	0.060	7.467	0.000
FAMSIZE	0.023	0.005	4.645	0.000
DR	0.082	0.037	2.222	0.027
RESPEDU	-0.018	0.004	-4.127	0.000
NetLand	-0.002	0.001	-2.917	0.004
Loc	-0.157	0.040	-3.884	0.000
DM	0.071	0.045	1.582	0.114
DT	0.003	0.050	0.066	0.947

N = 636, R^2 = 0.12, Ra^2 = 0.11, F = 11.845 Significant at 0.000**

Irrigation and Poverty Linkages

Irrigated agriculture in Bangladesh, particularly through large-scale surface water irrigation such as G-K and PIRDP systems, is dominated by rice culture. As reported earlier, the cropping pattern in the project areas shows that a major change has taken place in the cropping pattern from local to HYV T Aman and T Aus in G-K and HYV T Aman and Boro rice in PIRDP. The distribution of benefits from such a shift from local to HYVs depends on access to irrigation, which is often different for different reaches of irrigation canal systems. Linkage of irrigation and elements of poverty reduction for the small farmers and the landless can be examined along the following lines.

- Irrigation narrows, or stops deterioration in, inequity in land distribution: Public sector surface water irrigation services provide opportunities for the poor farmers (small and marginal) to retain their agricultural land through direct support in terms of irrigation water thereby raising agricultural income, unlike the case in the rain-fed areas where farmers do not enjoy such opportunities. Skewness of land distribution among farm households in the irrigated and rain-fed areas has been shown in Figures 3.2.1-3.2.4.

- Irrigation improves livelihood parameters of households including the poor: Information obtained from the survey on the occupations of household members is reported in Table 3.2.4. In 2001/2002, over 82 percent of the households were dependent on agriculture in G-K and about 85 percent in PIRDP. The majority of the heads of these households have an average of about 5 years of schooling (Table 3.2.7). Demand for labor in irrigated agriculture has increased well beyond the demand for the same in rain-fed agriculture (Table 3.2.11).

- Production and net return in crop production in the irrigated areas have increased by 2- 4 times over those in the rain-fed areas. Four selected major livelihood parameters (own dwelling house, safe drinking water from hand pump, safe sanitation by using sanitary latrines and use of electricity as energy and fuel-wood for cooking) are all enjoyed more by households taking irrigation from the canals compared to the households in the rain-fed areas of both the projects (Tables 3.2.8 and 3.2.9).

- Irrigation increases income of households including the land-poor and the landless: Availability of land for agriculture is declining sharply as a result of increasing population and non-agricultural use of land all over Bangladesh. The land-poor and small and marginal farm households (55 percent in G-K and 65 percent in PIRDP) have a high stake in the irrigation projects as the irrigation facilities offer opportunities for them to improve their living condition through increased productivity of land via adoption of modern varieties. Net cereal yield increase across farm sizes ranges from 2.5 to 3 tons. Production and net returns in the irrigated areas have increased by 2 to 4 times compared to those in the rain-fed areas. Landless households (owning less than 0.20 ha of land) also constitute a significant proportion of the total rural households. In G-K and PIRDP, the proportion of landlessness has been found to be 16 percent and 14 percent, respectively. Their access to incomes from agricultural labour wages (net increase due to irrigation by at least 80 person days per ha per annum) helps them improve their living condition from that under agriculture without irrigation.

- Irrigation reduces incidence and depth of poverty: Poverty analysis for both the projects demonstrates that the headcount index and poverty gap in the irrigated areas are much lower than those in the rain-fed areas. Productivity of land and intensity of cropping constitute the main reason for increased income of the poor households. Increases in wage income for the landless and the small farmers enable them to meet their basic livelihood needs better.

- Lower food prices due to increased production of food crops support the poor but disadvantage the producers: Although the production and income increases due to irrigation have been seen to be largely in the hands of the larger farmers, the small farmers and the landless families benefit from the consequent lower food prices. However, the reduced prices constitute a disincentive for the producers. A policy intervention for striking a balanced price regime is needed.

- Potential health benefits of irrigation: Better housing, sanitation, energy-use and safe drinking water (Tables 3.2.8 and 3.2.9) provide potential health benefits to the small and poor farmers in the irrigated areas. Increased food production and, hence, nutrition can be ensured through this type of medium and large-scale irrigation projects.

Findings viz-a-viz the Research Hypotheses

In relation to the research hypotheses stated at the outset of this part of the report, the findings are as follows.

i. Command areas at head, middle and tail reaches of the canals receiving less irrigation water per hectare generate lower productivity (Table 3.2.10). Farmers at tails often do not get adequate water for irrigation, and, therefore, produce less. But farmers at both head and tail of Canal S_{19}

of PIRDP and in Canal S_{11} of G-K produce cereals at the same yield level. Indeed the canal irrigation efficiency and the farmers' efforts are of crucial importance in raising land productivity, in addition to the availability of irrigation water. The other proposition of a higher incidence of poverty among the lower-reach farmers is also not always true, given the importance of these other factors.

ii. Under the existing conditions, small, marginal and poor farmers receive larger benefits from irrigation per unit of land than large landholding farmers. Although the share of land of these groups is very low (55 percent control only 21 percent of land in G-K and 64 percent only 37 percent of land in PIRDP), the proportion of area under modern rice varieties is higher for small and marginal farmers and their yield rates are also higher compared to the larger land owning groups. Intensity of irrigation and the proportion of coverage of HYV rice in the irrigated areas are higher for the small farmers. Other available empirical studies corroborate this finding (Hossain, 1997; Mandal, 1980).

iii. Thus, the benefits of irrigation in G-K and PIRDP, it has been found, per unit of land are higher for the relatively small and marginal farmers. This indeed is a pro-poor outcome. But, given their small or marginal holdings, the total benefit they derive is small compared to larger landowning groups. Through appropriate interventions such as participatory management, some enhancement of benefits can be made available to the small and marginal farmers. But, for substantial improvement in the benefits accruable to the land-poor and the landless, a land reform is a key necessity.

Recommendations

- Small and marginal farmers, who, it has been seen, actually take good advantage of the available irrigation water, should be organizationally involved in the management of irrigation activities so that their equitable access to irrigation water can be secure, and some enhancement of benefits receivable by them can occur. It should be relatively easy to accomplish this task. For a major breakthrough for the landless, an appropriate land reform is necessary, which is an involved and difficult objective to achieve under the prevailing socio-political dynamics.But this should be given serious consideration.
- Monotonic cultivation of rice in the irrigation projects needs to be discouraged, and diversification towards high value crops according to the agronomic setting encouraged and facilitated.
- Steps are needed to improve the irrigation system in terms of secure availability and equitable and efficient distribution of irrigation water leading to increased water (land) productivity and reduced cost of irrigation, contributing to reduction in poverty.
- Supplementary investment in sectors other than irrigation for rural poverty reduction may help the poor in the irrigation projects as well.

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3.4. IRRIGATION SYSTEM PERFORMANCE: IMPLICATIONS FOR THE POOR

There is significant evidence that performance of large and medium scale canal irrigation systems in most developing countries have been generally unsatisfactory. Most large and medium scale canal irrigation systems are generally characterized by poor management, unreliable water supplies, poor maintenance, deteriorated infrastructure, unsustainability, inefficiency and inequity in water distribution and use, and financial dependence on government budgets. The vicious circle of poor irrigation performance is generally perceived to reduce overall benefits to the communities from the available water resources. Since poor irrigation performance may reduce the overall benefits of irrigation, the central research issue here is, whether and to what extent poor irrigation performance affects the poor in irrigated agriculture, and what are the constraints and opportunities for increasing benefits of irrigation, through improved system performance to help the poor sections of the agricultural communities. The objective is to improve the understanding of irrigation performance and to establish and document knowledge of irrigation performance and management issues and their implications for the poor, specific to the study areas.

Performance of Irrigation Systems

Irrigation Coverage of G-K

In this project, agriculture is dominated by two types of transplanted HYV paddy: Aus (March-June) and Aman (July-October). In locations where irrigation water delivery is unreliable, cultivation of broadcast Aus, sugarcane, jute and tobacco are common. A winter crop (November- March) of wheat or pulses is grown as a follow-on crop to utilize residual soil moisture after the Aman crop. In some areas, private shallow tube-wells are used to augment the water supply, particularly for winter crops. Two major crops: Aus and Aman were considered for this study. It may be pointed out here that the G-K project is operational from March to November. The project is shut down from December to February for annual maintenance.

Table 3.4.1 shows the irrigation coverage of G-K project for five consecutive years, 1996/1997, 1997/1998, 1998/1999,1999/2000 and 2000/2001. Irrigation in G-K during Kharif-II (July- October) ranged from 53 percent to 80 percent. But the percentage of irrigation coverage drastically reduced from 53 percent to 32 percent during Kharif-II season of the year 2000/2001 due to public cut of the Ganges canal at Amla to ease the severe drainage congestion of Sagorkhali. For this, more than 90 percent of the command area of the Ganges canal could not be irrigated. To solve the problem of drainage congestion and bring the above-mentioned un-irrigated area under irrigation coverage, a mathematical model study was conducted during 2001/2002. The study recommended building a large syphon under the Ganges canal and excavation of rivers and other drainage system in the area.

During Kharif-I irrigation coverage in G-K ranged from 8.6 percent to 22.0 percent mainly due to shortage of water in the Ganges river (source of water). The other reasons are high seepage loss, especially in the tail-end areas, improper functioning of the water control structures, unauthorized interventions by the public (cutting of canals), breaches in the upper reaches, over-irrigation and tampering with the infrastructure in the upper-reaches, and lack of supervision of the operation of the irrigation system.

Field investigations were conducted to estimate seepage losses of three selected secondaries and three tertiaries of the G-K project and one tertiary ($I_3S_1T_4$) in PIRDP. It was observed that high seepage losses occurred in the tail-end tertiaries of all the secondaries. Highest seepage loss of 49.23 percent was observed in T_2S_1G followed by 33.6 percent in $I_3S_1T_4$. Significant losses were also observed in $S_{11}K$ and T_3AS_1G with 29.0 percent and 27.6 percent, respectively. Seepage losses at the head reaches of the canals were within the acceptable limit.

Table 3.4.1. G-K: Irrigation Coverage.

Year	Irrigable area (ha)	Area irrigated by farmers own arrangement (ha)	Area irrigated during crop seasons (ha)		% of irrigation coverage	
			Kharif-I (ha)	Kharif-II (ha)	Kharif-I	Kharif-II
1996-1997	116,000		25,000	93,302	22.0	80
1997-1998	116,000	20,586	25,006	72,914	22.0	63
1998/1999	116,000	17,218	10,654	76,382	9.2	66
1999/2000	116,000	31,788	10,029	61,862	8.6	53
2000/2001	116,000		14,510	37,660	12.5	32

Sources: G-K Project Authority, Annual Report 2000/01 and Annual Report 1999/00.

To augment the water supply, the farmers in the area have started to make their own arrangements by installing shallow tubewells (for groundwater) and LLPs (for surface water). It was observed that irrigation by STWs and LLPs ranged from 15 percent to 27 percent during 1998/99 and 1999/2000, respectively.

Table 3.4.2 shows the irrigation coverage of selected secondary and tertiary canals, which are situated at different chainage (distance from the main pumping station), for the year 2000/2001.

S_1G Canal System

This canal system is located closest to the main supply source. The average percentage of irrigation coverage during Kharif-II and Kharif-I were 93 percent and 26 percent, respectively. From this secondary, T_1AS_1G, T_2S_1G and T_3AS_1G tertiary canals were selected for the study. The percentage of irrigation coverage of the tertiary canals during Kharif-II ranged from 91 percent to 98 percent and during Kharif-I it ranged from 11percent to 56 percent.

Table 3.4.2. G-K: Irrigation Coverage of the Selected Canal.

Year	Name of canal	Distance from the source (km)	Length (km)	Q (m^3/s)	Command area (ha)	Area irrigated during crop seasons (ha)		% Irrigation coverage	
						Kharif-I (ha)	Kharif-II (ha)	Kharif-I	Kharif-II
2000/01	S_1G	1.00	-----	0.76	652	170	609	26	93
	T_1AS_1G	1.25	0.97		99	55	97	56	98
	T_2S_1G	2.25	3.96		301	50	273	17	91
	T_3AS_1G	2.75	0.98		91	10	86	11	95
2000/01	S_7K	37.96		2.52	2,192	745	1,970	34	90
	T_1S_7K	39.06	1.71		235	142	225	60	96
	T_3S_7K	40.46	4.25		405	81	128	7	32
	T_6S_7K	41.71	2.35		176	10	160	6	91
2000/01	$S_{11}K$	58.00		3.48	2,995	40	2,115	1	71
	$T_1S_{11}K$	58.35	1.11		107	0	100	0	93
	$T_6S_{11}K$	63.75	1.83		196	1	170	0	87
	$T_{10}S_{11}K$	67.75	2.21		240	0	128	0	53

Sources: G-K Project Authority, Annual Report 2000/01 and Annual Report 1999/00; field investigation.

S_7K Canal System

This canal system is located at 40 km from the main supply source. The average percentage of irrigation coverage during Kharif-II and Kharif-I was 90 percent and 34 percent, respectively. From this secondary T_1S_7K, T_3S_7K and T_6S_7K tertiary canals were selected for the study. The percentage of irrigation coverage of the tertiary canals during Kharif-II ranged from 32 percent to 96 percent and during Kharif-I from 6 percent to 60 percent.

$S_{11}K$ Canal System

This canal system is located at 58 km from the main supply source. The average percentage of irrigation coverage during Kharif-II and Kharif-I was 71 percent and 1 percent, respectively. From this secondary, $T_1S_{11}K$, $T_6S_{11}K$ and $T_{10}S_{11}K$ tertiary canals were selected for the study. The percentage of irrigation coverage of the tertiary canals during Kharif-II ranged from 53 percent to 93 percent and during Kharif-I there was no irrigation because the canal was closed for the construction of a bridge.

Irrigation Coverage of PIRDP

In this project, the major crops are HYV Boro paddy (Rabi season, November- March) and Aman Local Variety (LV) (Kharif-II, July-October). Vegetables, wheat and other minor crops are also grown in the area. In some areas, just as in G-K, private shallow tube-wells are used to augment the water supply. Two major crops: HYV Boro paddy and Aman (LV) were considered for this study.

Table 3.4.3 shows the irrigation coverage of PIRDP. The irrigation coverage during 2001/2002 and 2002/2003 was about 66 percent and 46 percent, respectively in the Rabi season. In the remaining areas farmers grow vegetables, pulses, oil-seeds, tobacco etc by using residual moisture.

Table 3.4.3. Irrigation Coverage in PIRDP, 2001/02 and 2002/03.

Year	Irrigable area (ha)	Irrigated by PIRDP project (ha)	Area irrigated during crop seasons (ha)	% of irrigation coverage
			Rabi (HYV Boro)	Rabi (HYV Boro)
2001/2002	18,680	12,335	12,335	66
2002/2003	18,680	8,515	8,515	46

Sources: Agricultural Extension office, Pabna.

Table 3.4.4 shows the irrigation coverage of selected secondary and tertiary canals, which are situated at different chainage, for the year 2001/2002.

I_3S_1 Canal System

Table 3.4.4 shows irrigation coverage by these canals in Rabi plus Kharif-I to be 29 percent and during Kharif-II only 7 percent. Irrigation coverage of the tertiary canal $I_3S_1T_1$ is 89 percent during Kharif-I and Rabi season, and nil during Kharif-II. Irrigation coverage of tertiary canal $I_3S_1T_2$ was 73 percent during Kharif-I and Rabi season, and 36 percent during Kharif-II. $I_3S_1T_3$ canal was under repair and modification during 2001-02.

Table 3.4.4. PIRDP: Irrigation Coverage of the Selected Canal Systems.

Year	Name of canal	Chain age (km)	Length (km)	Q m^3/s	Command area (ha)	Area irrigated during crop seasons (ha)		% irrigation coverage	
						Kharif-I &Rabi (ha)	Kharif-II	Kharif-I &Rabi (ha)	Kharif-II
2001-02	**I_3S_1**	**1.14**	**16.805**	**10.82**	**4,840**	**1,390**	**100**	**29**	**7**
	$I_3S_1T_1$	2.75	8.573	2.26	880	780	0	89	0
	$I_3S_1T_2$	4.50	1.96	0.488	275	200	100	73	36
	$I_3S_1T_3$	10.5	0.765	2.73	158	0	0	0	0
2001-02	**I_3S_{10}**	**20.41**	**5.461**	**2.26**	**895**	**430**	**100**	**48**	**11**
	$I_3S_{10}T_1$	20.91	1.15	0.337	157	150	15	96	10
	$I_3S_{10}T_2$	24.44	1.254	0.337	116	40	10	34	9
	$I_3S_{10}T_3$	25.24	1.463	0.403	163	0	15	0	9
2001-02	**I_3S_{19}**	**40.69**	**23.95**	**11.24**	**5,250**	**2,380**	**0**	**45**	**0**
	$I_3S_{19}T_1$	43.09	1.81	0.49	232	35	0	15	0
	$I_3S_{19}T_7$	50.29	1.419	0.273	226	0	0	0	0
	$I_3S_{19}T_{14}M_1$	74.09	1.23	0.206	102	210	0	205	0

Sources: Agricultural Extension office, Pabna.

I_3S_{10} Canal System

In secondary canal system I_3S_{10}, the irrigation coverage is 48 percent for Kharif-I plus Rabi season and in Kharif-II the irrigation coverage was about 11 percent . Irrigation coverage of the two tertiary canal of I_3S_{10} canal system ranged from 0 percent to 96 percent during Kharif-I plus Rabi and from 9 percent to 10 percent during Kharif-II.

I_3S_{19} Canal System

Irrigation coverage of secondary canal I_3S_{19} was 45 percent during Rabi plus Kharif-I season and no irrigation was observed in Kharif-II season. No irrigation was observed in the $I_3S_{19}T_7$ tertiary canal. Irrigation coverage of tertiary canal $I_3S_{19}T_{14}M_1$ was 206 percent during Rabi plus Kharif-I season and no irrigation was observed during Kharif-II season. (Table 3.4.4).

Irrigation Intensity

The definitions of the key performance assessment indicators are presented in the Annex.

1. G-K

Irrigation intensity of the project is shown in Table 3.4.5. It was observed that in G-K, irrigation intensity ranged from nil to 60 percent in Kharif-I and from 53 percent to 98 percent in Kharif-II in the selected tertiaries. However, at the secondary level, the highest irrigation intensity of 34 percent was observed in the middle reaches of S_7K, followed by 26 percent and 1percent, respectively in S_1G and $S_{11}K$ in Kharif-I season. In Kharif-II season, the highest irrigation intensity of 93 percent was observed in the head reaches of S_1G, followed by 90 percent and 71 percent, respectively in the middle and tail reaches of S_7K and $S_{11}K$. In $T_1S_{11}K$, $T_6S_{11}K$ and $T_{10}S_{11}K$ there was no irrigation in Kharif-I because $T_1S_{11}K$ acts as a drainage canal in Kharif-I to drain out the water form the low-lying areas of the command area and $T_6S_{11}K$ and $T_{10}S_{11}K$ were closed to construct a bridge. Very low irrigation intensity in Kharif-I season resulted from inadequate water flow in the Ganges at the intake.

Table 3.4.5. G-K: Irrigation Intensity.

Year	Name of canal	Distance from source, pump house (km)	Length (km)	Command area (ha)	Irrigation intensity (%)	
					Kha-I	Kha-II
2000/01	S_1G	1.00		652	26	93
	T_1AS_1G	1.25	0.97	99	56	98
	T_2S_1G	2.25	3.96	301	17	91
	T_3AS_1G	2.75	0.98	91	11	95
2000/01	S_7K	37.96		2,192	34	90
	T_1S_7K	39.06	1.71	235	60	96
	T_3S_7K	40.46	4.25	144	56	89
	T_6S_7K	41.71	2.35	176	06	91
2000/01	$S_{11}K$	58.00		2,995	01	71
	$T_1S_{11}K$	58.35	1.11	107	0*	93
	$T_6S_{11}K$	63.75	1.83	196	00**	87
	$T_{10}S_{11}K$	67.75	2.21	240	00**	53

*$T_1S_{11}K$ acts as a drainage canal.

** $T_6S_{11}K$ & $T_{10}S_{11}K$ were closed down to construct a bridge

The results indicate that irrigation intensity in the tail reaches of the canal system was extremely low in Kharif-I season and significantly low in Kharif-II season. This was reflected in the irrigation intensity as well; the lowest irrigation intensity of 53 percent has been found in $T_{10}S_{11}K$ (extreme tail end) and the highest irrigation intensity of 156 percent in T_1S_7K (middle reach). At the secondary level, S_7K has achieved the highest irrigation intensity of 124 percent, followed by S_1G and $S_{11}K$ with 119 percent and 72 percent, respectively. It is therefore quite evident that the tail reaches of the system suffer severe water shortages, which ultimately results in low irrigation intensity. It should be mentioned that farmers plant a third crop during the Rabi season using residual moisture and using shallow tubewell, which increases cropping intensity.

PIRDP

Irrigation intensity in the project is shown in Table 3.4.6. Results indicate that irrigation intensity in this project behaved highly erratically. Highest irrigation intensity of 206 percent was observed in $I_3S_{19}T_{14}M_1$ (extreme tail end reach of the system) and no information is available for $I_3S_{19}T_7$ (tail) and $I_3S_{10}T_3$ (middle). Due to major breaches, the canal $I_3S_{10}T_3$ was not in operation during Rabi and Kharif-I. The command area of $I_3S_{19}T_7$ requires secondary lifting, which the farmers were not interested to arrange. At the secondary level, the highest irrigation intensity of 48 percent was obtained in I_3S_{10} (middle) in Kharif-I and Rabi season followed by 45 percent, and 29 percent in I_3S_{19} (tail) and I_3S_1 (head), respectively. Irrigation intensities in all the canals in Kharif-II were negligible.

Table 3.4.6. PIRDP: Irrigation Intensity.

Year	Name of canal	Distance from source (km)	Length (km)	Command area (ha)	Irrigation intensity (%)	
					Kha-I & Rabi	Kha-II
2001/02	I_3S_1	1.14	16.805	4,840	29	2
	$I_3S_1T_1$	2.75	8.573	880	89	0
	$I_3S_1T_2$	4.50	1.96	275	73	2
	$I_3S_1T_3$	10.5	0.765	158	95	0
2001/02	I_3S_{10}	20.41	5.461	895	48	11
	$I_3S_{10}T_1$	20.91	1.15	157	95	10
	$I_3S_{10}T_2$	24.44	1.254	116	34	9
	$I_3S_{10}T_3$	25.24	1.463	163	0	9
2001/02	I_3S_{19}	40.69	23.95	5,250	45	0
	$I_3S_{19}T_1$	43.09	1.81	232	15	0
	$I_3S_{19}T_7$	50.29	1.419	226	N/A*	N/A
	$I_3S_{19}T_{14}M_1$	74.09	1.23	102	206	0

* Requires secondary lift for irrigation

Total Production, Output per Unit Command Area and Output per Unit of Diverted Irrigation Water

Table 3.4.7 shows the total production in the command area, output per unit command area and output per unit of diverted irrigation water. The output per unit command area is the lowest at the tail end of the individual canal system. It varies from 1.95 to 3.61 tons/ha at the tail end, 5.16 to 7.19 tons/ha at the middle reach and 2.76 to 6.09 tons/ha at the head reach of the canal system. The total production is 2,843 tons, 13,557 tons and 8,328 tons at head, middle and tail reaches, respectively of the selected secondaries and corresponding command areas are 652 ha, 2,192 ha and 2,995, respectively. Output per unit diverted irrigation water is maximum at the middle and lowest at the tail end of the canal system. The lowest value at different reaches is 0.12 Kg/m^3 at the tail end, 0.22 Kg/m^3 at the head and 0.28 Kg/m^3 at the middle reach of the canal system; and the highest value is 0.22 Kg/m^3 at the tail end, 0.37 Kg/m^3 at the head and 0.48 Kg/m^3 at the middle reach of the canal system. It is seen that the lowest production per unit command area has been realized at the tail end.

Table 3.4.7. G-K: Total Production, Output per Unit Command Area and Output per Unit of Diverted Irrigation Water.

Year	Name of canal	Command area (ha)	Output per unit command area			Total production in command area (Kg)	Unit Diverted ** water m3/s	Output per unit diverted irrigation water (Kg/m^3)
			(Ton/ha)		Kg/ha (both T Aus and Aman, area weighted)			
			T Aus (HYV)	Aman (HYV)				
2000/01	S_1G	652 (170;609)*			4,359.67	2,842,503	0.76	0.27
	T_1AS_1G	99 (55 ;97)	4.18	3.85	6,094.44	603,350	0.12	0.37
	T_2S_1G	301 (50 ;273)	3.13	2.47	2,760.17	830,810	0.27	0.22
	T_3AS_1G	91 (10; 86)	3.84	4.57	4,740.88	431,420	0.11	0.28
2000/01	S_7K	2,192 (745; 1970)			6,184.79	13,557,050	2.52	0.38
	T_1S_7K	235 (142; 225)	3.73	5.04	7,079.40	1,663,660	0.317	0.38
	T_3S_7K	144 (81; 128)	4.87	5.01	7,192.71	1,035,750	0.176	0.43
	T_6S_7K	176 (10; 160)	5.27	5.35	5,163.01	908,700	0.136	0.48
2000/01	$S_{11}K$	2,995 (40; 2115)			2,780.57	8,327,800	3.48	0.17
	$T_1S_{11}K$	107 (0; 100)	2.15	3.86	3,607.48	386,000	0.128	0.22
	$T_6S_{11}K$	196 (1; 170)	3.27	4.13	3,598.83	705,370	0.235	0.22
	$T_{10}S_{11}K$	240 (0; 128)	3.7	3.65	1,946.67	467,200	0.288	0.12

* Figures within parenthesis are the actual area irrigated for T-Aus (Kharif-I) and Aman (Kharif-II) respectively.
** Unit diverted water was multiplied by 160 days of effective irrigation in the G-K project to obtain the total volume of water diverted.

In PIRDP (Table 3.4.8) the output per unit command area ranges from 0.38 at the tail reach to 4.44 tons/ha at the head reach of the canal system. Output per unit diverted irrigation water is the lowest at the middle reach of the canal. It ranges from 0.006 Kg/m^3 to 0.403 Kg/m^3. This may have been due to the fact that the water level in the canal system never reaches the full supply level.

Output per unit diverted irrigation water is maximum (0.403 Kg/m^3) at the tail end and at different reaches minimum (0.006) at the middle reach of the canal system. The lowest value ranges from 0.006 at the middle reach to 0.013 Kg/m^3 and 0.125 Kg/m^3 at the tail end and head ends, respectively. The highest value ranges from 0.403 Kg/m^3 at tail end 0.163 Kg/m^3 at the head end and

0.147 Kg/m^3 at the middle reach of the canal system. These results are indicative of an erratic yield outcome as between canals and their reaches in the system.

Table 3.4.8. PIRDP: Assessment of Total Production, Output per Unit Command Area and Output per Unit of Diverted Irrigation Water.

Year	Name of canal	Command area (ha)	Output per unit command area			Total production in command area (Kg)	Diverted** water m3/s	Output per unit Diverted irrigation water (Kg/m^3)
			(Ton/ha)		Kg/ha (both T Aus and Aman, area weighted			
			Aman (LV)	Boro + Rabi (HYV)				
200/ 02	I_3S_1	4,840 (1,390;100)*			1,292	6,253,333	10.82	0.042
	$I_3S_1T_1$	880(780;0)	1.82	5.01	4,441	3,907,800	2.26	0.125
	$I_3S_1T_2$	275(200;100)	1.90	3.99	3,593	988,000	0.488	0.146
	$I_3S_1T_3$	158(150;0)	1.79	4.10	3,892	615,000	0.273	0.163
2001/02	I_3S_{10}	895(430;100)			2,151	1,925,467	2.26	0.062
	$I_3S_{10}T_1$	157(150;15)	1.4	4.42	4,357	684,000	0.337	0.147
	$I_3S_{10}T_2$	116(40;10)	1.94	5.24	1,029	119,400	0.337	0.026
	$I_3S_{10}T_3$	163(0;15)	2.05	5.26	189	30,750	0.403	0.006
2001/02	I_3S_{19}	5,250(2,380;0)			1,931	1,013,8800	11.24	0.065
	$I_3S_{19}T_1$	232(35;0)	1.27	5.99	380	88,200	0.49	0.013
	$I_3S_{19}T_7$	226(0;0)	1.71	N/A	N/A	0	N/A	N/A
	$I_3S_{19}T_{14}M_1$	102(210;0)	1.66	5.46	11,241	1,146,600	0.206	0.403

* Figures within parenthesis are the actual area irrigated for T-Aus (Kharif-I) and Aman (Kharif-II), respectively.
** Unit diverted water was multiplied by 160 days of effective irrigation in the G-K project to obtain the total volume of water diverted.,,

Output per Unit Consumed Water/ Labour, Water Delivery Capacity, Water Delivery Performance and Overall System Efficiency

From Table 3.4.9 it is evident that, in G-K, the output per unit consumed water is the lowest at the tail end, which is 0.16 Kg/m3, and the highest at the middle reach of the canal system, which is 0.60 Kg/m at the head end of the canal system, which is 0.51 Kg/m^3. Output per unit of labour is also lowest at the tail end of the canal system. The lowest to the highest value ranges from 14.97 Kg/labour at the tail end to 55.33 Kg/labour at the middle reach of the canal system. Water delivery capacity is the highest at the middle reach with a value of 0.98 followed by 0.89 at the head and 0.40 at the tail end of the canal system. Water delivery performance ranges from 0.20 in T_1S_{11} K (tail reach) to 0.49 in T_1S_7K (middle reach). At the secondary level, average values are almost identical with 0.43, 0.42 and 0.42 at the head, middle and tail reaches, respectively. The overall system efficiency ranges from 0.43 at the T_1S_7K (middle reach) to 0.74, also at the same reach. At the secondary level, the average overall system efficiency does not vary significantly.

Table 3.4.9. G-K: Output per Unit Consumed Water/ Labour, Water Delivery Capacity, Water Delivery Performance and Overall System Efficiency.

Year	Name of canal	Command area (ha)	Output per unit consumed water (Kg/m^3) (WET=1.2m)	Output per unit of labor (Kg/labor)	Water delivery capacity (50% efficiency)	Water delivery performance	Overall system efficiency
2000/ 01	S_1G	652	0.36	33.54	0.84	0.43	0.49
	T_1AS_1G	99	0.51	46.88	0.88	0.44	0.48
	T_2S_1G	301	0.23	21.23	0.65	0.33	0.64
	T_3AS_1G	91	0.40	36.47	0.88	0.44	0.50
2000/ 01	S_7K	2192	0.52	47.58	0.84	0.42	0.43
	T_1S_7K	235	0.59	54.46	0.98	0.49	0.47
	T_3S_7K	144	0.60	55.33	0.89	0.45	0.47
	T_6S_7K	176	0.43	39.72	0.56	0.28	0.74
2000/ 01	$S_{11}K$	2995	0.23	21.39	0.85	0.42	0..49
	$T_1S_{11}K$	107	0.30	27.75	0.40	0.20	0.44
	$T_6S_{11}K$	196	0.30	27.68	0.87	0.44	0.44
	$T_{10}S_{11}K$	240	0.16	14.97	0.87	0.44	0.44

In PIRDP (Table 3.4.10), output per unit of water consumed is quite erratic and ranges from 0.02 Kg/m^3 to 0.94 $Kg/m^{3.}$ Output per unit of labour ranges from 1.45 Kg/labour to 86.47 Kg/labour. The highest value is at the tail end of the canal system. This is due to cultivation of Boro HYV paddy in the Rabi season and crop overlapping between Kharif-I and Rabi season. Water delivery capacity ranges from 0.88 to 2.11, which indicates that theoretically, the canals are very good in terms of water availability. But, in reality, water in the canals never reaches these levels. Water delivery performance corresponds to the pattern of water delivery capacity. Overall efficiency ranges from 0.29 to 0.50. In I_3S_1 canal system, it ranges from 0.33 to 0.50; in $I_3S_{10,}$ it varies from 0.29 to 0.40; and in I_3S_{19} canal system, it varies from 0.40 to 0.70.

Table 3.4.10. PIRDP: Output per Unit of Water/ Labour, Water Delivery Capacity, Water Delivery Performance and Overall System Efficiency.

Year	Name of canal	Command area (ha)	Output per unit Consumed water (Kg/m^3) (WET=1.2m)	Output per unit of labor (Kg/labor)	Water delivery capacity	Water delivery performance	Overall system Efficiency
2001/02	I_3S_1	4,840	0.11	9.94	1.63	0.81	0.39
	$I_3S_1T_1$	880	0.37	34.16	1.87	0.94	0.33
	$I_3S_1T_2$	275	0.30	27.64	1.29	0.65	0.49
	$I_3S_1T_3$	158	0.32	29.94	1.26	0.63	0.50
2001/02	I_3S_{10}	895	0.18	16.55	1.84	0.92	0.34
	$I_0S_{10}T_1$	157	0.36	33.51	1.56	0.78	0.40
	$I_3S_{10}T_2$	116	0.09	7.92	2.11	1.06	0.29
	$I_3S_{10}T_3$	163	0.02	1.45	1.80	0.90	0.35
2001/02	I_3S_{19}	5,250	0.16	14.86	1.56	0.78	0.40
	$I_3S_{19}T_1$	232	0.03	2.92	1.54	0.77	0.41
	$I_3S_{19}T_7$	226	00	00	0.88	0.44	0.70
	$I_3S_{19}T_{14}M_1$	102	0.94	86.47	1.47	0.74	0.42

Relative Water Supply (RWS) and Relative Irrigation Supply (RIS)

RWS and RIS have been computed only for secondary canals. Table 3.4.11 indicates that, in G-K, both RWS and RIS are about the same in all the canals with values of about 50 percent and 46 percent, respectively. But in the PIRDP, RWS ranges from 0.94 to 1.10 and RIS from 0.86 to 1.01.

Table 3.4.11. Water Supply Against Water Demand.

Canal	Distance from Source (km)	RWS	RIS
G-K			
Ganges			
S_1G (head end canal)	1.00	0.51	0.47
S_7K (middle reach canal	37.96	0.50	0.46
$S_{11}K$ (tail end canal)	58.00	0.51	0.47
PIRDP			
I_3S_1 (head end canal)	1.00	0.98	0.90
I_3S_{10} (middle reach canal)		1.10	1.01
I_3S_{19} (tail end canal)		0.94	0.86

Head-Tail Equity Ratio in Output

The overall head and tail equity in G-K between two secondary canals, S_1G (nearest one) and $S_{11}K$ (farthest one) is 1.57, (Table 3.4.12) indicating that the tail canal system receives about 57 percent less water than that of the head canal system.

Table 3.4.12. Head-Tail Equity Ratio in Output.

Irrigation System	Production/ha (Kg)	Overall Equity
G-K		
S_1G (head end canal)	4,360	1.57
$S_{11}K$ (tail end canal)	2,781	
PIRDP		
I_3S_1 (head end canal)	1,292	0.67
I_3S_{19} (tail end canal)	1,931	

In PIRDP, head and tail equity ratio is 0.67, indicating that the nearer canal system receives about 33 percent times less water for irrigation than the tail end of the irrigation system.

Gross Value of Farm Production (GVP), Net Value of Farm Production (NVP) as Percent of Total Household Income

The GVP and NVP range from Tk. 11,680/ha to Tk. 43,156/ha and Tk. 8,175 to Tk. 29,875, respectively in G-K (Table3.4.13). The lowest GVP is found at the extreme end of the selected tertiary canal ($T_{10}S_{11}K$), while the highest GVP at the middle tertiary of the middle secondary. The average GVP at the secondary level is Tk. 26,158, Tk. 37,109 and Tk. 16,683, respectively at head, middle and tail reaches. NVP also exhibits a similar trend, with the average NVP at the secondary level being Tk. 20,510, Tk. 24,283 and Tk. 12,880, respectively at the head, middle and tail reaches.

In PIRDP, the findings are quite different (Table 3.4.14). The highest value of GVP has been found for the extreme tail end of the selected tertiary ($_{I3}S_{19}T_{14}$M1) and the range is from Tk. 67,447 to Tk. 11,131. The lowest value is found at the last tertiary of the middle secondary. At the secondary level, GVP is Tk. 27,752, Tk. 12,908 and Tk. 11,587, respectively at the head, middle and tail reaches. NVP also shows a similar trend with same canals having the highest and lowest values. At the secondary level, the average NVP is the highest at the head reach, followed by the middle and tail reaches.

Table 3.4.13. G-K: Gross Value of Farm Production (GVP), Net Value of Farm Production (NVP) as a Percentage of Total Household Income.

Year	Name of canal	Command area (ha)	Output per unit command area (Ton/ha)			Value of Total Production in Command Area (Tk) **	GVP (Tk/ha)	Cost/ha (Tk)	NVP (Tk/ha)
			(Ton/ha)		Kg/ha (both T Aus and Aman area)				
			T Aus (HYV)	Aman (HYV)					
2000/01	S_1G	652 (170,609)*	3.72	3.63	4,359.67	17,055,020	26158	5,648	20,510
	T_1AS_1G	99 (55,97)	4.18	3.85	6,094.44	3,620,100	36566	7,242	29,325
	T_2S_1G	301 (50,273)	3.13	2.47	2,760.17	4,984,860	16561	4,385	12,176
	T_3AS_1G	91 (10,86)	3.84	4.57	4,740.88	2,588,520	28445	5,318	23,127
2000/01	S_7K	2,192 (745,1970)	4.62	5.10	6,184.79	81,342,300	37109	12,826	24,283
	T_1S_7K	235 (142,225)	3.73	5.04	7,079.40	9,981,960	42476	13,314	29,162
	T_3S_7K	144 (81,128)	4.87	5.01	7,192.71	6,214,500	43156	13,281	29,875
	T_6S_7K	176 (10,160)	5.27	5.35	5,163.01	5,452,200	30978	11,883	19,095
2000/01	$S_{11}K$	2,995 (40,2115)	3.04	3.88	2,780.57	49,966,800	16683	3,804	12,880
	$T_1S_{11}K$	107 (0,100)	2.15	3.86	3,607.48	2,316,000	21645	3,063	18,582
	$T_6S_{11}K$	196 (1,170)	3.27	4.13	3,598.83	4,232,220	21593	4,843	16,750
	$T_10S_{11}K$	240 (0,128)	3.70	3.65	1,946.67	2,803,200	11680	3,505	8,175

* Figures within parentheses are the actual area irrigated for T-Aus (Kharif-I) and Aman (Kharif-II) respectively.
** Paddy Price was assumed at Tk. 6/k.g + 10% for straw.

Table 3.4.14. PIRDP: Gross Value of Farm Production (GVP), Net Value of Farm Production (NVP) as a Percentage of Total Household Income.

Year	Name of canal	Command area (ha)	Output per unit command area			Value of Total Production in Command Area (Tk)	GVP (Tk/ha)	Cost/ha (Tk)	NVP (Tk/ha)
			(Ton/ha)		Kg/ha (both T Aus and Aman area weighted)				
			Aman (LV)	Boro + Rabi (HYV)					
2001-02	$_{13}S_1$	4,840 (1390,100)*	1.84	4.36	1,292.01	37,520,000	27,752	6,100	21,652
	$_{13}S_1T_1$	880 (780,0)	1.82	5.01	4,440.68	23,446,800	26,644	6,880	19,764
	$_{13}S_1T_2$	275 (200,100)	1.90	3.99	3,592.73	5,928,000	21,556	5,262	16,294
	$_{13}S_1T_3$	1,58 (150,0)	1.79	4.10	3,892.41	3,690,000	23,354	5,850	17,504
2001-02	$_{13}S_{10}$	8,95 (430,100)			2,151.36	11,552,800	12,908	7,695	5,213
	$_{13}S_{10}T_1$	157 (150,15)	1.40	4.42	4,356.69	40,569,000	26,140	11,716	14,424
	$_{13}S_{10}T_2$	116 (40,10)	1.94	5.24	1,029.31	6,216,400	16,175	9,296	6,879
	$_{13}S_{10}T_3$	163 (0,15)	2.05	5.26	188.65	184,500	11,131	7,130	4,001
2001-02	$_{13}S_{19}$	5,250 (2380,0)			1,931.20	60,832,800	11,587	4,565	7,022
	$_{13}S_{19}T_1$	232 (35,0)	1.27	5.99	380.17	529,200	12,281	3,982	8,299
	$_{13}S_{19}T_7$	226 (0,0)	1.71	4.80	00	0	0	0	0
	$_{13}S_{19}T_{14}M_1$	102 (210,0)	1.66	5.46	11,241.18	6,879,600	6,7447	35,005	32,442

* Figures within parentheses are the actual area irrigated for T-Aus (Kharif-I) and Aman (Kharif-II) respectively.

Irrigation Benefit per Unit Area/Water (Farm Level)

Irrigation benefits per unit area/water obtained at the farm level are presented in the Tables 3.4.15 and 3.4.16 for G-K and PIRDP, respectively. In G-K, rain-fed agriculture was practised in 4 of the 9 selected tertiaries. At the head reach only one tertiary (T_3AS_1G) and at the tail end all the tertiaries grew rain-fed crops. In the tertiaries of the middle secondary, no rain-fed agriculture was practised. The highest irrigation benefit was realized at the head reach and, except for the middle tertiary ($T_6S_{11}K$) of the tail end, secondary irrigation benefit was marginal.

Table 3.4.15. G-K: Irrigation Benefit per Unit Area/Water (Farm Level).

Year	Name of canal	NVP (Tk/ha) Irrigated	NVP-Rain-fed (Tk/ha)			Irrigation Benefit/Unit Area (Tk. ha)
			Return	Cost	NVP	
2000/01	S_1G	--	--	--	--	--
	T_1AS_1G	--	--	--	--	--
	T_2S_1G	--	--	--	--	--
	T_3AS_1G	23,127	12,250	7,962	4,288	18,839
2000/01	S_7K	--	--	--	--	--
	T_1S_7K	--	--	--	--	--
	T_3S_7K	--	--	--	--	--
	T_6S_7K	--	--	--	--	--
2000/01	$S_{11}K$	--	--	--	--	--
	$T_1S_{11}K$	18,582	29,827	12,413	17,414	1,168
	$T_6S_{11}K$	16,750	15,100	6,718	8,382	8,368
	$T_{10}S_{11}K$	8,175	12,500	6,213	6,287	1,888

In PIRDP, rain-fed agriculture was practised in six out of 9 tertiaries, one at the head, three at the middle and two at the tail end. Highest irrigation benefit of Tk 28,148 was realized in $I_3S_{19}T_{14}M_1$, the extreme tail end tertiary and the lowest benefit of Tk 708 at the first tertiary of the tail end secondary.

Table 3.3.16. PIRDP: Irrigation Benefit per Unit Area/Water (Farm Level).

Year	Name of canal	NVP (Tk/ha) Irrigated	NVP-Rain-fed (Tk/ha)			Irrigation Benefit/Unit Area (IB)
			Return	Cost	NVP	
2000/01	$_{13}S_1$					
	$_{13}S_1T_1$					
	$_{13}S_1T_2$	16,294	12,512	6,522	5,990	10,304
	$_{13}S_1T_3$					
2000/01	$_{13}S_{10}$					
	$_{13}S_{10}T_1$	14,424	11,504	6,196	5,308	9,116
	$_{13}S_{10}T_2$	6,879	10,681	7,129	3,552	3,327
	$_{13}S_{10}T_3$	4,001	5,221	3,958	1,263	2,738
2000/01	$_{13}S_{19}$					
	$_{13}S_{19}T_1$	8,299	14,116	6,525	7,591	708
	$_{13}S_{19}T_7$					
	$_{13}S_{19}T_{14}M_1$	32,442	8,732	4,438	4,294	28,148

Water Charge Collection Performance

Table 3.4.17 shows the status of water charge collection in both the projects. In G-K, up to 1992/93, there was no collection. The highest receipt of 15.12 percent of the target amount was collected in 1995/96. But, in the very next year, it was down to 4.6 percent. In PIRDP, data for only 2001/2002 are available, showing a collection of under 9.0 percent of the assessment. From the past trend, it seems that tax collection in near future may not easily improve, and the projects shall have to depend heavily on the subsidies from the government to operate and maintain the systems.

Table 3.4.17. Status of Water Charge Collection.

System	Collection authority	Collection method	Basis of tax fixation	% Achieved of targeted tax	
				Year	%
G-K	BWDB	Revenue officer assesses and serves demand notices on farmers	Per acre/ season	1992-93	0
				1993-94	10.37
				1994-95	10.04
				1995-96	15.12
				1996-97	4.60
PIRDP	BWDB	Revenue officer assesses and serves demand notices on farmers	Per acre/ season	2001-02	8.95

Source: Office of the Water Management (tax collection), BWDB, Kushtia.

Impact of Waterlogging and Salinity on the Command Areas

As both G-K and PIRDP are flood control and irrigation projects, water-logging is not a major problem in either area. Some very low-lying areas suffer from temporary drainage congestion, which is not very significant and has very little impact on the command areas either seasonally or annually.Incidence of salinity has not been observed in either of the two projects.

Groundwater Depth and Percent Change in Depth (Seasonal/Annual)

Both the project areas have good groundwater potential, which is reflected in the increased use of shallow tube-wells by the farmers to supplement surface water irrigation. Groundwater fluctuation data collected from 1982 to 1997 indicate that the average static water table varies from 4.87m in the wet season to 7.52m in the dry season. The water table usually fully recovers after the rainy season and there has been no evidence of overdraft or mining.

Number of Structures at the Primary Secondary and Tertiary Levels

Information on structures is given in Tables 3.4.18 and 3.4.19 for G-K and PIRDP, respectively. The number of structures per 1000 ha is 0.149, 0.322 and 0.306, respectively in the Ganges main canal, the Kushtia main canal and the Alamdanga main canal. In PIRDP, the number of structures per 1000 ha is 2.78, which is significantly higher than in G-K. Theoretically, because of comparatively high density of structures per unit of irrigated area, the overall performance in PIRDP should be much higher than in G-K. However, due to weaknesses in the operation, maintenance and supervision of the project, the desired results could not be obtained.

Table 3.4.18. G-K: Information on Structures.

Number of Structures			**Number of Structures per 1000 ha**		
Ganges Main Canal	Kustia Main Canal	Alamdanga Main Canal	Ganges Main Canal	Kustia Main Canal	Alamdanga Main Canal
6	12	11	0.149	0.322	0.306

As per proposed structure and command area.

Table 3.4.19. PIRDP: Information on Structures.

Number of Structures							Structures/1000 ha
Aquaduct	Check structure	Drainage	Regulator	Escape	Trunout	Total number of structures	
2	83	62	3	207	260	517	2.78

Impacts of System Performance on Poverty

Barring few exceptions, an assessment of the selected performance indicators clearly indicate that, in all cases, tail end reaches of both the G-K and PIRDP systems perform significantly poorly compared to the head ($_{I3}S_{19}T_{14}M_{1}$) and middle reaches. One notable exception is the extreme tail end tertiary in PIRDP, where both irrigation intensity and cropping intensity are the highest. The reason of this has been explained earlier. The ultimate impact of any irrigation system is the amount of increased income derived by farmers from agriculture.

In this context, the following comments may be made with reference to farm income data presented in Table 3.2.11 of Section 3.2.of this study.

In both G-K and PIRDP, the household income has increased for all categories of households (small, medium, and large farmers as well as the landless) in all locations (head, middle and tail) of all selected secondary canals. Net annual financial return per ha (from cultivation of cereals only; other crops produced are not irrigated) varies from Tk. 15,000 to Tk. 23,000 in G-K and from Tk. 18,000 to Tk. 22,000 in PIRDP, while net economic return (from 1.0 ha) varies from Tk. 13,000 to Tk. 16,000 in both G-K and PIRDP.

There are significant differences in the total agricultural income between farm households of different categories (large, medium, small, marginal) and the landless, given differential landownership. A large farm household obviously receives much more total agricultural income compared to a small or marginal farm household, which owns a maximum of 1.0 ha. However, given that HYVs cultivated consequent upon the introduction of irrigation facilities require significantly more labour compared to rain-fed agriculture, the land-poor and the landless, whose main source of income is usually sale of labour, derive increased income from this source. Also, non-agricultural activities have increased in both G-K and PIRDP in the wake of the implementation of the irrigation projects, leading to increased household incomes from these activities. Households belonging to the land-poor and the landless categories have taken up such activities more than those in the medium and large farm categories. Yet, the total household incomes of the land-poor and landless remain low.

Also, generally, the households at head and medium reaches have benefited more than the tail enders, although there are exceptions. But, comparable or better performance at tail end tertiary (e.g. the tail tertiary, T_4M_1 of S_{19} in PIRDP) is also due to tubewell irrigation used by these farmers to supplement the inadequate surface irrigation water they have access to. Also, given comparatively lower irrigation coverage in that location, the overall water availability may be sufficient for the area covered.

Participation of farmers in irrigation management through WMGs and WMAs has brought about a positive impact in relation to reduction in inequity in water distribution. But, there is ample scope for improvement in irrigation management through more efficient and purposeful functioning of WMGs and WMAs. Simultaneously, improved transparency and efficiency on the part of BWDB functionaries is necessary for ensuring maximum possible water availability in the canals at appropriate times (i.e. as required at various stages of crop growth) and improving equity in water distribution to farmers of various categories and at different locations.

Conclusions and Recommendations

It emerges from the analyses presented above that the G-K and PIRDP irrigation systems have not performed satisfactorily and, as a result, their full potential has not been realized. The performance has been evaluated in terms of area coverage, irrigation intensity, output per unit of water, output per unit of labour, and head-tail equity. Results indicate that, because of inadequate system performance, the most adversely affected are the land-poor and the landless groups.

It has also emerged that public agencies alone have not been making a significant impact towards improving agricultural performance. Beneficiaries should, therefore, be involved in the management of the irrigation systems through participatory irrigation management (PIM) or irrigation management transfer (IMT) activities e.g. effective formation and functioning of WMGs and WMAs. Some successes have been achieved, more so in G-K, regarding irrigation management transfer through WMGs and WMAs. But, these institutions are yet to be formed in certain areas, particularly in PIRDP; formed but not properly operational in certain other areas, and there is scope for improvement in still other areas where these institutions are already on operation. The approach is promising, and more purposeful efforts are needed for realizing the full potential. Regarding collection of water charges, the results have been very disappointing.

Recommendations

- There is ample scope for increasing agricultural yield in both G-K and PIRDP. For improved agricultural yield per unit of land, labour or irrigation water used, proper application of irrigation-seed-fertilizer technology is needed through coordinated action by BWDB and other government agencies on the one hand and WMGs/WMAs on the other. Tertiary canals and below may be handed over to the WMGs for management.

- BWDB, responsible for O&M, should improve its own performance and keep the system operating at the optimum level. An extensive agricultural extension campaign needs should be initiated to improve agricultural practices and, hence, yield.

- To improve the beneficial impact of irrigation on the poor, effective steps are needed to bring the entire potential command area under irrigation and to ensure equitable distribution of water to all areas, and to all categories of households. Given that their access to irrigation water improves, they will secure increased agricultural productivity. The landless will benefit as a result of increased employment opportunities arising from expanded irrigation and, hence, expanded cultivation of HYV.

- Towards enhancing the benefits receivable by the land-poor and the landless, they may be employed in water distribution operations under an IMT agreement.

- Efforts should also improve to involve the land-poor and the landless in rural non-agricultural activities. The scope of this pe would expand as agricultural income increases as a result of improved irrigation management and agricultural practices. Through appropriate advisory arrangements and ensuring availability of credit, technologies and other needed services, they may be encouraged and facilitated to start tiny/small enterprises in agro-support (e.g. fertilizer, pesticide, farm implements) and agro-processing (as vegetable, fruit processing) activities.

Annex

The indicators are assessed, conforming the following definitions:

1. **Irrigation Intensity:** Irrigation Intensity (II), is defined by the ratio of net irrigated area (NIA) and the design command area (DCA): II=NIA/DCA

2. **Cropping Intensity:** Cropping intensity (CI), is defined by the ratio of gross cultivated area (GCA) to design command area (DCA): CI=GCA/DCA

3. **Output per Unit Command Area**: Output per unit command area (OCOA) is defined as the ratio of total production (TP) and command area (COA): OCOA=TP/COA

4. **Total Production in Command Area:** The command area is the nominal or design area to be irrigated i.e. considering irrigated area that nominally is to serve 1000 ha. During the rainy season, 800 ha are irrigated and during the dry season 400 ha are irrigated. In this case, the irrigated-cropped area is 1200 ha. The command area is 1000 ha. Production here is the output of command area in terms of gross or net value of production.

5. **Output Per Unit of Diverted Irrigation Water**: Output per unit of diverted irrigation water (ODW), is defined as the ratio of actual total production (ATP) to diverted irrigation water (DIW): OEW= ATP/DIW. DIW is the volume of surface irrigation water diverted to the command area, plus net removal from groundwater.

6. **Output Per Unit of Consumed Water:** Output per unit of consumed water (OCW), is defined as the ratio of actual total production (ATP) to volume of water consumed by ET (WET): OCW= ATP/WET. WET is the actual evapotranspiration of crops.

7. **Output Per Unit of Labour:** Output per unit of labour (OL), is defined as the ratio of actual total production (ATP) to total number of person days of labour (PDL): OL=ATP/PDL

8. **Head Tail Equity Ratio in output:** Head tail equity ratio in output (HTERO) is computed as the ratio of average output per unit area of the upper 25 percent of the system-head- (OUAH) to average output per unit areas of the tail 25 percent of the system (OUAT) HTERO=OUAH/OUAT. Output may be defined in terms of GVP.

9. **Relative water supply (RWS):** Relative water supply is defined as the ratio of total water supply (TWS-which is equal to surface diversions plus net groundwater draft plus rainfall) and crop demand (CD- is equal to potential crop ET or ET under well watered condition- incase of rice deep percolation an seepage losses are added to crop demand) RWS= TWS/CD

10. **Relative Irrigation Supply**: Relative irrigation supply (RIS) is the ratio of total irrigation supply (TIS) plus net groundwater draft and crop demand, RIS=TIS/CD. It is also an indicator of adequacy and shortage of water supply.

11. **Water Delivery Capacity:** Water delivery capacity (WDC), is defined as the ratio of canal capacity to deliver water at system head (CCD- the present discharge capacity of the canal at the system head) and peak consumptive demand (PCD- the peak crop irrigation requirements for a monthly period expressed as a flow rate at the head of the irrigation system): WDC=CCD/PCD. Here the month of April has been considered for computation.

12. **Water Delivery Performance:** Water delivery performance (WDP), is defined as the ratio of actual (AD) to target (TD) volume of water delivered: WDP=AD/TD.

13. **Over all System Efficiency:** Over all system efficiency (OPE), is defined as the ratio of crop water requirements (CWR) and total inflow into the canal system (TI): OPE=CWR/TIC.

14. **Head Tail Equity:** Head tail equity ratio (HTERW) defined as the ratio of average delivery performance ratio (DPR- which is the ratio of actual to target discharge) of upper 25 percent of the system (DPRH) to average DPR of tail 25 percent of the system (DPRT): HTERW=DPRU/DPRT.

15. **Gross Value of Farm Production Per Unit Area:** It is defined as output per unit area measured at local or world prices. Standardized gross value of production (SGVP) is a better indicator than GVP as it accounts for differences in local prices, accounts for crop not traded in the international markets, and is useful for cross system comparison purposes.

16. **Net Value of Farm Production Per Unit Area:** Net value of farm production per unit area is defined as GVP per unit area minus cash costs of production.

17. **Irrigation Benefit Per Unit Area/Water (farm level):** Irrigation benefit per unit area (IB) is defined as the net value of farm production per unit area (NVP) from irrigated area minus net value of farm production per unit area from rain-fed (Irrigation benefit per unit of water diverted can be calculated simply by dividing the differences in NVPs by the total water diverted).

18. **Water Charge Collection Performance:** Water charges collection performance (WCCP) is defined as the ration of actual total annual income from irrigation water charges (TIWC) collected to maximum collectable, assessed, or due (MCWC).

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3.5. ANALYSIS OF WATER MANAGEMENT INSTITUTIONS: IMPLICATIONS FOR THE POOR

Introduction

Different policy and planning documents of the Government of Bangladesh have emphasized the need for the adoption of new technologies, especially the seed-fertilizer-irrigation technology, with a view to bring about rapid increase in crop production, food security and poverty alleviation (GoB, 1998; Khan, 1991). This is particularly so in the case of rice production in which the adoption of high yielding varieties (HYVs) has accelerated in both the crop seasons of the year (Boro-HYV in dry season and Aman-HYV in monsoon). For successful adoption of HYVs, irrigation is necessary. Expansion of irrigation is thus, considered to be a crucial input for increasing production of rice and wheat.

In Bangladesh, there are two main types of irrigation: surface irrigation and groundwater irrigation. Total irrigation coverage in the country amounts to 53 percent of country's arable land. Of all irrigated areas, the share of surface irrigation is of about one-fourth, while the remaining area is irrigated by tubewells; and tubewell irrigation has been gradually rising. For surface irrigation the government has several large-scale surface irrigation projects such as G-K Project, Chandpur Irrigation Project (CIP), Karnaphully Irrigation Project (KIP), Muhuri Irrigation Project, and Pabna Irrigation and Rural Development Project (PIRDP). These state-managed projects irrigate about 0.20 million hectares of land. The surface irrigation coverage has been continuously declining, mainly due to water shortages as a result of upstream (in India) diversion of waters of transboundary rivers. Its adverse effect is more pronounced in the tail end reach of the irrigation canals and also perhaps on the small and marginal farmers. To mitigate the sufferings of the irrigators through improvement of irrigation performance and regaining the irrigation coverage earlier achieved, water use efficiency must be raised. Some innovative approaches have been adopted to this end in some of these projects, of which G-K and the PIRDP have been selected for the present study.

Of the two selected projects, G-K is the oldest and the PIRDP is the newest among the large surface irrigation projects in Bangladesh. In PIRDP, field channels are still being developed. In both these projects, there are main, secondary and tertiary canals spread over many villages in the command areas. The irrigation coverage achieved in both cases is significantly lower than the area planned during the project preparation. Further, it has been noticed that, in some parts of G-K, the area irrigated has also declined from the level achieved earlier. Consequently, costs of irrigation are rising. But the amount of water charges collected has been declining, threatening the sustainability of the projects.

The decline in irrigation coverage is caused by several factors such as shortage of water supply in the canals, poor maintenance of the structures (sluice gates, syphons, outlets etc.), excessive seepage loss and poor management of water distribution in the fields. This component of the research study seeks to investigate the institutional factors affecting the use of water and to suggest suitable measures towards farmers' effective participation in irrigation management. Traditionally, Bangladesh Water Development Board (BWDB), an agency under the Ministry of Water Resources, and the project authorities appointed by it were responsible for all actions relating to provision of water flows in the canals and their distribution among command area farmers as well as maintenance of irrigation infrastructure. There are other government agencies involved in similar tasks but in smaller projects.

Recently, Water Resources Planning Organization (WARPO) has been set up to deal with policy aspects of water management, while BWDB retains the responsibility of managing large projects. However, the following innovative steps have been undertaken recently to ensure the best possible development and utilization of water resources, within the guidelines provided by the National Water Policy adopted in 1999 and the recently adopted Participatory Guidelines for Water Management (PGWM).

Towards ensuring participation of water users in the allocation and distribution of water, Water Management Groups (WMGs) are to be formed in each field outlet, which are then to be organized into Water Management Associations (WMAs) within the same tertiary canal. These field level institutions are mandated to play a key role in the determination of different uses of water across households. It is also expected that this institutional innovation will lead to more efficient use of irrigation water and, consequently, to higher agricultural yield and production.

The principal hypothesis of the study in the context of institutional interactions and innovations is that planned allocation and distribution of irrigation water and effective implementation of water and irrigation rights will benefit the farmers more. It is also hypothesized that innovative institutional arrangements at farm level will improve the performance of the existing irrigation systems.

The main objectives of the study are, therefore, to examine the impact of recently introduced interventions/innovations on irrigation outcome in terms of equitable access of irrigation water to farmers of various categories at different reaches of the irrigation system and the consequent increased agricultural production reaped by them. As a management issue, the level of collection of water charges will be reviewed. An attempt will be made to identify the institutional factors. By addressing them in an appropriate manner, irrigation performance can be improved.

The study is based on both qualitative and quantative information collected through Participatory Rural Appraisals (PRAs), focus group discussions (FGDs) with the key stakeholders and household surveys. Available relevant secondary sources have also been made use of. The details of the methodology may be seen in Section 3.2.

Relevant primary and secondary data and information generated through the above mentioned methods have been used to analyze the institutional factors towards fulfilling the objectives and test the hypotheses relating to this part of the study. The main limitation of the present research study is the lack of benchmark information i.e. pre-project situational statistics. Institutional performance at the project level has been analyzed focusing, in particular, on the effectiveness of WMGs and WMAs. Before embarking on that analysis, a brief discussion on the existing macro level institutional framework for the water sector is presented to set the scene.

Institutional Framework – Macro to Micro[14]

Water, is a scarce resource in Bangladesh agriculture in many parts of the country during the dry period of the year (March to May) given its limited availability on the one hand, and other uses on the other. Other uses include adequate flow of water in the river for its riverine health, in conjunction with the in-stream need for water for navigation, fish production, industrial use, and drinking and other household uses. There is a growing demand for water as a result of the increasing population, and expanding economic activity including crop production. Incremental demand for water due to increasing production of crops is now met largely from groundwater, harnessed through tube-wells.

[14] This section is based mostly on (Huda, 2001).

The surface irrigation coverage remains stagnant or has, in some areas, declined due to reduced flows of water caused by upstream diversion of water in India. Given the objective of increasing agricultural production and surface water shortages for irrigation, groundwater irrigation has been extensively used, leading to over-exploitation of groundwater with adverse environmental consequences in many areas. Also, the widespread arsenic contamination of groundwater in the country might be a consequence of this groundwater over-exploitation.

Proper guidelines should be in place for proper water management with a view to promoting, through water sector interventions, economic development, poverty alleviation, food security, public health and safety, decent standard of living for the people and protection of the natural environment. For managing the country's water resources in a holistic manner, a National Water Management Plan and its periodic updating is necessary in addition to a comprehensive National Water Policy, which itself needs to be updated to address issues not already addressed or newly emerging from time to time. A Water Management Plan, within the framework of the National Water Policy adopted in 1999, has been prepared, which is awaiting government approval.

The highest decision-making body concerned with the water sector is the National Water Resources Council (NWRC) chaired by the Prime Minister of which there is an Executive Committee chaired by the Minister for Water Resources. The NWRC provides the policy guidelines and approves the plans and programmes of the sector. The Ministry of Water Resources is the line ministry responsible for the coordination and direction of water sector activities.

The preparation and updating of both the National Water Policy and the National Water Management Plan is the key responsibility of Water Resources Planning Organization (WARPO), an agency under the Ministry of Water Resources. In addition, WARPO is also mandated to advise other water-related organizations in the development, use and conservation of water, and provide specialized multi-disciplinary and cross-sectional training to concerned functionaries. While WARPO is responsible for water sector macro planning, it is also expected to promote appropriate linkages between macro and micro level planning and provide guidelines for the efficient use of the country's water resources by all users and in all uses.

The key arm of the government for the implementation of the water sector projects is the Bangladesh Water Development Board (BWDB), which is also under the Ministry of Water Resources. It has been implementing flood control and drainage (FCD) and flood control, drainage and irrigation (FCDI) projects, which are major water development projects in the country. Two of the large surface water irrigation projects that BWDB has been implementing are Ganges-Kabadak (G-K) and Pabna Irrigation and Rural Development (PIRDP) projects. Operation and maintenance of these two projects are the responsibility of BWDB.

It seems in order to briefly describe three other organizations with important water sector responsibilities, although they are not involved in the operation and maintenance or in any other way in the management of G-K or PIRDP. The Local Government Engineering Department (LGED) of the Ministry of Local Government, Rural Development and Cooperatives has a major responsibility in the water sector, which is to undertake small irrigation and flood management infrastructure development projects. Its responsibilities also include technical support to the rural local government institutions and local level planning, implementing and maintaining and monitoring infrastructure development projects in rural and urban areas; and also imparting training to LGED officials and others when needed. LGED works with local communities in the development of rural infrastructure and, more recently with promoting community participation at all stages of project cycles as it implements various projects.

Another agency is Bangladesh Agricultural Development Corporation (BADC) of the Ministry of Agriculture, which took the lead in minor irrigation by introducing low-lift pumps and deep tube-wells through cooperatives. Shallow tube-wells have always been in the private sector, installed by individuals. In the late 1980s, BADC withdrew its irrigation services, leaving all irrigation equipment to farmers' groups or individuals. Minor irrigation is at present managed by the farmers themselves except in the Barendra area of the Rajshahi Division where Barendra Multipurpose Development Authority (BMDA) has taken that responsibility. In this development programme, irrigation water has been given the top priority and, accordingly, due support is being extended for the installation of shallow and deep tube-wells.

Department of Agricultural Extension (DAE) of the Ministry of Agriculture has a major responsibility relating to agricultural development in the country. The new Agricultural Extension Policy adopted in 1999 takes into account all important sub-sectors of agriculture: crop, fisheries, livestock, and forestry. The DAE's principal mandate is to disseminate available new technologies to the farm households. It has many area-specific agricultural development projects implemented in collaboration with other related government agencies and, also, NGOs when useful. Such collaborative programmes can also be promoted in both G-K and PIRDP, where such programmes do not exist now.

It is now well recognized that, given the objective of increasing irrigation coverage and improving water use efficiency, collaboration of public development agencies and private institutions such as WMGs and WMAs at different levels of operation is necessary. It is also recognized that people's participation in water management will create an enabling environment. In both G-K and PIRDP, people's (farmers) participation is being promoted through WMGs and WMA.

Findings and Analyses

Irrigation Infrastructure

Before an in-depth analysis of information collected from G-K and PIRDP, the existing irrigation structures and their coverage in the two projects as shown in Statistical Table 1, may be briefly discussed. G-K is six times larger than PIRDP and, as such, it has many more canals and field outlets. The number of field outlets per primary canal is, however, eight in both the projects, although per kilometer of primary canal it is 3.5 in G-K and 6.2 in PIRDP, suggesting that the latter is better endowed with field outlets. However, the command area for irrigation per outlet is larger in PIRDP (about 44 ha). The project is essentially a low basin area where irrigation requirement of a crop is low. The cropping intensity is higher in G-K as most of its land is medium to medium-high, where two crops can be easily grown. The main cropping pattern in G-K involves HYV Aman and HYV Aus. In PIRDP, the principal irrigated crop is HYV Boro. During the monsoon, much of its land is submerged by flood water.

Socio-economic Conditions

The average family size is almost the same in both the projects (about 6 members) and over 80 percent of the people in both are involved in agriculture. The farm size is a bit higher in G-K (larger than one hectare). The land distribution is very skewed in both, more so in G-K. The respective proportions of owners, owner-cum-tenants and tenants are 65 percent, 28 percent and 7 percent in

G-K and 62 percent, 24 percent and 14 percent in PIRDP. The gross per ha yield is significantly higher in G-K than in PIRDP.

Coverage of G-K and PIRDP Systems

G-K, the oldest surface irrigation project in the country, is predominantly a Transplanted Aman cropped (monsoon rice) area, where irrigation is needed for raising seedlings and also during the crop growing period, particularly during periods of moisture stress. Boro is less important in the area due to scarcity of water but instead HYV Aus is grown in the pre-monsoon season, often with the help of tubewell irrigation; it had the highest coverage of about 43,000 hectares, about 37 percent of the command area, in 1990/91. Aman rice, on the other hand, occupied a record maximum area of about 100 thousand hectares or 86 percent of the command area in 1995/96 (BWDB, 2002).Later on it tended to decline and was sharply down in 2001/02 (Statistical Table 2) covering only 45 percent of the command area as a result of breaching of the embankment by the members of the public at Amla in Sagarkhali in September of that year in response to serious drainage problems in the nearby localities. The situation did not improve in 2002/03.

HYV Boro, the main irrigated crop in the low lying PIRDP area, replaces deep water Aman paddy grown under rain-fed condition. HYV Boro was cultivated in record 10 thousand hectares, or 54 percent of PIRDP command area, in 2001-02 (Statistical Table 2). Little Transplanted Aman is grown there. The area suffers widely from drainage problem. Irrigated area in PIRDP is slowly increasing as irrigation infrastructure is being developed.

Performance of the Selected Canals

In each of G-K and PIRDP, three secondary canals have been included for study, which are S_1G, S_7K and $S_{11}K$ from G-K and I_3S_1, I_3S_{10} and I_3S_{19} from PIRDP. Among the three selected canals in G-K, S_1G had the highest irrigation coverage ever of about 78 percent of the command area in the main Aman season, while, in PIRDP, I_3S_{10} had the best ever performance irrigating 54 percent in Boro season (Statistical Table 3). The overall performance of the secondary canals with respect to irrigation coverage is, however, not up to the expectation in most cases, as there is still huge potential for irrigation expansion (Statistical Table 4).

Identification of the 'Best' and the 'Worst' Performing Tertiary Canals

Tertiary canals selected for the study are nine in each irrigation project, three from each of the three selected secondary canals (at head, middle and tail). A total of 18 tertiary canals from the two projects are thus included in the study. Three key indicators have been used for the purpose of comparison, between the tertiaries, based on immediate availability of data and information. These indicators are irrigation coverage achieved, crop productivity, and water use output in the respective main irrigation season (Aman in G-K and Boro in PIRDP) as of 2000/01 (Statistical Table 4). Of the nine selected tertiary canals in G-K, T_1A, the head tertiary of S_1G, had the highest irrigation achievement covering 97 percent and T_1S, the tail tertiary of S_7K, the least achievement irrigating only 23 percent of the respective command areas in the Aman season. In PIRDP, $T_{14}M_1$, the tail tertiary of S_{19}, performed the best in terms of irrigation coverage, irrigating the whole of the command area, while T_3, the tail end tertiary, of the secondary canal of S_{10} performed the worst in this respect. Irrigation coverage by different tertiary canals indicate that although most of the head tertiaries of the selected secondary canals performed better, there are also middle and tail end tertiaries that have records of good performance.

According to the level of paddy output (per hectare), the best performing tertiary in G-K is the tail end of S_7K (5.4 tons/ha) followed by the head reach of the same canal (5.04 tons/ha). That means, the earlier identified best tertiary (head of S_1G) based on highest irrigation performance is not the best performer in terms of yield (3.85 tons/ha). In terms of water use output, the head tertiary of S_7K stands at the top (0.018 ton/unit of water), followed by middle tertiary of S_1G. The head tertiary of S_1G again fails to reach the highest level. If all these three indicators are taken into consideration, the head tertiary of S_7K seems to be the best in G-K. It has an irrigation coverage of 85 percent generating paddy yield of 5.04 tons/ha and paddy output of 0.018 ton per unit of water use (Statistical Table 4).

Given that in G-K, the tail end reach of S_7K has the least irrigation coverage (23%), and high paddy output (5.35 tons/ha), it may be surmised that, for the area covered, there was no shortage of water. Moreover, farmers there also use tube-well irrigation as a supplement. On the other hand, the head tertiary of $S_{11}K$ is characterized by lower irrigation performance (37%) as well as lower productivity (3.86 tons/ha). It suffers from water use in-efficiency. On the whole, the head tertiary of $S_{11}K$ can be considered the worst performer in G-K. (Statistical Tables 3 and 4).

In PIRDP, the paddy output is the highest at the tail end reach of S_{19} (5.46 ton/ha). Irrigation performance varies substantially across canals. With respect to crop output per unit of water use, the performance in PIRDP varies little across canals and their different reaches. On the whole, it appears that the tail end reach of S_{19} is the best performer while the head reach of S_{19} the worst tertiary. It appears that, for the area covered, the tail end reach of S_{19} is served well by surface water availability, supplemented by tubewell irrigation as necessary. Other tertiaries in the project with small irrigation coverage are either under repair and maintenance or are not being properly used as tubewell irrigation is available. (Statistical Tables 3 and 4).

To conclude, the tertiaries identified as the best, according criteria outlined are head reach of S_7K in G-K and the tail end reach of S_{19} in PIRDP, while worst tertiaries are the head reach of $S_{11}K$ in G-K and head reach of S_{19} in PIRDP,respectively. The differential levels of performance of the selected tertiary canals at different locations indicate that, besides the location of a tertiary, there are many other factors that determine the overall performance. These include access to tubewell irrigation and institutional factors. The institutional factors are discussed in the following sections.

Institutional Innovations

In the late 1990s, for sustainable improvement of irrigation performance and rapid adoption of new HYV technology in rice and wheat, participatory character of water management in G-K was sought to be enhanced and, to that end, the earlier Outlet Committees were re-named as Water Management Groups (WMGs). A WMG consists of nine members; one-third each from large, medium and small farm categories. Further, 10-15 WMGs from each of the tertiary canals are then formed into an Association, known as Water Management Association (WMA). These institutions are expected to manage water distribution in all field outlets from head to tail, attached to the same tertiary canal. The WMGs and their constituent WMGs work under close supervision of the BWDB officials, responsible for distribution of water up to the tertiaries and their expansion in the project areas (Ali, 2001).

These innovations in field operations and irrigation extension in G-K have been carried out for promoting farmers' direct participation in irrigation management to contribute to improved performance of the irrigation system. In PIRDP, the changed organizational set-up, as introduced in

G-K, has been initiated from the very beginning and its water management groups are still being formed as infrastructural facilities are expanded in the command areas of the project.

These institutional changes at the field level are expected to help increase crop production and productivity for all categories of farm households, especially the poor farmers, given equitable access to water and irrigation water use efficiency. Furthermore, the differences in irrigation performance between the head and the tail end reaches are expected to be narrowed as a result of improved water distribution, provided the farmers are equally responsive to improving agronomic practices and input use.

Distribution of irrigation water for crop use from available flows in the canals in both G-K and PIRDP is now determined by the WMGs and the corresponding WMAs in collaboration with the BWDB field officials. Irrigation water is distributed to the crop fields on the basis of requirements with reference to land quality, given the availability of surface water in the tertiary canals. Any conflict relating to the distribution of water is taken care of by the concerned officials of the BWDB in consultation with the WMGs. There is, however, no specific government rule in this regard. Land nearer to the canals as usual get irrigation earlier. No differentiation is made between small and large farms. The shortages of canal water in the project areas compel farmers to install shallow tubewells to supplement canal irrigation. At present there are no restrictions on the installation of tubewells. So far, 10,000 shall tubewells have been installed in G-K and 3,000 in PIRDP to facilitate irrigation expansion in the respective areas.

Effects of Institutional Factors on Water Use Efficiency

WMGs and WMAs

In-depth investigations into access of the households to WMGs and WMAs in G-K clearly show that in the 'best' performing canal area, the access of the households to WMGs and WMAs is the highest and the member farmers are well-informed about the relevant issues (Statistical Table 5). With respect to membership, another tertiary – S_7K at middle – is also quite advanced but the members in this case have poorer perception about the activities of WMGs and WMAs and their irrigation performance appears to be relatively poor. In the 'worst' tertiary, proper formation of WMGs and WMAs has not occurred and the farmers do not have access to systematic irrigation information. Overall also, it is to be noted that only few meetings of the general bodies of the groups and associations were held in G-K, indicating inadequacy of consultations taking place. However, in both the S_7K head and S_7K middle, respondents have not mentioned any institutional constraints (Statistical Table 6). In G-K, the major problems are water scarcity in the canals and poor infrastructure (Statistical Table 7).

In PIRDP, in the identified 'best' canal (S_{19} tail) area, WMG membership is low and, hence, many do not have irrigation related information. The performance of the WMGs and WMAs is not good and about the same as that in the case of the 'worst' canal. However, in the case of head tertiaries of S_{10} and S_1, institutional membership and irrigation information are much better (Statistical Table 8). Interviews, however, reveal that institutional constraints faced in S_{10} and S_1, e.g. poor performance of the concerned government officials, problems with the patway, theft of water etc., have not been addressed properly. (Statistical Table 9). Regarding physical factors, poor O&M generally appears more of a constraint compared to others (Statistical Table 10). It is seen that, in PIRDP, the identified 'best' tertiary has almost the same level of performance as attained by S_1 or S_{10}.

In summarizing the above findings, it may be suggested that, in G-K, the successful performance of the tertiary canal is determined largely by the active participation of water users through WMGs and WMAs and the efficiency of the BWDB officials, which perhaps can, to some extent, take care of the weaknesses of the existing poor O & M of irrigation infrastructure. In the case of PIRDP, a clear identification of the institutional factors has not been possible as the performance in the command areas of all the selected canals do not vary much. Moreover, participatory water management has been more recently introduced in this project and is yet to generate its impacts properly. The only factor favourable to good performance that can be easily identified is the adequacy of field outlets.

Field surveys reveal that, in both G-K and PIRDP, proper coordination of activities carried out by BWDB, other government agencies and WMGs/WMAs is generally lacking. Effective coordination, it has been suggested, can remove bottlenecks in relation to timeliness and appropriateness concerning maintenance of structures, more equitable distribution of irrigation water timely and adequate access of farmers to other inputs, transparency and efficiency in the discharging of responsibilities by BWDB officials, and effectiveness of WMGs/WMAs.

Involvement of Government Agencies

As pointed out earlier, the principal government agency in the management of both G-K and PIRDP is the BWDB, of which the Engineering and the Extension Divisions are directly involved. Besides, the DAE of the Ministry of Agriculture and the Cooperatives Division of the Local Government and Rural Development and Cooperatives are also implementing programmes focused on agricultural development. The DAE is mainly concerned with the promotion of new crop production technologies and improved and balanced input use; while the Cooperatives Division distributes credit to farmers' associations formed within the framework of its mandate, which are known as Krishak Samabaya Samity (KSS), for agricultural and rural development. The involvement of BADC is highly concentrated in seed distribution. RKUB distributes agricultural credit according to its own programmes. It has both short-term and long-term credit programmes in the G-K and PIRDP areas as also elsewhere in Bangladesh. It does not provide any special credit for shallow tubewells and other agricultural equipment. Clearly, support for agricultural development in the area is dependent on public sector agencies such as BWDB, DAE, and RAKUB. In addition, there are some NGOs operating in the areas, mainly providing micro-credit for non-farm activities.

Distribution of Institutional Credit

About 34 percent of the farmers received intuitional credit in G-K and about 10 percent in PIRDP. Amount of credit per recipient amounts to only Tk. 15.34 thousand in G-K and about 55.8 thousand in PIRDP in 2001/02. Considering all farm households, the average is estimated at only Tk. 5.15 thousand in G-K and Tk. 5.34 thousand in PIRDP in 2001/02. BKUB's share in all credits distributed is 73 percent in G-K and almost all in PIRDP (Statistical Tables 11 and 12).

Among the selected canals, there is no clear pattern regarding credit recipients with reference to the location of the canals, i.e. head, medium or tail. In the identified 'best' performing canal in G-K, only 22 percent of farm households received institutional credit, averaging Tk. 5,130 only, which is about the same as in the 'worst' tertiary. Maximum credit recipients in G-K are from S_1G canal, particularly at its tail end (62%). In PIRDP, institutional credit is the least in the identified 'best' tertiary (only 4%), averaging Tk. 120 per farm household. There are relatively more recipients in the identified 'worst' (17%) canal, while the average per household credit is the highest at Tk. 20.39

thousand at head tertiary of S_{10}. In PIRDP, as a whole, the average per household credit received is Tk. 5.34 thousand only (Statistical Tables 11 and 12).

In summary, it has been seen that there are no special credit programmes in G-K or PIRDP, and that irrigation based agricultural development in the two areas appears to be the exclusive responsibility of the BWDB.

Water Policy and Irrigation

The National Water Policy, adopted for the first time by the Government of Bangladesh in January 1999, provides guidelines and directions for a comprehensive, integrated and equitable management of water in the country. It also emphasizes on the need for participatory approach in planning and management of water, including irrigation water. However, it provides no detailed guidelines on water pricing and cost recovery. To that end, there is the Bangladesh Irrigation Water Rate Ordinance 1983, amended as the Bangladesh Irrigation (Amendment) Act 1990 (GoB, 1990). The law mainly relates to the imposition of water rate for supply, regulation or storage of water for irrigation or drainage. Assessment of water charge is made on the basis of the area irrigated irrespective of the size of the farm. There is no provision favouring the tenant or landless farmers in the project areas. The BWDB is the only authority responsible for assessment and collection of water charges.

Collection of Water Charges

As mentioned earlier, the BWDB is the only agency responsible for distribution of irrigation water to the primary canal and that it decides water rates for irrigated crops, sometimes in consultation with the WMAs. Examples of water rates charged are Tk. 500 per acre in G-K and Tk.540 in PIRDP. Different rates are charged for different crops depending on the requirement of irrigation water. The rate for a crop is, however, uniform throughout the project area. It does not differentiate between the land topography or soil quality, perhaps for the sake of easy administration. But collection of the water charges is poor in both G-K and PIRDP. In G-K as a whole, annual rates of collection in the 1990s range from 5 percent to 15 percent of the targeted sum; moreover, the collection rate has fallen overtime. In PIRDP, collection amounts to only 9 percent for 2000/01 (Chapter 4 of this study, Table 4.17).

Beneficiaries of Irrigation

Canal Irrigation

Irrigation in an area may be expected to benefit the farm households according to the amount of the cultivated land owned by them in the command area, that is, a large land owner would benefit more than a small farmer. But such proportional sharing of benefits of irrigation accruing to different sizes of farms may not necessarily happen due to various reasons such as shortage of irrigation water in the canal leading to its chaotic distribution, improper location of outlets and irrigation channels, mis-management by the BWDB staff, and unfavourable land topography.

Land distribution is very skewed in both G-K and PIRDP, more so in the former. Small farmers (owning 0.21 to 1.0 ha/household) and the landless (defined as owning less than 0.2 ha/household) constitute 71 percent of all farmers owning 25 percent of the irrigated land in G-K and 78 percent owning 45 percent in PIRDP. On the other hand, medium and large farmers constitute 29 percent and 22 percent owning 75 percent and 55 percent of irrigated land in the two projects respectively (Chapter 1 of this study, Tables 1.2 and 1.3).

Irrigation intervention in the two project areas improved the cropping patterns with the expansion of HYVs. In G-K, HYV Aman area has increased by 55 percent and HYV Aus by 44 percent. In PIRDP, the increase is exclusively in HYV Boro but, proportionally more than in G-K. Substantial growth in the adoption of HYVs has led to higher farm income (Tk. 29.000 to Tk.46,000 per ha in G-K and Tk. 28,000 to Tk.29,000 in PIRDP). There has also been an overall increase in production, employment and net return in irrigated areas compared to rain-fed areas in all sections – head, middle and tail.

On average, per capita annual income (farm plus non-farm) across farm size groups ranges from Tk.12,000 to Tk.14,000 in the irrigated areas, which is estimated to be 14 percent higher compared to that in the rain-fed areas. Although, larger landowners benefit more, small landowners have also secured irrigation water. The land-poor and the landless have also derived benefits from increased employment resulting from HYV varieties being cultivated more and more. But the benefits they derive remain limited, given their very limited access to land (Chapter 1). Increase in employment and wage income as a result of irrigation expansion has also been reported by other studies (Quasem, 1994 and Khan, 1991). The benefits can be further increased in the irrigated areas in terms of both irrigation expansion and productivity increase. A more equitable distribution of those benefits through strengthening of the WMGs and WMAs in place or are being formed in the project areas will particularly help the land-poor and the landless. The land-poor and the landless may also take advantage of the expanding economic opportunities in the non-agricultural sector, arising as a result of increased agricultural income due to irrigation expansion.

Summary and Recommendations

Irrigation performance of the selected canals in both G-K and PIRDP is significantly below the respective designed levels, more so in the former mainly due to inadequate supply of irrigation water to the canals and poor O&M. In PIRDP, there has been little improvement in irrigation performance overtime despite adequate availability of irrigation water. The main reason seems to be poor participation of farmers in water management.

Irrigation performance of the canals under study in terms of irrigation coverage, crop productivity and water use output, attained in the year 2000/01 was very substantial in both G-K and PIRDP. Generally, the head tertiaries have performed better. Improved performance is also exhibited by the middle tertiaries, but a mixed picture emerges from the tail teriaries. The differential levels of performance among the tertiaries are important due to institutional factors, as the existing physical and operating constraints can be removed through effective management.

Towards improving irrigation performance in the project areas, some institutional reforms were initiated in the mid-1990s. These reforms include formation of Water Management Groups (WMGs) at the outlet; Water Management Associations (WMAs) consisting of the WMGs under the respective tertiaries, at the tertiary level; and Water Management Federation at the apex level formed by the WMGs. The purpose of establishing these field organizations was to promote farmers' direct participation in the allocation and distribution of water to individual farms. Institutional reorganizations are expected to expand irrigation coverage in the command areas, reduce O&M costs, increase crop productivity, and improve collection of water fees towards sustainable improvement of the irrigation projects.

Large landowners necessarily benefit more than the smaller landowners. But, it has been seen that smaller landowners have derived increased benefits by efficiently using the available water on the limited account of land they cultivated. The increased labour requirement under irrigated conditions is also benefiting the small and marginal farmers, who also sell labour, and the landless. These opportunities of earning incomes have helped many land-poor to retain their land and save themselves from joining the ranks of the landless in the two project areas. In G-K, the number of small and marginal farmers and the landless is less than one-third so that a very large portion of the total benefit arising in the area as a result of irrigation accrues to medium and large farms. Appropriate land reform will improve the opportunities of the land-poor and the landless to enhance benefits to be received by them. The land-poor and the landless, being more in the tail end (83%) of PIRDP, adequate availability of surface water there will benefit them more.

To identify the factors determining irrigation performance, what has been happening in the command area of the selected canals in terms of farmers' membership of the WMGs and WMAs and their participations in the meetings held, and visits by the WMG and WMA leaders to farmers for dialogues has been examined.

Based on the irrigation performance, per hectare yield of paddy and water use output, the 'best' tertiary canal is identified to be the head tertiary of S_7K in G-K and the tail end tertiary of S_{19} in PIRDP. The 'worst' tertiaries in G-K and PIRDP are the head tertiary of S_{11}k and the head tertiary of $S_{19,}$ respectively. A review of different institutional factors indicate that active involvement of the WMGs and WMAs has helped improve the performance of the best tertiary in G-K, while, in PIRDP, the organizations are yet to make a major impact. Reforms being implemented seem to be more effective when water supply to the tertiary canals is maintained at appropriate levels, particularly at critical stages of crop growth. In this context, the BWDB officials including the patwary at the field level have a crucial role to play, particularly for proper maintenance of the infrastructure and ensuring appropriate water levels and flows and reducing seepage. Illegal diversion of water should also be stopped to regain the farmers' full confidence in BWDB staff to help improve water use efficiency and collection of service charges.

Most of the WMG members interviewed are of the opinion that the existing WMG and WMG committees are not effective and that new committees need to be properly constituted for effective contribution for efficient operation of the irrigation systems. Coordination of activities also needs to be improved.

The National Water Policy adopted in 1999, talks of water rights, but not specifically about irrigation rights and obligations. Irrigation is customarily distributed first to the farmers having plots nearer to the channel. It does not differentiate between small and large farms. While fixing the water rates by BWDB, the main consideration is the electric bill. It does not at all consider the soil quality and topography of the crop land and rarely consults the WMGs and WMAs even above they are in existence, in this regard. These issues need to be addressed at both policy and implementation levels.

It has been observed that, in both G-K and PIRDP, except for BWDB, no other organization has any special programme in support of the irrigation expansion and its efficiency improvement. The RKUB's credit support is within the framework of its general credit giving activities and also minimal (just over Tk. 5000 per farm household). The credit recipients in the year 2000/01 were only one-tenth of the households in PIRDP and one-third in G-K.

On the collection of water charges from irrigators, tertiary-specific information is not available. Annual rates of collection in G-K as a whole are very low and have not improved overtime; the WMGs and WMAs appear to be still least interested in this matter. In PIRDP, WMGs and WMAs have recently been formed or are still being formed and the motivation work is continuing. The amount of service charges collected remains poor.

1. Steps need be taken to ensure honest, efficient discharging of duties by the BWDB officials. Transparency in their functioning is needed, which can be ensured through mandatory regular consultation with the farmers and their organizations viz. WMGs and WMAs. In this context, a crucial need is effective supervision and coordination.

2. Interviews with the farm households and discussions with the stakeholders reveal that the existing water management groups and associations (WMGs and WMAs) are not yet fully active even in the long standing G-K project. They are still at early stages of operation or even formation in different parts of PIRDP. Steps need to be taken to make these organizations more effective, properly following the PGWM adopted by the government.

3. Surface water in the country has overtime become increasingly scarce and, hence, its optimum use needs to be ensured. To that end, water losses from the canals should be reduced through poorer maintenance of water infrastructure. WMGs and WMAs should be appropriately involved in O & M activities.

4. The National Water Policy has not specifically addressed the issue of irrigation rights and obligations; and no regulation exists for dealing with defaults on water charges. It is necessary to spell out equitable irrigation rights and obligations at the policy level and involve WMGs and WMAs at the field level in the process of ensuring that the codified irrigation rights and obligations are properly observed by all concerned to ensure equity in water distribution and efficiency in water use.

Statistical Tables

Sources of data presented in the following tables are, unless otherwise specified the field surveys conducted for this study

Table 1. Irrigation Canals and Water Outlets in G-K and PIRDP.

Project	Number of secondary Canals	Length of secondary canals (kms.)	Number of primary Canals	Length of primary canals (km.)	Number of outlets	Maximum area ever irrigated	
						Aman season (ha)	Boro/Aus season (ha)
G-K	49	467	444	995	3500	99,119	42,742
						(116,000)*	
PIRDP	19	91	65	84	524	-	18680
						(22,000)*	

Source: BWDB.

- Command area for irrigation.

Table 2. Irrigation Coverage during 1998/9 to 2001/02 in G-K and PIRDP.

Year	G-K Project			PIRDP		
	Command area (ha)	Irrigated area in Aman season (%)	Irrigated area in Aus season (%)	Command area (ha)	Irrigated area in Boro season (%)	Irrigated area in Aus season (%)
1998/99	116,000	81	9.2	22,000	-	-
1999/00	”	81	8.6	”	-	-
2000/01	”	81	12.5	”	-	-
2001/02	”	45	-	”	46	25

Source: BWDB.

Table 3. Irrigation Coverage by Secondary Canals, 2001/02.

Name of the project	Secondary canal	Irrigation coverage by the canal in the best cropping season (%)
G-K	S_1G	78 (Aman season)
	S_7K	67 (Aman season)
	$S_{11}K$	54 (Aman season)
PIRDP	I_3S_1	29 (Boro season)
	I_3S_{10}	67 (Boro season)
	I_3S_{19}	54 (Boro season)

Source: Annual Report, 2000/01 and the Agricultural Extension Office, Pabna.

Table 4. Performance Indicators of the Tertiary Canals Selected for the Study, 2000/01.

Project	Secondary canal	Tertiary canal	Irrigation coverage in the main aman/boro season (%)	Paddy output (Ton/ha)	Output per unit of consumed water (ton/ha/mm) WET=850 mm
G-K	S_1G	Head (T_1AS_1G)	97	3.85	0.006
		Middle (T_2S_1G)	68	2.47	0.017
		Tail (T_3S_1G)	77	4.57	0.014
	S_7K	Head (T_1S_7K)	86	5.04	0.018
		Middle (T_3S_7K)	43	5.01	0.008
		Tail (T_6S_7K)	23	5.35	0.009
	$S_{11}K$	Head ($T_1S_{11}K$)	37	3.86	0.008
		Middle ($T_6S_{11}K$)	30	4.13	0.004
		Tail ($T_{10}S_{11}K$)	50	3.65	0.006
PIRDP	S_1	Head (S_1T_1)	89	5.01	0.005
		Middle (S_1T_2)	73	3.99	0.005
		Tail (S_1T_3)	-	3.60	0.004
	S_{10}	Head ($S_{10}T_1$)	99	4.42	0.005
		Middle ($S_{10}T_2$)	47	2.50	0.005
		Tail ($S_{110}T_3$)	-	5.26	0.005
	S_{19}	Head ($S_{10}T_1$)	15	2.52	0.004
		Middle ($S_{19}T_7$)	-	4.80	0.004
		Tail ($S_{19}T_{14}$ M_1)	-	5.46	0.005

Source: Annual Report 2000/01 and the Agricultural Extension office, Pabna in addition to the Household Survey conducted for this study.

Note: In G-K, paddy output relates to Aman (HYV) and in PIRDP to Boro (HYV).

Table 5. G-K: Contribution of Membership of WMGs/WMAs to the Performance of the Canals.

Canal	Membership (out of responding HHs) of WMGs (%)	Improvement perceived by members of WMGs as a result of their joining to groups (% of responding HHs)	Access to complete information from WMGs/WMAs (%) of responding HHs)	Performance of WMGs and WMAs as perceived by members (% of responding HHs)
'Best' (S_7 head)	100	62	100	100
'Worst' (S_{11} head)	80	31	0	0
Other Tertiaries				
S_1G head	25	64	15	8
S_1G middle	24	77	4	0
S_1G tail	0	33	0	0
S_7K middle	100	33	89	9
S_7K tail	100	0	0	0
S_{11}K middle	67	68	3	11
S_{11}K tail	87	49	6	3
All tertiaries	67	46	20	20

Note: 'Best' and 'Worst' as explained in text.

Table 6. G-K: Institutional Factors Constraining Irrigation Performance in the Selected Canal Areas.

(percentage of responding households)

Project	Theft of water	Inefficiency of BWDB officials	Problem with Patwari	Ineffective role played by WMGs/WMAs	Legal disputes with the BWDB
'Best' (S_7K head)	0	0	6	0	0
'Worst' (S_{11}K head)	42	30	4	39	7
Other tertiaries					
S_1G head	10	45	30	25	5
S_1G middle	28	28	68	44	40
S_1G tail	28	28	70	43	43
S_7 Middle	0	0	0	0	11
S_7K tail*	0	0	0	0	0
S_{11}K middle	65	48	15	20	4
S_{11}K tail	38	18	0	60	6
All tertiaries	24	19	22	25	12

* Little surface water was used

Table 7. G-K: Physical Factors Constraining Irrigation Performance in the Selected Canal Areas.

(percentage of responding households)

Project	Poor O&M of the Structures	Timely non-availability of water	Heavy siltation on the canal bed	Unsuitability or inadequacy of outlets from the distributory
'Best' (S_7K head)	97	39	39	0
'Worst' (S_{11}K head)	60	3	14	51
Other tertiaries				
S_1G head	80	20	0	5
S_1G middle	78	40	0	28
S_1G tail	93	43	7	21
S_7K middle	78	66	66	0
S_7K tail	100	100	100	0
S_{11}K middle	79	7	59	28
S_{11}K tail	63	32	56	20
All tertiaries	80	39	39	19

Table 8. Contribution of Membership of WMGs/WMAs to the Performance of the Canals.

Canal	Membership (out of responding HHs of WMGs (%)	Improvement perceived by members of WMGs as a result of their joining the groups (% of responding HHs)	Access to complete information from WMGs/WMAs (% of responding HHs)	Good performance of WMGs and WMAs as perceived by members (% of responding HHs)
'Best' (S_{19} tail)	50	50	54	75
'Worst' (S_{19} head)	33	69	56	78
Other tertiaries				
S_1 head	45	70	64	83
S_1 middle	9	43	33	42
S_1 tail	33	0	50	66
S_{10} head	57	100	78	78
S_{10} middle	30	52	54	72
S_{10} tail	38	69	50	71
S_{19} middle	36	52	62	76
All tertiarries	36	63	58	75

Table 9. PIRDP: Institutional Factors Constraining Irrigation Performance in the Selected Canal Areas.

(percentage of responding households)

Project	Theft of water	Inefficiency of BWDB officials	Problem with Patwari	Ineffective role played by WMGs/WMAs	Legal disputes with the BWDB
'Best' (S19 Tail)	7	20	15	20	0
'Worst' (S_{19} head)	8	17	20	8	8
Other tertiaries					
S_1 head	8	26	16	15	3
S_1 middle	9	18	20	14	10
S_1 tail	0	40	0	20	20
S_{10} head	10	0	20	10	0
S_{10} middle	11	34	12	16	9
S_{10} tail	5	16	12	28	0
S_{19} middle	9	31	14	19	7
All tertiaries	8	25	15	16	6

Table 10. PIRDP: Physical Factors Constraining Irrigation Performance in the Selected Canal Areas.

(percentage of responding households)

Project	Poor O&M of the structures	Timely non-availability of water	Siltation on the canal bed	Unsuitability or inadequacy of outlets from the distributory
'Best' (S_{19} tail)	25	14	0	12
'Worst; (S_{19} head)	33	16	0	46
Other tertiaries				
S_1 head	22	13	0	24
S_1 middle	16	10	0	29
S_1 tail	40	20	0	33
S_{10} head	33	10	0	30
S_{10} middle	20	12	0	35
S_{10} tail	25	17	0	14
S_{19} middle	16	11	0	24
All tertiaries	22	13	-	27

Table 11. G-K: Distribution of Institutional Credit to Farm Households by Canal Areas.

Tertiary canals	Total respondent farm households (No.)	Households that received institutional credit (% of total credit receiving HHs)	Average credit per recipient (000 Taka)	Average credit per household (000 Taka)	RKUB's share in total credit (%)
S_1G Head	28	46	8.35	3.88	34
Middle	76	49	13.00	6.33	71
Tail	24	62	9.13	5.71	64
S_7K Head ('best)	62	32	15.91	5.13	84
Middle	18	44	6.12	2.72	88
Tail	48	27	39.46	10.69	68
$S_{11}K$ Head ('worst')	44	23	21.50	4.89	59
Middle	34	26	13.44	3.56	82
Tail	50	8	9.00	0.72	86
All tertiaries	384	34	15.34	5.15	73

Table 12. PIRDP: Distribution of Institutional Credit to Farm Households by Canal Areas.

Tertiary canals	Total respondent farm households (No.)	Households that received institutional credit (% all of farm HHs)	Average credit per recipient HH (000 Taka)	Average credit per household (000 Taka)	RKUB's share in total credit (%)
S_1					
Head	91	13	57.33	7.56	97
Middle	45	4	8.00	0.36	0
Tail	9	-	-	-	-
S_{10}					
Head	27	22	91.75	20.39	98
Middle	78	6	16.10	1.03	79
Tail	26	4	3.00	0.12	100
S_{19}					
Head ('worst')	60	17	86.40	14.40	99
Middle	57	5	9.00	0.47	0
Tail ('best')	25	4	3.00	0.12	100
All Tertiarries	418	10	55.80	5.34	99

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Summary, Conclusions and Pro-poor Interventions

Agriculture in developing Asia as a whole has made remarkable progress over the past three decades. Between 1970 and 1995, cereal production more than doubled from over 300 million metric tons (t) to 650 million t, while the population increased during the same period by 60 percent This remarkable growth in food production was largely attributed to the growth in irrigated agriculture coupled with the use of high-yielding varieties of crops, and the application of fertilizers and pesticides. At present, about 40 percent of the cropland in Asia is irrigated, and accounts for about 70 percent of the total cereal production. Irrigation has greatly improved the incomes of farmers with access to fertile and well-drained land, reliable water supplies, yield-enhancing inputs, and credit as well as other supporting services. It has also benefited the overall population by providing more food at reduced prices.

Despite these achievements, the productivity of a large part of irrigation systems remains severely constrained by insufficiency of some or all of these inputs. Such low-productivity areas are characterized by persistent rural poverty. The distribution of the benefits from irrigation development is thus largely skewed and unequal. While the determinants of low productivity are numerous and complex, they are, to a large extent, associated with poor performance of many of the established irrigation systems. This causes low, inequitable, and unreliable water supplies in those areas. It has been widely acknowledged that actual irrigated area in many of the irrigation schemes is much smaller than planned. Large areas within the irrigation schemes suffer from chronic and severe water shortages, especially the tail-end reaches. Large-scale water logging has also been reported. It is now widely understood that these are caused largely by institutional and managerial factors, such as poor governance, and lack of funds for maintenance, rather than technical constraints, which could be addressed without large physical interventions, but with greater cost-effectiveness benefiting the poor. A number of other determinants contribute to poverty in the low-productivity irrigated areas: (i) physical factors (poor design, unsuitable topography, poor drainage, poor soil conditions); (ii) economic constraints (smaller landholdings, lack of financial resources and credit, lack of key inputs and marketing outlets); and (iii) socio-cultural problems (tenure arrangements such as insecure rights and large landholdings leased to individual farmers, caste-related inequities, gender bias).

Attempts made by Developing Member Countries (DMCs) to improve the productivity of these irrigated areas by addressing the constraints specifically, have been minimal and ineffective for the most part. There has been a lack of proactive policies, effective institutions, and actions to this end. Additionally, previous irrigation-related research studies focused on general agricultural productivity increased under the overall goal of enhancing food security. While IWMI has pursued the improvement of irrigation systems performance, the research efforts have not gone much beyond technical and physical interventions and general irrigation management transfer to farmer organizations at large. Little scientific knowledge exists on how a range of non-technical interventions such as economic, financial, institutional, and governance measures can most effectively contribute to reducing poverty in these low-productivity areas.

The agriculture sector in the Asian and Pacific region is now facing the dual challenges of increasing food demand and looming water scarcity. Its population is expected to grow from the current 3.0 billion people to over 4.5 billion by 2025. The per capita availability of water in 2025 is estimated between 15 percent and 35 percent of the levels of 1950. It is becoming increasingly difficult to expand irrigated areas, as most accessible water resources have already been developed to capacity in a growing number of river basins. ADB's 1999 rural Asia study showed that the cost of investing in new irrigation schemes has also increased substantially.[15] Moreover, the demand for water for other economic uses is rising fast in association with the rapid economic growth and urbanization in the region, along with the growing pressure to protect the environment. As the single most dominant user of available water resources, irrigated agriculture is facing increasing pressure to produce more food with less water through significant improvements in water use efficiency at the farm and system levels. Low-productivity irrigated areas, in particular, are in stress, as resource-poor farmers in those areas are most vulnerable to water shortages, while there is also a significant need to enhance food production there to ensure food security for the growing population. To meet these challenges, many DMCs in the region are now willing to adopt major policy and institutional reforms toward integrated water resources management at the river basin level, and improved management of water delivery at the individual system level. Such reforms are aimed at optimal allocation of water resources through better coordination of conflicting interests, and improved efficiency and sustainability for individual users.

Under the circumstances, attention should now be focused on improving the productivity of the less productive irrigated areas, while addressing the range of specific poverty-related problems therein. This should be pursued in the context of improving the overall water use efficiency, and sustainability of the concerned irrigation schemes. ADB's draft water policy encourages the transfer of management to autonomous and accountable service delivery agencies with appropriate user representation. The ADB's draft water policy also emphasizes reducing poverty by ensuring equitable distribution of water in this process, in line with ADB's poverty reduction strategy. Some DMCs have already initiated programs toward this direction, adopting certain levels of management transfer of irrigation facilities to water user associations, and installing financial autonomy and accountability measures. However, there is little evidence that these measures have resulted in more efficient water use. Even less available is the evidence that they have contributed to poverty reduction.

To significantly enhance the livelihood of poor farmers in these areas, while improving the overall performance of irrigation schemes, a more elaborate set of appropriate interventions and their sequencing, along with policies, institutional arrangements and support systems, such as capacity building, should be defined. The interventions should be able to provide necessary incentives and mechanisms for improved equity and reliability of water supply to those areas, ensuring the participation of poor farmers in the decision-making process of water management. Necessary measures to ensure the sustainability of operation and maintenance (O&M) should also be put in place, adopting the user-pay principle, while taking affordability of the poor into account. Furthermore, specific interventions should be identified and designed to address other types of location-specific constraints faced by poor farmers. This objective can only be pursued through a rigorous assessment of the determinants of poverty in the low-productivity areas, and analysis of the poverty impacts of a range of alternative pro-poor economic, financial, institutional, governance, and technical interventions that are available or emerging within the region. Necessary changes in the overall policy and institutional framework should also be assessed to ensure an enabling environment.

[15] The real cost of new irrigation schemes increased by 150 percent in South and Southeast Asia between 1966 and 1988, thus weakening the justification for investing in new irrigation.

Given that the managerial and institutional weaknesses largely contribute to the persistent poverty in these areas, the proposed study will pay due attention to a range of non-technical interventions. These include managerial reforms in water user organizations, administration of water rights and water pricing, regulatory and supervisory measures, and other incentives and mechanisms to improve equity while improving system performance.

Goal, Objectives, and Scope

The overall goal of the proposed study is to promote and catalyze equitable economic growth in rural areas through pro-poor irrigation interventions in the participating DMCs (including Bangladesh, People's Republic of China [PRC], India, Indonesia, Pakistan, and Vietnam).

The immediate objective is to determine what can realistically be done to improve the returns to poor farmers in the low-productivity irrigated areas within the context of improving the overall performance and sustainability of the established irrigation schemes.

The study will focus on selected representative low-productivity irrigated areas and their peripheries with a large number of people under persistent poverty in the participating DMCs. The emphasis is on identifying and assessing a set of appropriate economic, financial, institutional, governance, and technical interventions at field and system levels, and changes in overall policy and institutional framework as far as they affect access to water resources for the poor. The scope is as follows:

(i) Analysis and field research on the impacts of the current policy and institutional framework, and the impacts of underlying physical, economic, and socio-cultural conditions on the selected areas in particular and on the overall irrigation systems at large, including the assessment of opportunities for and constraints on improving productivity in these less productive areas through improved access to irrigation water;

(ii) Identification and in-depth evaluation of a range of potential pro-poor economic, financial, institutional, governance, and technical interventions at field and system levels against a set of criteria including the cost of implementation and potential to reduce poverty; and assessment of necessary changes in the overall policy and institutional framework under which interventions could most effectively address the poverty reduction in the study areas; and

(iii) Formulation of a set of appropriate interventions, and the policy and institutional framework, including the adequate support systems, required to ensure large-scale uptake, replicability, and higher impacts within and between Asian countries, to culminate into (a) the guidelines for identifying and evaluating appropriate pro-poor interventions and enabling policy and institutional framework for irrigated agriculture in Asia, and (b) country-specific action agendas for the selected low-productivity areas of the participating DMCs.

Research Questions

1. What are the poverty situations in the study area?

2. Where are the poor people located along irrigation systems, and are there any geographic patterns of the poor within an irrigation system?

3. What are the poverty prevalence and depths, trends, main causes, relation to income/asset distribution pattern, and key issues and strategies to reduce poverty (including those not related to irrigation)?

4. What are the benefits of surface irrigation for the poor and to what extent, including indirect benefits to small farmers and the landless? The issues include; (a) level of income/production/employment impacts, (b) distribution of increased income/production among poor and non-poor, and (c) impacts on other dimensions including food security, vulnerability, and empowerment.

5. What is the level of system performance in the study area?

6. What are the major irrigation water-related constraints to productivity?

7. What are the causes of unsatisfactory performance?

8. To what extent is poor system performance related to technical (farm water use, distribution pattern among canals or higher levels), institutional economic/financial and regulatory aspects of system management?

9. To what extent will poor system performance (system efficiency and financial sustainability) harm the poor?

10. To what extent will improved system performance benefit the poor and what are the opportunities to reduce poverty by improving performance of irrigation systems?

11. What are the impacts of irrigation-related institutions, laws, and policies on overall system performance, including impacts, on productivity, and on equity in access to irrigation water?

12. What various interventions and innovations have been adopted for improving system performance, and what is their effectiveness?

13. What are their implications for the poor?

Review of Past Work

Agriculture dominates the economy of Bangladesh, generating about 25 percent of Gross Domestic Product (GDP) and employing some 65 percent of the civilian labour force. During the last three decades the production of food grains has largely increased and the expanded irrigation coverage was the engine of this growth.

At present, over three million ha of land is irrigated. The Ganges-Kobadak (G-K) is the first large surface water irrigation project in Bangladesh. The Asian Development Bank supported the rehabilitation of this project through several studies (ADB 1983, 1992). For improved water management, technical assistance to G-K project was provided by ADB (ADB, 1992). The current operations are not adequate to support efficient field irrigation. The procedures proposed for revised operations are:

1. Rotation by secondary and tertiary canals unless main system supply falls below 60 percent full supply discharge (FSQ);
2. Supply schedule will allocate equitable volumes of water based on cropped area to all secondary and tertiary canal head regulators;
3. Minimum abstraction to secondary canals will be set at 50 percent FSQ and delivery time will be shortened if requirements fall below that level;
4. Rotations will be based on the planned or sanctioned planted area for a season, deliveries being made to tertiary canals for either 4 or 6 days in each irrigation interval of the days; in canals where the total cropped area is restricted and the proposed rotation would schedule excessive supplies, the supply period will be reduced; and
5. Rotations will be designed to achieve stable discharge in main canal reaches. The operation of the main canal cross regulators will be determined to ensure that adequate command can be maintained at secondary and tertiary head regulators. Where adequate command cannot be maintained, the affected reaches will be identified and alternative operations considered. Increased discharge in the canal reach, or even remodeling the canal section to obtain more hydraulically suitable sections may be necessary in some cases. Discharge at the pump house will be determined to provide adequate supplies for field water requirements and delivered according to the rotational programme. Stable discharge will be maintained at the head of the Ganges Main Canal whenever possible.

During the early 1990s, Bangladesh Rice Research Institute (BRRI), International Rice Research Institute (IRRI) and Bangladesh Water Development Board jointly conducted studies on the various aspects of G-K irrigation project (Ghani, et al., Islam, et al., 1991, Rashid, et al., 1996).

Ghani et al (1989) suggested a water rotation schedule, a 9-day rotation cropping plan and its adjustment and pumping suspension opportunities based on rainfall for about 30-40 days during June-July. Islam et al (1991) recommended few control structures in the G-K system to facilitate the reuse of drainage water. Rashid, et al (1996) found the efficiency of G-K system about 86 percent during T-Aman season. The irrigated area during Aus season did not exceed 32 percent of the command area, because of inadequate water supply in the main canal.

The feasibility study report (ADB, 1994) of the command area development recommended the following interventions:

- Beneficiary participation in water resources related projects should lead to community management of the associate natural resources – face and catalyze further local level initiatives. The inputs on non-targeted and adversely affected population should be identified and addressed under the project design.
- In the planning stage, participation as part of the social design study (SDS) would facilitate the beneficiary preference and priorities as well as guide the types of interventions proposed. During the design and planning stage, indigenous knowledge of local people on irrigation management should be incorporated for the smooth implementation of the project.
- Community organizations are necessary to manage the natural resources base following the completion of the project. Most rural areas have traditional community based systems, but externally assisted development projects are often of a scale far larger than the local framework. As a consequence, the project replaces the traditional system, undermine the local level initiative, and alienate the beneficiaries. Projects, therefore, need to propose methods to develop suitable-sized organizations by working with the existing social framework. Similarly, projects should give the consideration to the absorptive capacity of the targeted beneficiaries; this includes their capabilities to operate and maintain completed facilities as well as adopt new cropping practices. Human resources development for the organizations formed and for specific extension training programmes is a key component.
- Parker and Hakim (1990) studied socio-economic and institutional issues in irrigation management for rice-based farming systems in Bangladesh. They suggested active involvement of farmers and irrigation managers in the following areas:
- *Since farmer participation can become more predictable, productive and sustainable if they participate in groups through some forms of organizations rather than individual basis, farmer organizations should be developed, natured and sustained.*
- *While developing farmer organizations, care should be taken so that their irrigation emphasis is clear; principles of equity are followed so as to give representation to a cross section of farmers; farmers are organized on the basis of hydraulic characteristics of irrigation systems; some sort of quasi-ownership of the systems is given to the organizations.*
- *Farmers, and their leaders, are to be provided with training on socio-technical aspects of irrigation management.*
- *Irrigation managers should participate in the improved management process not as administrators but as managers in a participatory style.*
- *As demonstrated in the rotation and MICA (Minimum Irrigated Crops Acreage) expert, managers should help initiate effective agency – farmer interaction, communication and co-operation.*
- Addressing poverty in Bangladesh, ADB (2000) mentioned that the pace of poverty reduction cannot be accelerated within the given national boundary. The report reveals that development of human capital has been relatively the largest input towards poverty alleviation followed by investment in physical infrastructure. There is need for balance between investment in social infrastructure (education, health and nutrition) and physical infrastructure (road, drainage,

irrigation and flood control) as they provide critical inputs in the overall process of poverty reduction. The study on partnership agreement on poverty reduction between the Government of Bangladesh and ADB (2000) emphasises on improvement on good governance, including at local levels, to promote growth and improve income distribution for pro-poor development in Bangladesh.

During 2000, ADB/BWDB conducted a socio-economic household survey in Pabna Irrigation and Rural Development Project (PIRDP) and MDIP. In PIRDP, the annual per capita income of about 78 percent of the respondents was below Tk. 10,378 but in MDIP, the income of 68 percent of the respondents was less then Tk. 10,378, indicating that proportionally more poor people living in the PIRDP area was poor. The literacy level is also lower (48%) in PIRDP than MDIP (77%). It was concluded that, in PIRDP, 51 percent of the respondents were below poverty line, while the figure was 39 percent in MDIP.

Koppen and Mahmud (1995) studying the impact of irrigation on women, found that the majority of female irrigation groups operating in Bangladesh related to men's interests. Women's direct economic gain is negligible.

The Grameen Bank and later its sister organization Grameen Krishi Foundation (G-KF) became active participants in the irrigation sector of Bangladesh. In 1997, Jordans and Zwaterveen of IWMI studied the effect of irrigation on rural women. They found that the development of irrigated agriculture has affected women belonging to different classes differently—women from middle landowning families have benefited relatively more than women from marginal farm households. Female family labour is increasingly used in one's own land irrigation cultivation, especially among the poor households.

The National water Policy, adopted for the first time by the Government of Bangladesh in January 1999, provides guidelines and directions for a comprehensive, integrated and equitable management of water in the country. It also emphasizes on the need for participatory approach in planning and management of water, including irrigation water. However, it provides no detailed guidelines on water pricing and cost recovery. To that end, there is the Bangladesh Irrigation Water Rate Ordinance 1983, amended as the Bangladesh Irrigation (Amendment) Act 1990 (GoB, 1990). The law mainly relates to the imposition of water rate for supply, regulation or storage of water for irrigation or drainage. Assessment of water charge is made on the basis of the area irrigated irrespective of the size of the farm. There is no provision favoring the tenant or landless farmers in the project areas. The BWDB is the only authority responsible for assessment and collection of water charges.

Approach and Methodological Framework

The main research focus is at the irrigation system and household levels, but relevant macro aspects and procedural issues are also considered. The study seeks to analyze poverty and assess irrigation performance, constraints and opportunities, and institutional interventions.

The study is based on both primary and secondary data and information. Five main sources have been tapped for necessary data and information, which are:

- Participatory rural appraisals (PRAs)
- Key stakeholder interviews/consultations
- Household surveys
- Primary measurements, for example, water productivity measurement
- Secondary sources, including government publications, research studies, and project reports and documents.

Selection of Households

There are households in the irrigated areas that own land and there are others who are landless. Landowning households are divided into small (owning 0.2 ha to 1 ha or 0.5 acre to 2.49 acre), medium (1 ha to 3 ha or 2.49 acre to 7.49 acres), and large (3 ha+ or 7.50 acres+) farmers.

Landlessness is defined to include households owning up to 0.2 ha or 0.5 acre. All these categories of households in the irrigated areas are included in the sample in predetermined numbers. From the rain-fed areas, however, only landowning households of a predetermined number have been included.

The following steps were undertaken to prepare the sample frame.

- Maps of the chawkbandi areas under all the selected tertiaries were collected
- Mouza maps with reference to the chawkbandi, and the related list of villages which include most recent household numbers and population were selected
- Up-to- date list of heads of households for each chawkbandi was collected from the project offices
- Total number of households in each of the tertiary was divided by 50 (arbitrarily chosen) to obtain a fixed interval for selecting households. If the head of a selected household is either absent or does not fit the landholding status the survey team moved on to the next household to be included for substitution. Following this procedure, households were picked from each tertiary in required numbers in each category, as indicated below.
- 450 (9x50) sample households in G-K as also in PIRDP were surveyed in the three selected tertiaries in each project, including households from the selected rain-fed areas. The broad distribution of households in the command area of each tertiary is as follows.

Landowning households in the secondary system	:	106-108
Landless household in the secondary system	:	21-22
Landowning households in the rain-fed areas	:	21-22
Total	:	150

Participatory Rural Appraisal (PRA)

Among various tools of Participatory Rural Appraisal (PRA), three were used for conducting the PRAs. The tools are (i) open meetings (ii) focus group discussion (FGD) and (iii) stakeholder interviews. These three tools were used in each location on three different days. In G-K, the selected areas under three secondary canals—viz. S_1GT_2 at head, S_7KT_3 at middle, $S_{11}KT_6$ at tail—are the West Bahirchar, Bharra and Sreepur villages, respectively. For PIRDP, the selected areas under of three secondary canals— viz. $I_3S_1T_1$ at head, $I_3S_{10}T_2$ at middle, $I_3S_{19}T_{14}M_1$ at tail—are Hatigara, Tetulia and Kabarikhola, respectively.

Open meetings, arranged in advance, were conducted, which were participated by local people including farmers, non-farm operators, poor, distressed women, journalists, teachers, members of the Union Parishad, and others concerned. Each session was conducted by PRA facilitators in the presence of the chairperson of the WMA under the secondary canal.

Focus group discussion (FGD) was conducted by semi-structured interviews with the participation of both male and female local elite, small and medium entrepreneurs, local *upazila parisad* representatives, local *tahshilders*, *patwaries*/water rate collectors.

Stakeholders were interviewed using semi-structured questionnaires. The interviews were conducted with the owners of Shallow Tubewell (STW) & Deep Tubewell (DTW), public representatives such as *upazila parishad* chairmen and presidents of WMAs.

Study Settings and Data

Selection of the Canals, Villages, Households in G-K and PIRDP

Canals

G-K. Three secondary canals (S_1G, S_7K and $S_{11}K$) were selected according to the location of the canals at the head, middle and tail of the G-K system. Three tertiary canals for each selected secondary canal were picked according to the three stratified location of the tertiaries of each secondary as follows:

For S_1G: T_1A, T_2, T_3A at head, middle and tail, respectively
For S_7K: T_1, T_3, T_6 at head, middle and tail, respectively, and
For $S_{11}K$: T_1, T_6, T_{10} at head, middle and tail, respectively

PIRDP. Three secondary canals (I_3S_1, I_3S_{10}, I_3S_{19}) were selected according to the location of the canals at the head, middle and tail of the total Pabna project system.

Three tertiary canals for each selected secondary canal were included according to the three stratified location of the tertiaries of each secondary as follows:
For I_3S_1: T_1, T_2, T_3 at head, middle and tail, respectively
For I_3S_{10}: T_1, T_2, T_3 at head, middle and tail, respectively, and
For I_3S_{19}: T_1, T_7, $T_{14}M_1$ at head, middle and tail, respectively

The cropping pattern, access to water and irrigation infrastructure are almost similar in both the systems. The chawkbandi maps and schedules were excellent sources of necessary information and were helpful in the selection of sample households.

Villages Included under the Selected Canals

G-K. A total of 41 villages were identified at the head, middle, and tail of the selected canals. More specifically, at the head of the selected secondary canal (S_1G), 21 villages were identified and the survey households were randomly picked from those villages. Similarly, under secondary canals at middle (S_7K) and tail ($S_{11}K$), 14 and 6 villages, respectively were identified for the household survey.

Name of tertiary	Names of villages/mouzas of households surveyed
<u>Head</u>	
$S_1G\ T_1A$	[Sholadag], [Bheramara], Farakpur, Chardamukdia, {Ramkrishnapur}, Shahebnagar, {Baramail}, Collegepara
$S_1G\ T_2$	Baradag, [Sholadag], Pakuria, Ruppur, [Bheramara], {Nawdapara}, {Chandgram}, {Baramail}, {West Bahirchar}, {Chandipur}, Khadimpur, {Baradi}, {Kharara}
$S_1G\ T_3A$	[Bheramara], {Nawdapara}, [Sholadag], {Chandgram}, Damukdia, {Chandipur}, Charkapur, {West Bahirchar}, {Ramkrishnapur}, Majhpara, {Kharara}, {Baradi}
<u>Middle</u>	
$S_7K\ T_1$	Dharmapara, Bharra, Durgapur, Chapra, Madhupur, Bawlat
$S_7K\ T_3$	Sheikhpara, Natiria
$S_7K\ T_6$	Khagrabaria, Gobra, Ramchandrapur, Anandanagar, Brittidevirajnagar, Kacherkona
<u>Tail</u>	
$S_{11}K\ T_1$ $S_{11}K\ T_6$ $S_{11}K\ T_{10}$	[Chandrapara], [Sreepur], [Hogoldanga], [Madanpur], [Bkhna], [Sonaikandi]

[ ] indicates that the village is under all three tertiaries.
{ } indicates that the village is under two tertiaries.

PIRDP. 29 villages were identified at the head, middle, and tail of the selected canals. More specifically, at the head of the selected secondary canal (I_3S_1), 9 villages were identified and the survey households were randomly selected from those villages. Similarly, under secondary canals at middle (I_3S_{10}) and tail (I_3S_{19}), 10 villages in each location were identified for the household survey.

Name of tertiary	Names of villages/mouzas surveyed
<u>Head</u>	
$I_3S_1T_1$	{Bangabari}, Hatigara, Painateghri, Teghrishanonda, Haturia, {Boroshila}, Shalpaboroshila
$I_3S_1T_2$	Jordha, {Bangabari}, {Boroshila}
$I_3S_1T_3$	Chakchakla
<u>Middle</u>	
$I_3S_{10}T_1$	Nandanpur, Krishnapur, Shibrampur, Devgram

Name of tertiary	Names of villages/mouzas surveyed
$I_3S_{10}T_2$ $I_3S_{10}T_3$	Tetulia, Darmuda, {Shandaha}, Ramchandrapur, {Joragacha} {Joragacha}, {Shandaha}, Piadaha
Tail $I_3S_{19}T_1$ $I_3S_{19}T_7$ $I_3S_{19}T_{14}M_1$	 Hatbaria, Gobindapur, Sundarkandi, Khapur Gadhuli, Hasanpur, Khetupara, Bishnupur Kabarikhola, Chatokborat

{ } indicates that the village is under two tertiaries

A comprehensive household survey questionnaire was used to obtain field data on irrigation, productivity, poverty and other related issues, given the purposes at hand from both G-K and PIRDP projects. The questionnaire is divided into four modules that include basic information module, agricultural module, income and expenditure module, and credit module. The questionnaire was administered to randomly selected 450 sample households in the aforesaid locations of each of G-K and PIRDP, following a single stage random sampling method. Since the area under each portion (head/middle/tail) is not large, the single stage stratified sampling method was used to select the sample households for conducting household surveys in both the project areas.

Poverty in Irrigated Agriculture: Spatial Dimensions

Results of the household survey reveals that the largest land holding group (above 3.01 ha.) owns the largest share of land in G-K but in PIRDP, the largest land area belongs to the small land holding group (0.5-1.0 ha). In both the sites, the relative degree of skewness is more in the rain-fed areas than in the irrigated areas, positively indicating the influence of the irrigation intervention on the improvement of distribution of land among various holding size groups.

The primary occupation of households in the study area varies a great deal. In G-K, about 85 percent of the households were found to be farming, but for PIRDP the figure is much less (68%). People in PIRDP who were initially employed as farm labourers are increasingly seeking employment in rural service sector.

Headcount and poverty gap analyses show less spread and depth of poverty in the irrigated areas than in the rain-fed areas. For G-K the headcount indices are 58 percent and 77 percent, respectively in the irrigated and rain-fed areas. In PIRDP, the indices are 35 percent and 51 percent, respectively.

In the irrigated areas, increased cropping intensity and higher adoption of modern technologies, resulting in improvement of land productivity, have contributed to a higher income of the small farmers. Increased employment upon modern rice cultivation has also been a useful source of income for the land-poor and the landless. All this has resulted in better livelihood conditions of the small farmers, in particular, in the irrigated areas. Thus access to safe drinking water, sanitary latrine and use of electricity for domestic purposes have improved in the irrigated areas compared to rain-fed areas.

Determinants of Poverty in Irrigated Areas

Annual agricultural household income and gross agricultural output per hectare and poverty (poverty defined with reference poverty line income of Tk. 10,200 per person per annum) were used in the regression analyses as independent variables. Agricultural household income is significantly influenced by the technology used, increased membership of the farmers in the WMGs and the credit taken. Increase in the cropping intensity as a result of irrigation, has greatly influenced the gross agricultural output per hectare.

In the rain-fed areas, modern rice cultivation is restricted, particularly during the Boro and T. Aus seasons. Sometimes, modern rice is cultivated during T. Aman season, but the yields often remain low. Therefore, lack of opportunities of using modern technologies such as HYV cultivars and production inputs has been an important cause of poor productivity and persisting poverty.

Besides, a number of factors such as households with a larger family size, high dependency ratio and low education of household heads are important determinants of the poverty status in the study areas.

Irrigation System Performances and its Impacts on Poverty

In the G-K project, transplanted HYV Aus and Aman paddy are the principal crops receiving irrigation. In PIRDP, HYV Boro and local variety of Aman are the main crops.

It has been observed that in G-K, irrigation intensity is up to 60 percent in Kharif-I and from 53 percent to 98 percent in Kharif-II in the selected tertiaries. However, at the secondary level, the highest irrigation intensity of 34 percent has been observed in the middle reaches of S_7K, followed by 26 percent and 1 percent, respectively in S_1G and $S_{11}K$ in Kharif-I season. In Kharif-II season, the highest irrigation intensity of 93 percent has been observed in head reaches of S_1G, followed by 90 percent and 71 percent, respectively in the middle and tail reaches of S_7K and $S_{11}K$. In $T_1S_{11}K$, $T_6S_{11}K$ and $T_{10}S_{11}K$, there was no irrigation in the survey year in Kharif-I reason because $T_1S_{11}K$ acts as a drainage canal in Kharif-I to drain out the water from the low-lying areas of the command area and $T_6S_{11}K$ and $T_{10}S_{11}K$ were closed to construct a bridge. Very low irrigation intensity in Kharif-I season resulted from inadequate water flow in the Ganges at the intake.

The results indicate that irrigation intensity in the tail reaches of the canal system was extremely low in the Kharif-I season and significantly low in Kharif-II season. This is reflected in the irrigation intensity as well; the lowest irrigation intensity of 53 percent has been found in $T_{10}S_{11}K$ (extreme tail end) and the highest irrigation intensity of 156 percent in T_1S_7K (middle reach). At the secondary level, S_7K has achieved the highest irrigation intensity of 124 percent, followed by S_1G and $S_{11}K$ with 119 percent and 72 percent, respectively. It is therefore quite evident that the tail reaches of the system suffer severe water shortages, which ultimately results in low irrigation intensity.

Study results for PIRDP indicate that irrigation intensity in this project has behaved highly erratically. Highest irrigation intensity of 206 percent has been observed in $I_3S_{19}T_{14}M_1$ (extreme tail end reach of the system). However, no information is available for $I_3S_{19}T_7$ (tail) and $I_3S_{10}T_3$ (middle). Due to major breaches, canal $I_3S_{10}T_3$ was not in operation during Rabi and Kharif-I. The command area of $I_3S_{19}T_7$ requires secondary lifting, which the farmers are not interested to arrange. At the secondary level highest irrigation intensity of 48 percent has obtained in I_3S_{10} (middle) in Kharif-I and Rabi seasons, followed by 45 percent and 29 percent in I_3S_{19} (tail) and I_3S_1 (head), respectively. Irrigation intensities in all the canals in Kharif-II have been found to be negligible.

In both G-K and PIRDP, household income has increased for all categories of households including small, medium, and large farmers as well as the landless in all locations (head, middle and tail) of all selected secondary canals. Net annual financial return per ha (from cultivation of cereals only; other crops produced are not irrigated) varies from Tk. 15,000 to Tk. 23,000 in G-K and from Tk. 18,000 to Tk. 22,000 in PIRDP, while net economic return (from 1.0 ha) varies from Tk. 13,000 to Tk. 16,000 in both G-K and PIRDP.

There are significant differences in the total agricultural income between farm households of different categories (large, medium, small, marginal) and the landless owing to differential landownership. A large farm household obviously receives much more total agricultural income compared to a small or marginal farm household that owns a maximum of 1.0 ha. However, given that HYVs cultivated consequent upon the introduction of irrigation facilities, require significantly more labour compared to rain-fed agriculture, the land-poor and the landless, whose main source of income is usually sale of labour, derive increased income from this source. Also, non-agricultural activities have increased in both G-K and PIRDP in the wake of the implementation of the irrigation projects, leading to increased household incomes from these activities. Also, generally, the households at head and medium reaches have benefited more than the tail enders, with some exceptions.

Based on the evaluation of G-K and PIRDP in terms of area coverage, irrigation intensity, output per unit of water and labor, head tail equity and involvement of beneficiaries in the management, it is concluded that the systems are not performing satisfactorily and the full potential of the systems has not been realized.

Analysis of Water Management Institutions: Implications for the Poor

The Bangladesh Water Development Board (BWDB), an autonomous organization of the Ministry of Water Resources, has been implementing flood control and drainage (FCD) and flood control drainage and irrigation (FCDI) projects. The operation and maintenance of the two large surface water irrigation schemes, Ganges-Kobadak (G-K) and Pabna Irrigation and Rural Development Projects (PIRDP), included in this study are thus the responsibility of the BWDB. The Department of Agricultural Extension (DAE) has a major responsibility to disseminate available new technologies to the farm household, throughout the country. In some area-specific situations, a few NGOs are working on technology transfer and credit programmes in collaboration with DAE or other government agencies.

Distribution of irrigation water for crop use from available flows in the canals in both G-K and PIRDP is now determined by the WMGs and the corresponding WMAs in collaboration with the BWDB field officials. Irrigation water is distributed to the crop fields on the basis of requirements, with reference to land quality, given the availability of surface water in the tertiary canals. Any conflict relating to the distribution of water is taken care of by the respective officials of the BWDB, in consultation with the WMGs. There is, however, no specific government rule in this regard. Land nearer to the canals as usual get irrigation earlier. No differentiation is made between small and large farms.

On the basis of the evaluation of the achieved coverage, crop productivity and water use output in G-K, T_1A, the head tertiary of S_1G, has been found to have the highest irrigation coverage (97%) and the tail tertiary of S_7K the lowest coverage (23%). In PIRDP, $T_{14}M_1$, the tail tertiary of S_{19}

has performed the best by irrigating the entire command area, while T_3, the tail end tertiary of the secondary canal of S_{10} the worst.

In both G-K and PIRDP, people's participation is being promoted through WMGs and WMA. In G-K, the successful performance of the tertiary canal is largely determined by the active participation of water users through WMGs and WMAs and the efficiency of the BWDB officials. In the case of PIRDP, a clear identification of the institutional factors has not been possible as the performance in the command areas of all the selected canals do not vary much. Moreover, participatory water management has been more recently introduced in this project and is yet to generate its impacts properly.

Irrigation intervention in the two project areas has improved the cropping patterns in terms of expansion of HYVs. In G-K, HYV Aman area has increased by 55 percent and HYV Aus by 44 percent. In PIRDP, the increase is exclusively in HYV Boro but, proportionally more than in G-K. Substantial growth in the adoption of HYVs has led to higher farm income (Tk. 29.000 to Tk.46,000 per ha in G-K and Tk. 28,000 to Tk.29,000 in PIRDP). There has also been an overall increase in production, employment and net return in irrigated areas compared to rain-fed areas in all sections – head, middle and tail.

Although larger landowners benefit more, small landowners have also secured irrigation water and the resulting benefits through higher yields. The land-poor and the landless have also derived benefits from increased employment resulting from HYV varieties being cultivated more and more. But the benefits they derive remain limited, given their very limited access to land.

Analysis of Constraints and Opportunities for Increasing Crop Productivity

Both G-K and PIRDP irrigation systems have been performing much below potentials. Irrigation intensity has been found to be low and erratic, varying widely in different sections and seasons of the irrigation systems. The crop yield is rather low, ranging from 2.47 to 5.04 tons of T-Aman per hectare in G-K. In PIRDP, HYV Boro paddy yield varies from 3.99 to 5.99 tons per hectare. Adoption of modern technologies is also low in both the systems. Adoption of HYV rice varieties varies from 44 percent and 55 percent.

Major constraints on increasing crop productivity are:

(i) Low adoption of HYV rice varieties, (ii) Poor irrigation intensity, (iii) Lack of specific, organized technology transfer, (iv) Weak or no participation of poor farmers in water management, (v) Ineffectiveness of WMGs/WMAs in certain areas and (vi) non availability of adequate credit.

Both the project areas are almost flood-free due to construction of embankments. The soil quality in these areas does not pose any constraint on productivity and the agro-climatic variables are suitable for year round crop production. There is ample scope for expansion of irrigated areas and increase in irrigation intensity in both the projects.

In both G-K and PIRDP there are considerable opportunities of increasing crop productivity through:

- expanding irrigation coverage in both Rabi and Kharif seasons by improving system efficiency.
- increasing HYV rice cultivation from present level of 55 percent to 80 percent.
- application of precision technology through organized extension system for the irrigated agriculture and providing on-farm water management training to the water users groups and association.
- increasing cropping intensity by growing a wide variety of crops in the different growing seasons.
- Both the project areas are suitable for intensive practices, and inter-cropping patterns with pulses and oilseeds. Many high value winter vegetables including potato are now cultivated in some areas and there is considerable potential of expanding cultivation of these crops, during Rabi and pre-kharif seasons, with partial irrigation practices.

Institutional and Technological Interventions

In the late 1990s, for sustainable improvement of irrigation performance and rapid adoption of new HYV technology in rice and wheat, participatory character of water management in G-K was sought to be enhanced and, to that end, the earlier formed outlet committees were re-named Water Management Groups (WMGs). A WMG consists of nine members; one-third each from large, medium and small farm categories. Further, 10-15 WMGs from each of the tertiary canals are formed into an Association, known as Water Management Association (WMA). These institutions are expected to manage water distribution in all field outlets from head to tail. The WMGs and their constituent WMGs work under close supervision of the BWDB officials, responsible for distribution of water up to the tertiaries.

These innovations in field operations and irrigation extension in G-K have been carried out for promoting farmers' direct participation in irrigation management to contribute to improved performance of the irrigation system. In PIRDP, the changed organizational set-up, as introduced in G-K, has been initiated from the very beginning and its water management groups are still being formed as infrastructural facilities are expanded in the command areas of the project.

These institutional changes at the field level are expected to help increase crop productivity and production for all categories of farm households, especially the poor farmers, given equitable access to water and irrigation water use efficiency. Furthermore, the differences in irrigation performance between the head and the tail end reaches are expected to be narrowed as a result of improved water distribution, provided the farmers are equally responsive to improving agronomic practices and input use.

Constraints and Opportunities for Reducing Poverty in Irrigated Agriculture

The yield of crops and cropping intensity contributed largely to the household income. The average per capita annual income across the farm size groups ranges from Tk. 12,000 to Tk. 14,000 in the irrigated areas against the annual expenditure ranging from Tk. 12,000 to Tk. 12,250. Low yields of crops and poor irrigation intensity are the major constraints on increasing per hectare annual output.

Availability of land for agriculture is declining sharply as a result of increasing population and non-agricultural use of land and the proportions of small and landless farmers have been continuously increasing. In G-K, 4 percent of large landowning households own 43 percent of the total land and, in the PIRDP, 10 percent of the large households own 25 percent of the land.

The poor performance of both the systems has resulted in diminished irrigation coverage and increasing cost of water per hectare of irrigated land. The output per unit of diverted irrigation water ranges from the lowest 0.12 kg/m^3 ($T_{10}S_{11}K$) to a maximum 0.48 kg/m^3 (T_6S_7K) in the G-K system. In PIRDP, it ranges from 0.006 kg/m^3 ($I_3S_{10}T_3$) to 0.163 kg/m^3 ($I_3S_1T_3$). In general, the performance of the tail end reaches of both G-K and PIRDP have been reported to be significantly poor because of the inequality in irrigation water distribution and poor management practices. These have considerably reduced the total productivity in both the irrigation projects, affecting the incomes of the small and landless households. Moreover, the WMG and the WMA are not effective in all areas of the two projects, leaving on-farm water management practices poor, with low water use efficiency and low crop yields.

The opportunities of reducing poverty are available in terms increasing irrigation command areas, better WMG performance, efficient on-farm water management practices and use of more HYV technologies with appropriate agronomical practices. There is potential for improving irrigation system performance by establishing field organizations to improve farmers' direct participation in the allocation and distribution of water to individual farms. Institutional reorganizations are expected to expand irrigation coverage in the command areas reduce O&M cost, increase crop productivity and improve collection of water charges.

Under the existing conditions in both the study projects, small, marginal and poor farmers receive larger benefit from irrigation per unit of land than the larger landholding farmers. Although, the share of land belonging to small and marginal farmers is very low, the proportion of area under modern rice varieties and irrigation intensity are higher for them. This intensive management practices for increased productivity of land will, therefore, benefit the small and poor farmers. In order to capture this increased benefit, the small and marginal farmers should be organically involved in the management of irrigation activities so that their equitable access to irrigation water can be secured. Besides, an appropriate land reform to benefit the landless and small farmers, although complex under the existing socio-political reality, requires serious consideration.

Conclusions

In G-K, transplanted HYV Aus and Aman paddy are the principal crops and the maximum irrigation intensity has been seen to be 60 percent in Kharif-I and between 53 percent and 98 percent in Kharif-II seasons. Irrigation intensity in the tail reaches of the canal system is extremely low. In PIRDP, irrigation intensity has been found to behave erratically, the highest being 206 percent at $I_3S_{19}T_{14}M_1$. In general, the households at head and medium reaches have benefited more than the tail enders.

In G-K, T_1A, the head tertiary of S_1G, has achieved the highest irrigation coverage of 97 percent and the tail tertiary of S_7K, the lowest coverage (23%). In PIRDP, $T_{14}M_1$, the tail tertiary of S_{19} has performed the best by irrigating the entire command area, while T_3, the tail end tertiary of the secondary canal of S_{10} has done the worst.

In general, head, middle and tail reaches of the canals receiving less irrigation water per hectare generate lower productivity. Farmers at tails often do not get adequate water for irrigation and, therefore, produce less per unit of land. The proportion of area under modern rice varieties is higher for small and marginal farmers and their yield rates are also higher compared to large land owning groups. Under the existing conditions, small, marginal and poor farmers receive larger benefits from irrigation per hectare of land than large landholding farmers. But the landholdings of the households belonging to the land- poor groups are very low, with the consequent low total benefit.

The poor performance of the systems has resulted in the diminished irrigation coverage in both G-K and PIRDP systems; and, as a result, the cost of irrigation per hectare is high. The output per unit of diverted irrigation water ranges from lowest 0.12 kg/m^3 ($T_{10}S_{11}K$) to maximum 0.48 kg/m^3 (T_6S_7K) in the G-K system. In PIRDP it ranges from 0.006 kg/m^3 ($I_3S_{10}T_3$) to 0.163 kg/m^3 ($I_3S_1T_3$). In general, the tail end reaches of both G-K and PIRDP systems have performed significantly poorly, because of the inequality of irrigation water supply and poor management practices, constraining productivity in general and incomes of the small farm and landless households in particular.

In both G-K and PIRDP, household income has increased for all categories of households (small, medium, and large farmers as well as the landless) in all locations (head, middle and tail) of all selected secondary canals. Net annual financial return per ha (from cultivation of cereals only; other crops produced are not irrigated) varies from Tk. 15,000 to Tk. 23,000 in G-K and from Tk. 18,000 to Tk. 22,000 in PIRDP, while net economic return (from 1.0 ha) varies from Tk. 13,000 to Tk. 16,000 in both G-K and PIRDP.

It has been observed that household agricultural income and gross agricultural output are significantly influenced by the technology used, increased membership in WMG, and credit support. Lack of use of modern technologies, larger family size, high dependency ratio, and low education of household heads are the main determinants of poverty.

On average, per capita annual income (farm plus non-farm) across farm size groups ranges from Tk.12,000 to Tk.14,000 in the irrigated areas, which is estimated to be 14 percent higher compared to that in the rain-fed areas. Although larger landowners benefit more, small landowners also have secured irrigation water and have, as a result, benefited in many areas under the two projects through higher yields. The land-poor and the landless have also derived benefits from increased employment resulting from HYV varieties being cultivated more and more. But the total benefits they derive remain limited, given their very limited access to land.

In both G-K and PIRDP areas, irrigation has been helpful in reducing the skewness of land distribution and the spread and depth of poverty, and improving livelihood conditions of the small farmers as evidenced by the increased use of safe drinking water, more access to sanitary latrine, and domestic use of electricity.

Towards improving irrigation performance, innovations like formation of water management groups at the outlets Water Management Association (WMAs) consisting of the WMGs under the respective tartiaries at the tertiary level, and Water Management Federation at the apex level have helped improve performance in G-K; but, in PIRDP, the organizations are yet to be formed in all areas under its command.

In G-K, the successful performance of the tertiary canal is determined largely by the active participation of water users through WMGs and WMAs and the efficiency of the BWDB officials. In the case of PIRDP, a clear identification of the institutional factors has not been possible as the performance in the command areas of all the selected canals does not vary much. Moreover, participatory water management has been more recently introduced in this project and is yet to generate its impacts properly.

Based on the evaluation of G-K and PIRDP in terms of the area coverage, irrigation intensity, output per unit of water and labor, head-tail equity and involvement of beneficiaries in the management, it is concluded that the systems have not been performing satisfactorily and the full potential of the systems have not been realized.

The major constraints on increasing crop productivity are:

(i) low adoption of HYV rice varieties, (ii) poor irrigation intensity, (iii) lack of specific organized technology transfer, and (iv) Weak or no participation of poor farmers in water management (v) ineffectiveness of WMGs and WMAs in many areas under the two projects and (vi) non-availability of adequate credit.

In both G-K and PIRDP, there are considerable opportunities of increasing crop productivity through:

- expanding irrigation coverage both in Rabi and Kharif seasons by improving system efficiency,
- increasing HYV rice cultivation from present level of 55 percent to 80 percent,
- application of precision technology, through organized extension system for the irrigated agriculture and providing on-farm water management training to the water users groups and associations, and
- increasing cropping intensity by growing a wide variety of crops in the different growing seasons.

Opportunities of reducing poverty are available in terms of increasing irrigation coverage, better WMG performance, efficient on-farm water management practices and use of more HYV technologies with appropriate agronomical practices. There is potential for improving irrigation system performance by establishing consolidated field organizations to improve farmers' direct participation in the allocation and distribution of water to individual farms. Institutional reorganizations are expected to expand irrigation coverage in the command areas, reduce O&M cost, increase crop productivity and improve collection of water charges.

The way forward

Crop agriculture is the major contributing sector in the national economy. The country now produces more than 26 million tons of food grains. The population of the country is still growing at 1.5 percent per annum and would be around 170 million by 2020 resulting in per capita arable land availability of less than 0.04 ha. By 2020, the demand for food will increase very substantially and with the number employment seekers – each by 30 percent or more.

Since irrigation is the engine of agricultural growth it would be necessary to expand irrigation coverage considerably for increasing agricultural productivity and production and employment opportunities through HYV cultivation. There are, however, major concerns related to surface water irrigation development and management. The performance of the surface water based irrigation projects so far developed is largely unsatisfactory. Given that the potential for further expansion of groundwater irrigation is limited, emphasis in surface water irrigation development is important to support sustainable agricultural development in Bangladesh. The development of surface water irrigation requires adoption of measures to promote efficient and socially responsive water use in gaining agricultural productivity, delineate public and private sector responsibilities, and decentralize planning and management functions.

Issues have emerged due to institutional and managerial problems, poor governance, poor O&M and weak on-farm water management practices, which should be resolved. This study has gained further insights relating to field problems, both in G-K and PIRDP. Based on these findings, the following actions are identified.

- To improve the beneficial impact of irrigation on the poor, effective steps are needed to bring the entire potential command area under irrigation and to ensure equitable distribution of water to all areas and to all categories of households. Given that their access to irrigation water improves, they will secure increased agricultural productivity. In both G-K and PIRDP, there is a strong need for diversification towards high value crops according to the agronomic and agroecological settings. The landless will benefit as a result of increased employment opportunities arising from expanded irrigation and the consequent increased cultivation of HYV and high value crops.

- Surface water in the country has overtime become increasingly scarce and hence, its optimum use needs to be ensured in terms of secure availability and equitable and efficient distribution of irrigation water leading to increased water productivity. To that end, water losses from the canals should be reduced through poorer maintenance of water infrastructure. WMGs and WMAs should be appropriately involved in O & M activities. Steps need be taken to ensure honest, efficient discharging of duties by the BWDB officials. Transparency in their functioning is needed, which can be ensured through mandatory regular consultation with the farmers and their organizations viz. WMGs and WMAs. In this context, a crucial need is effective supervision and coordination.
- For improved agricultural yield per unit of land, labour or irrigation water used, proper application of irrigation-seed-fertilizer technology is needed through coordinated action by BWDB and other government agencies on the one hand and WMGs/WMAs on the other. Tertiary canals and below may be handed over to the WMGs for management.
- The existing water management groups and associations (WMGs and WMAs) are not yet fully active in all areas, even in the long-standing G-K project. They are still at early stages of operation or in formation in different parts of PIRDP. Steps need to be taken to make these organizations more effective.
- The National Water Policy has not specifically addressed the issue of irrigation rights and obligations; and no regulation exists for dealing with defaults on water charges. It is necessary to spell out equitable irrigation rights and obligations at the policy level and involve WMGs and WMAs at the field level in the process of ensuring that the codified irrigation rights and obligations are properly observed by all concerned to ensure equity in water distribution and efficiency in water use.
- For the landless and small farmers and equitable distribution of water resources, an appropriate land reform is to be considered. A strong political will is needed for implementing an appropriate land reforms programme.

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Report on National Workshop

22-23 May 2003, Dhaka, Bangladesh

Introduction

The two day National Workshop on "Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia - Bangladesh Component" was jointly organized by the Bangladesh Unnayan Parishad (BUP) and the Institute of Water Modeling (IWM) in Dhaka on 22-23 May 2003. Study team members from BUP and IWM attended the workshop. Dr. Intizar Hussain, the IWMI Project Leader for the Project, invited water sector experts, and officials from concerned government agencies. Altogether, over 100 researchers and water experts from related government agencies, research organizations and NGOs participated. Keynote presentations were made by Dr. Q. K. Ahmad, the country Team Leader for the Study Project and the Chairman of BUP, as well as Dr. Intizar Hussain, IWMI Senior Economist and Project Leader of the Study Project. The purpose of the workshop was to present, discuss, and review the progress of the research, and formulate recommendations for successfully completing the study. The workshop was divided into the following sessions:

- Inaugural session
- Session on water and poverty
- Session on presentation and review of progress reports on various components of the project

Inaugural Session

The workshop was inaugurated by the chief guest, Mr. Md. Sayef Uddin, Secretary, Ministry of Water Resources, Government of Bangladesh, and presided over by the Vice Chancellor of North South University Dr. Hafiz G. A. Siddiqi. The Resident Representative of Asian Development Bank in Dhaka, Mr. Toru Shibuichi, was present as special guest.

The session opened with a welcome address by Q. K. Ahmad. In his keynote presentation, he discussed the theme of poverty reduction through water sector interventions. He mentioned that lack of access to safe drinking water jeopardizes life and living of the poor. In addition, lack of water for agricultural production, particularly during the critical crop growth stages, has a disastrous impact on the smallholders. He highlighted the fact that irrigation water is available to large and powerful farmers while small holders are often unable to meet the cost of water. Ahmad underscored the need for developing strategies to address the causes and processes of poverty, based on contextual realities. Causes and processes of poverty, he said, are mutually reinforcing. Also, all members of the specific target groups are not homogeneous. Therefore, Ahmad suggested that the adopted strategy should be clear but flexible. In respect of water management, he said that responses to the crisis are best sought through a holistic approach. He underscored the need for a coordinated development and management of water, land, and, related resources to maximize social and economic welfare. Development, he stressed, must ensure sustainability of the ecosystem.

Intizar Hussain, speaking next, began with a brief introduction to the project. The project background, goals, and objectives and project scope were briefly outlined. While discussing the importance of the project, Hussain highlighted the fact that the six countries under study, account for a large majority of the poor people in Asia. The economies are agro-based and the living conditions of the poor are closely related to the performance of agriculture. He, therefore, underscored the need for developing a set of pro-poor interventions in irrigated agriculture for improving the condition of the poor. While discussing how irrigation and the condition of the poor are intertwined, Hussain mentioned that in most developing countries of Asia, poor management has resulted in unsatisfactory performance of irrigation. The physical impacts of the poor performance, he mentioned, include tail end water deprivations, salinity and water logging. The project's aim was not only focused on physical impediments but also on socioeconomic impacts of irrigation performance. The purpose was to examine the socioeconomic linkages between irrigation performance and poverty in a greater depth so as to devise interventions appropriate for the needs of the poor, which would contribute to poverty reduction. Having discussed the general issues regarding the project, Hussain moved on to highlight some of the specific findings of the study from different participating countries. One striking finding of the study so far, revealed that land distribution is far more skewed in the countries of South Asia than in China. In conclusion, Hussain thanked the participants and guests, particularly Mr. Toru Shibuichi for his support in initiating the study.

Following the two keynote presentations, Special Guest Mr. Toru Shibuichi presented his address. Mr. Shibuichi said that the Asian Development Bank would continue its support to Bangladesh for poverty reduction activities and implementation of various reform programmes. The Bangladesh Development Forum meeting that had just concluded, also stressed the need for good governance and reform programmes, he added.

Speaking as the chief guest, Water Resources Secretary Mr. Md. Sayef Uddin stressed the need for increasing the irrigation facilities in the country for reducing poverty. He emphasized the need for capacity building to ensure optimum use of water resources in the country. He pointed out that Bangladesh's success and achievements in implementing projects would motivate donors to provide funds in future. The Secretary mentioned that the marginal farmers have been facing tremendous difficulties in retaining their lands owing to river erosion and land grabbing by the rich. He underscored the need for a legal framework to protect the land of the marginal farmers.

In his address, the Chair, Hafiz G A Siddiqi underscored the need for regional cooperation for maximum use of water in the country. He emphasized the need for a regional approach to water management system, because more than three-fourths of the water run-off in the country comes from the upstream. Finally, he thanked the distinguished guests, participants and the organizers and then concluded the inaugural session.

Session on Water and Poverty

In this session of the workshop, five research papers related to water and poverty were presented by experts on the subject. The session was presided over by Dr. A T M Shamsul Huda, former Secretary, Ministry of Water Resources, Government of Bangladesh.

Paper by Rezaur Rahman

The paper on "Water and Poverty in Different Hydrological Regions of Bangladesh" was presented by Dr. Rezaur Rahman, Associate Professor, Institute of Water and Flood Management, Bangladesh University of Engineering and Technology (BUET). The objective of Rahman's paper was to understand and compare water poverty in different hydrological regions of Bangladesh through an index developed by Center for Ecology and Hydrology, UK. This index measures water inadequacy and inefficiency in the supply of water at critical crop development stages. Hydrological regions are a convenient way of describing the country in terms of how surface waters interact. With the exception of actions in the major rivers, interventions that change the flow regime within one region may have little effect on another region. For Bangladesh, eight hydrological regions are defined, namely, North West (NW), North Central (NC), North East (NE), South East (SE), South Central (SC), South West (SW), Eastern Hills (EH), and the active floodplains and charlands of the Rivers and Estuary Region (RE). Water poverty indices (WPIs) for different hydrological regions show that all the hydrological regions are water poor. While the best achievable value for WPI is 100, the value for the hydrological regions vary from 45 to 59. Water poverty is the highest in EH region and the lowest in NW region. EH scores badly almost in all WPI components except environment. In conclusion, Rahman suggested that WPI values give an indication as to where new investments have to be made in order to improve the water poverty situation. For example, he mentioned that EH region requires interventions in future.

Paper by M. Eklimur Reza

Mr. Reza, Consultant, Water Resource Development Planning and Design, presented a paper on "Rubber Dams in Bangladesh Harness Surface Water for Farmers to Irrigate at Lower Cost". He said there is no scope to develop reservoirs for storage of water in this flat country. Against this backdrop, Bangladesh has adopted Rubber Dams for conservation of water in some of the channels of its small and medium rivers to support winter-summer irrigation. Since the introduction of the technology in 1995, Rubber Dams have been recognized as a successful method of water conservation under conditions prevailing in Bangladesh. The paper discusses the technology of Rubber Dams in some detail, together with last seven years' experience of Bangladesh with rubber dams. References are made to the impact of the Rubber Dam projects on agriculture and poverty status of small and marginal farmers, and also on the scope of other economic activities for the local poor. Reference has also been made to the potential of application of Rubber Dams in regional countries.

Paper by M H Siddiqi

The paper on “Sustainable Water Development in Bangladesh” was presented by Mr. M H Siddiqi, BU, an eminent Water Resources Expert. At the outset, Mr. Siddiqi gave an overview of water, economy and environment of the country. The paper addresses issues relating to water management planning. According to Siddiqi, in a poverty stricken agrarian economy like Bangladesh, optimal agricultural development is a sine-qua-non for national economic growth. There is strong evidence in Bangladesh as well as in many other developing countries that agricultural development is a powerful tool for poverty reduction, social welfare, and economic growth, primarily due to three main broad linkages, namely, additional employment opportunity, generation of rural non-farm activities, and welfare-increasing reduced cost of food.

Paper by Giasuddin Ahmed Choudhury

Mr. Choudhury, Chief Engineer, O&M, Bangladesh Water Development Board (BWDB) presented a paper on “Impact of Water Sector Projects on Water and Poverty”. The paper contains a general discussion on the impact of water sector projects on poverty reduction. It has been argued that water sector projects contribute greatly towards reducing poverty. Improving access to clean water and sanitation for poor people is a critical element in the battle against poverty and for integrated water resources management. Choudhury said that this sector needed large investment, which he hoped would be available in the future.

Paper by Dhali Abdul Qaium

The last paper was presented by Mr. Dhali Abdul Qaium, Principal Scientific Officer, Water Resources Planning Organization (WARPO) on “FCD/FCDI Interventions and Poverty Reduction: the Bangladesh Experience”. Qaium mentioned that FCD/FCDI projects in Bangladesh are not only an option but also one of the driving forces of the economy. Rural Bangladesh is dependent on such projects for employment, food and prosperity. The Poverty Reduction Strategy Paper (PRSP) being prepared by developing countries around the world, puts emphasis on the implementation of programmes/projects aimed at poverty reduction. In this context, Bangladesh has already adopted an Interim-PRSP, which includes aspects of water sector’s role towards poverty reduction. FCD/FCDI interventions are helping the country towards poverty reduction by generating employment for rural people and attaining food security for small and marginal farmers. Logically FCD/FCDI projects deserve due attention in the I-PRSP of the government.

Following the presentation of the papers, a general discussion was held on the contents presented in different papers. Afterwards, the Chairman Huda summed up the day’s deliberations and thanked all the participants and the organizers.

Session on Presentation of Progress Reports of various research components of the project

This session was held on 23rd May, 2003 and dedicated to the presentation of the research components of the study on Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia, Bangladesh Component. Presentations were made by the Team Members of the study. The session was chaired by Mr. M.H. Siddiqi, BU, an eminent Water Resources Expert.

Presentation of the Research Component 1: Assessment of Poverty in Irrigated Areas and Analysis of Linkages between Poverty and Irrigation

The presentation of this component was made by Mr. Nittananda Chakravorty, a member of the study team. He started with the general background of the two projects selected for the Pro-Poor study, the Ganges-Kobadak Irrigation Project (G-K) and the Pabna Irrigation and Rural Development Project (PIRDP). The G-K Project comprises two units, phase-1 and phase-2. The project implementation commenced in 1954 and completed in 1983. The Pabna Project was initiated in 1992 and the command area development programme was carried out between 1996-97 and 2002-2003 by the Government, with funding support from the Asian Development Bank. Chakravorty explained the selection of surveyed households by location of canal reaches for the two projects. On the income and consumption patterns, the study reveals that, in the G-K project, poor households at the lowest tail portion of the irrigation system earn relatively more from agriculture than from wage labour, while in the Pabna project, poor households at similar location earn relatively more as day labour than from agriculture. The land price after irrigation intervention has increased by 25 percent to 40 percent in the G-K project while by 75 percent to 100 percent in the Pabna Project. The cropping intensity and irrigation facilities have caused appreciation of land value, which is an indirect benefit for the poor households in particular.

Chakravorty then presented a general review of agricultural changes due to irrigation intervention in the two projects. As a result of the projects, additional on-farm employment opportunities arose in the project areas. In explaining linkages between irrigation and poverty, it was observed that, due to the intervention, the yield increased, more jobs were created, and the land prices went up. Better livelihood outcomes were also observed, such as more income, sustainable land and water use, and small fisheries for poor households and women. He summed up his presentation highlighting key findings and recommendations.

Presentation of the Research Component 2: Assessment of Irrigation System Performance and Associated Impacts on Poverty

The presentation of this component was made by Dr. M Afzal Hossain. A major part of this research component was entrusted to the Institute of Water Modelling (IWM). Hossain presented an overview of both the G-K and the Pabna Irrigation Projects. The salient features and the technical data were presented. In carrying out the research both primary and secondary data were collected from the three selected canal systems at the head, middle and tail reaches in each project. It was revealed from the field survey that the tail end canals get less water and the canal at the head receives more water. Analysis of the data on the seepage loss indicated that, in the G-K project, the seepage loss per million square kilometer of wetted perimeter of the canals was in the range of $2m^3$/sec to 15 m^3/sec. The irrigation water loss due to seepage in the Pabna project was about 14.63 m^3/sec. It was pointed that there were 324 water management groups, seven water management associations and one water management federation in the G-K project, while in the Pabna Project there were 368 water management groups, 6 water management associations and one water management federation. These organizations have been carrying out specific functions and responsibilities.

Hossain presented the research findings and said that in the G-K project the irrigation coverage ranged from 67-97 percent during wet season and 5.5-33 percent in the dry season, while the irrigation coverage in the Pabna project is 100 percent during the Rabi season. The constraints on productivity in G-K include shortage of irrigation water at the system intake near the Ganges, supply of inadequate water in the canal system due to breaches, and non-performance of duties by the water management groups as well as by the water management associations. In the Pabna project the situation is similar.

Presentation of the Research Component 3:
Assessment of Institutional Interventions and Innovations

This research component was presented by Ms. Roushan Akhter, a member of the study team. She discussed the institutional interventions that were adopted for improving the irrigation performance in the two projects. A number of socio-economic are factors involved in irrigation management, which should need to be addressed, for improving the performance in, for example, collection of irrigation water fee from the projects. The efficiency in the collection of water fees is very low in the two projects. There is no involvement of the farmers' representatives in the collection of irrigation water fees. The members of the Water Management Associations (WMAs) are not involved in this process. The current irrigation fee fixed for the study areas is too low to cover O&M costs.

Akhter underscored the need for effective community participation in irrigation management, towards ensuring the community ownership of any irrigation project. O&M, tax collection, training etc. are not possible without participatory irrigation management (PIM) by the community. For PIM, the stakeholders suggested certain necessary steps, including the following:

- WMG/WMA should be involved in the collection.
- Assistance of the law enforcement agencies, where needed.
- O&M training to be imparted to the communities by the officials of BWDB.
- Ownership of the irrigation canals (tertiary) should be handed over to the communities as a pro-poor intervention and towards ensuring community ownership.

Akhter highlighted some aspects of PIM and IMT (Irrigation Management Transfer) of the present irrigation networks, which were built by BWDB, and are managed and maintained by the organization. The common attitude prevailing in the community, is that the management, maintenance and operations of these projects are to be performed by the government. The community seems to take no responsibility in O&M of any project implemented by the government. A sense of community ownership is still at the formative stage.

Regarding involvement of non-governmental organizations in water development, she said, that it was a relatively recent phenomenon. It started with the introduction of labour contracting societies for providing employment to the landless groups, where women were mainly engaged for maintenance works. Later, embankment maintenance (EMG) and canal maintenance groups (CMGs) were formed to work in those projects. However, very few NGOs showed interest in irrigation water management, especially in the project areas.

Discussion on the Presentations by the Participants

Following each presentation, comments and suggestions were offered by the participants. Based on these discussions, a summary of the comments/observations offered by the distinguished participants is outlined below.

The participants, while commenting on Component 1, felt that some of the issues such as poverty and irrigation linkages need to be elaborated on. The analysis of the data related to poverty linkages with irrigation, calls for more comprehensive treatment. The benefits accruing to the small and marginal farmers need to be looked into further. Appropriate regression analysis must be conducted.

Participants pointed out that, in the Research Component 2, the sub-component of Associated Impacts on Poverty was not addressed. The indicators used in the study for the system performance are to be re-examined to remove inconsistency.

Regarding Component 3, the participants were of the view that the findings presented were not always supported by analysis, which needs to be corrected. A re-look at aspects of institutional analysis would be useful.

Some participants suggested that poor farmers are being deprived of timely adequate water for irrigation due to lack of proper monitoring of water supplied from the projects. The involvement of the poor farmers in fish cultivation and maintenance of irrigation canals under the projects was emphasized. As there was a lack of control on the cost of irrigation water by the authorities, the poor farmers had to pay huge amounts of money for this purpose, resulting in adverse impact on the poor. It was also suggested that, although the yield of rice increased and substantial employment opportunities were created due to the implementation of the G-K and PIRDP, the poor farmers derived limited benefit and that their participation in irrigation management was not yet ensured. It was opined by some that the poor farmers should be vocal for ensuring their effective participation in the irrigation projects.

The session Chair Mr. M.H. Siddiqi, BUP thanked all participants of the workshop for their very valuable contributions. He suggested that, overall, the research being carry out covered a wide range of pertinent issues and achieved useful outcomes. However, the workshop identified certain weaknesses in the analyses presented in different papers, which, it is understood that BUP will address in finalizing the reports.

In concluding, Q. K. Ahmad said that, in addition to the workshop comments, Intizar Hussain provided detailed comments on the draft papers and BUP would take into account all those comments towards finalizing the reports. He thanked all participants for their contribution.

ACRONYMS

ADAB	-	Association of Development Agencies of Bangladesh
ADB	-	Asian Development Bank
ADP	-	Annual Development Programme
AEZ	-	Agro Eco Zone
AM	-	Analysis Model
B/C ratio	-	Benefit Cost ratio
BADC	-	Bangladesh Agricultural Development Corporation
BARI	-	Bangladesh Agricultural Research Institute
BBS	-	Bangladesh Bureau of Statistics
BCS	-	Beneficiaries Contracting Society
BIDS	-	Bangladesh Institute of Development Studies
BKB	-	Bangladesh Krishi Bank
BME	-	Benefit Monitoring and Evaluation
BMEU	-	Benefit Monitoring and Evaluation Unit
BRAC	-	Bangladesh Rural Advancement Committee
BRDB	-	Bangladesh Rural Development Board
BRRI	-	Bangladesh Rice Research Institute
BWDB	-	Bangladesh Water Development Board
BWFMS	-	Bangladesh Water and Flood Management Strategy
CAD	-	Command Area Development
CADP	-	Command Area Development Project
CARE	-	Cooperative for American Relief Everywhere
CBA	-	Community Based Association
CHT	-	Chittagong Hill Tracts
CIRDAP	-	Centre on Integrated Rural Development for Asia and the Pacific
CMG	-	Canal Maintenance Group
CRP	-	Canal Reclamation Project
CWM	-	Cooperative for Water Management
DAE	-	Department of Agriculture Extension
DCA	-	Development Credit Agreement
DCC	-	District Coordinating Committee
DDC	-	Design Development Consultant
DDP	-	Delta Development Project
DFID	-	Department for International Development
DFR	-	Draft Final Report
DHV	-	Dwars Heedevick Verhey (Dutch Consultants)
DLIPEC	-	District Level Inter-sector Project Evaluation Committee
DoE	-	Department of Environment
DoF	-	Directorate of Fisheries
DSSTW	-	Deep-Set Shallow Tubewell

DTP	-	Deep Tubewell Project
DTW	-	Deep Tubewell
ECA	-	Environment Conservation Act
ECNWRC	-	The Executive Committee of National Water Resources Council
ECR	-	Environment Conservation Rules
EIA	-	Environmental Impact Assessment
EIP	-	Early Implementation Project
EIRR	-	Economic Internal Rate of Return
EMG	-	Embankment Maintenance Group
EPC	-	Engineering and Planning Consultants Limited
EPWAPDA	-	East Pakistan Water and Power Development Authority
EU	-	European Union
FAO	-	Food and Agricultural Organization
FAP	-	Flood Action Plan
FCD	-	Flood Control and Drainage
FCDI	-	Flood Control, Drainage and Irrigation
FGD	-	Focus Group Discussion
FHH	-	Female Headed Household
FIGs	-	Female Irrigation Groups
FMTW	-	Force Mode Tubewell
FPCO	-	Flood Planning Co-ordination Organization
FSQ	-	Full Supply Discharge
FWUA	-	Federation of Water Users Association
GAD	-	Gender and Development
GDA	-	Ganges Development Area
GDP	-	Gross Domestic Product
G-K	-	Ganges-Kobadak
G-KF	-	Grameen Krishi Foundation
GNP	-	Gross National Product
GoB	-	Government of Bangladesh
GoN	-	Government of Netherlands
GPP	-	Guidelines for People's Participation
GPWM	-	Guidelines for Participatory Water Management
GR	-	Green Revolution
GUI	-	Geographical User Interface
HES	-	Household Expenditure Survey
HTW	-	Hand Tubewell
HYV	-	High Yielding Variety
ICID	-	International Commission on Irrigation and Drainage
IDGs	-	International Development Goals
IFAD	-	International Fund for Agricultural Development
IGA	-	Income Generating Activities
IGs	-	Irrigation Groups

IHP	-	International Hydrological Program
IIMI	-	International Irrigation Management Institute
IIS	-	Interactive Information System
ILO	-	International Labour Organisation
IMT	-	Irrigation Management Transfer
INWRDAM	-	Inter-Islamic Network on Water Resources Development and Management
IPM	-	Integrated Pest Management
IRBD	-	International Bank for Reconstruction and Development
IRR	-	Internal Rate of Return
IRRI	-	International Rice Research Institute
JICA	-	Japan International Cooperative Agency
JRC	-	Joint Rivers Commission
KIP	-	Karnaphuli Irrigation Project
KSS	-	Village Cooperative Society (Krishi Samabay Samities)
LCS	-	Landless Contracting Society
LGED	-	Local Government Engineering Department
LGI	-	Local Government Institution
LLP	-	Low Lift Pump
MDIP	-	Meghna Dhonagoda Irrigation Project
MICA	-	Minimum Irrigated Crop Acreage
MOA	-	Memorandum of Agreement
MoI	-	Ministry of Industry
MoL	-	Ministry of Land
MOSTI	-	Manually Operated Shallow Tubewell for Irrigation
MoU	-	Memorandum of Understanding
MoWR	-	Ministry of Water Resources
MPO	-	Master Plan Organisation
MTFPP	-	Mid Term Food Production Plan
MV	-	Modern Varieties
NAEP	-	New Agricultural Extension Policy
NAP	-	National Agricultural Policy
NEDECO	-	Netherlands Engineering Company
NEP	-	National Environmental Policy
NGOs	-	Non Governmental Organisations
NMIDP	-	National Minor Irrigation Development Project
NWC	-	National Water Code
NWMP	-	National Water Management Plan
NWMPP	-	National Water Management Plan Project
NWP	-	National Water Plan
NWPo	-	National Water Policy
NWRC	-	National Water Resources Council
NWRD	-	National Water Resources Database
O&M	-	Operation and Maintenance

OCs	-	Outlet Committees
ODA	-	Overseas Development Administration
OED	-	Operations Evaluation Department of World Bank
OMC	-	Outlet Management Committee
PAP	-	Project Affected Persons
PC	-	Project Council
PCP	-	Project Concept Paper
PG	-	Poverty Gap
PIM	-	Participatory Irrigation Management
PIRDP	-	Pabna Irrigation and Rural Development Project
PPCP	-	People's Participation and Consultation Process
PRA	-	Participatory Rural Appraisal
PROSHIKA	-	Proshika Manobik Unnayan Kendra (a Bangladeshi NGO)
R&I	-	Rehabilitation and Improvement
RAJUK	-	Rajdhani Unnayan Katripakha
RDMS	-	Relational Database Management System
RRA	-	Rapid Rural Appraisal
SAP	-	South Asia Partnership
SAR	-	Staff Appraisal Report
SDOs	-	Surface Drainage Outlets
SDS	-	Social Design Study
SL	-	Sustainable Livelihood
SPG	-	Squared Poverty Gap
SRP	-	Systems Rehabilitation Project
SSWRDS	-	Small-Scale Water Resources Development Sector
SSWRDSP	-	Small-Scale Water Resources Development Projects
STW	-	Shallow Deep Tubewell
T Aman	-	Transplanted Aman
TA	-	Technical Assistance
TCCA	-	Thana Central Co-operative Association
ToT	-	Training of Trainer
TW	-	Tubewell
TWUA	-	Tertiary Water Users' Association
UCCA	-	Upazila Central Co-operative Association
UDCC	-	Upazila Development Coordinating Committee
UN	-	United Nations
UNDP	-	United Nations Development Programme
UPB	-	Upazila Plan Book
WARPO	-	Water Resources Planning Organisation
WB	-	World Bank
WMA	-	Water Management Association
WMF	-	Water Management Federation
WMG	-	Water Management Group

WMU	-	Water Management Unit
WUAs	-	Water Users' Associations
WUF	-	Water Users Federation
WUG	-	Water Users' Group
WUOs	-	Water Users Organisations
XEN	-	Executive Engineer