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WATER MANAGEMENT SYSTEMS DESIGN

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CHAPTER I

THE SETTING

GENERAL

Bangladesh has an area of 35.3 million acres lying in the delda of the world's three great rivers - the Ganges, the Brahmaputra and the Meghna, of which 20.8 million acres (60%) are cultivated. The population is about 91 million (more than 4 persons on a cultivable acre), of which 90% live in rural areas.

It has a population density of about 1600 per square mile. Bangladesh is the most densely populated country in the world, if the city states of Singapore and Hongkong are excepted. It is the most densely populated country by a fairly large marign and this is all the more remarkable since density is related in most cases to high degree of urbanization, whereas over 90 per cent of the total population of Bangladesh live in rural areas, and about 80 percent are engaged in agriculture.

Foodgrain self-sufficiency has emerged as one of the major policy objectives in Bangladesh. The population growth rate has generally surpassed that of food production in recent years, necessitating the annual imports of more than 1.6 millions tons of grain - a serious difficulty in a

country which depends primarily on agriculture. Consequently, the overall development program, particularly agricultural investment have been geared to a foodgrain self-sufficiency objective. In this context, the Government of Bangladesh has perceived that the activities should focus more on irrigation investments with immediate impact on the foodgrain production.

At present, 20.8 million acres, or almost all of the arable lands are cultivated, but only 1.6 million acres are tripple cropped and 7.8 million acres are double cropped and 11.4 million acres are single cropped. This implies the potential for cultivating additional crops particularly in the dry season (November to March) through the provision of irrigation.

Agriculture is the most important sector of the economy. It accounts for about 57% of gross domestic product (GDP), gives employment to 75% of population and provides the base for more than 80% of the country's export. The development of agriculture in Bangladesh has lagged behind that of the sub-continent as a whole for two main reasons. First apart from periodic famines caused by extreme floods and cyclonic storms, the agricultural production in this high rainfall region met the needs of the people till 1950's. Secondly the development of water

resources, whether by irrigation of the dry lands or by protection and drainage of the flooded land, is relatively expensive and technically complex compared with most other parts of the world. Over the last 20 years, the balance of flood supply and demand has changed rapidly and Bangladesh has become an area of serious food deficit.

TOPOGRAPHY

The nearly flat topography, while ideal for agriculture, is prone to drainage and flood problems under the prevailing rainfall pattern and river regimes. The lowlying alluvial plain, comprising most of Bangladesh, rises with very low gradients from the Bay of Bengal in the south towards the foothills of the Assam Hills in the northeast and those of the Himalayas a few miles outside Bangladesh in the northwest. Most of the country lies less than 60 feet above Mean Sea Level(MSL). The highest part of the flood plain, on the northwestern border, is about 280 feet above MSL. The coastal tidal land lies only a few feet above seas level as well as lowest parts of the Sylhet depression. Inland, the overall gradient of the river floodplains is less than a foot per mile, except in the extreme northwest where it increases to about 3 feet per mile.

The overall picture of a very gentle sloping alluvial plain disguises considerable variability in local relief which is of decisive importance to present and future land capability, and to patterns of human habitation. Few flood plain areas are truly flat. The smoothest areas are on the old Meghna floodplain and the Ganges tidal floodplain, where differences in elevation between adjoining ridges and basins are generally less than 5 feet. On the Brahmaputra, Jamuna, Surma, Kushiara, middle Meghna and Ganges river floodplains, relief differences of 5-15 feet are common, increasing to as much as 20-30 feet on the boundary between the old Brahmaputra floodplain and the Sylhet basin. These complex local differences in elevation are important in planning drainage and irrigation, especially as they are usually associated with important differences in soil permeability and associated crop suitability. It is also of particular importance to note that local drainage basins exist requiring individual planning and treatment.

RAINFALL

The mean annual rainfall in Bangladesh varies from about 60 inches in the western part of the country to almost 200 inches in the northeast and is characterized by wide seasonal fluctuations with about 90% of the rainfall occuring in the 5 months period of the monsoon (May to

September). In spite of an overall abundance of rainfall, serious droughts to occur. There are instances of inadequate rainfall during the monsoon and the minimum rainfall during the dry season (October to March) is almost 'nil', when much of the land remains uncultivated unless irrigated.

A number of constraints are inherent in the monsoon rainfall and climate pattern. The 5-6 months dry season restricts the cultivation of perennial and annual dry land crops to soils with superior moisture holding capacity, found only in limited areas, or to irrigated land. Uncertainty of pre-monsoon showers causes variations in aus and jute acreages and yields and cloudiness impose limitations in monsoon season production, encouraging various crop diseases and making it difficult to harvest, dry, store and transport crops. Finally monsoon season cloudiness reduces the yield potential of most rice varieties below what can be achieved in the sunny dry season.

SURFACE FLOW

On an annual basis, large amount of water enters Bangladesh. The average annual surface water inflow into Bangladesh is 870 million acre feet (MAF) and the average annual rainfall in Bangladesh is 203 MAF - a total of 1.073 MAF. With a gross area of some 35 million acres, the country receives annually about 30 feet of water per year.

The average annual evaporation is about 45[1/] inches or 131 MAF over the gross area. This, 65% of the rain or only a little more than 12% of the total volume of water entering Bangladesh cannot be used for agriculture, and virtually all the rest flows off to the sea.

This annual picture conceals the important fluctuation in the course of the year. The average rainfall over most of Bangladesh amounts to only 2.5 - 4.5 inches during November through March (minimum rainfall is zero during this period) which is insufficient to sustain crops. In addition, the flows in the rivers are also significantly reduced during the period of low rainfall. Water supplies are needed between November and May for agriculture, domestic and industrial purposes, for maintaining river depths to allow adequate navigation, to avoid damage to fisheries and to limit inland penetration of sea water. These are conflicting damands and optimal division of scarce winter water among them is the crux of the planning task associated with the "low flow" problem.

1/ The Land and Water Resources Sector Study-Bangladesh, IBRD, 1972, Vol. VII, Technical Report 20, page 6.

Large volume of water are required for the irrigation of crops in the non-monsoon season and for control of salt-water intrusion. Requirements for navigation are maintenance of minimum water depths and widths in strams used for that purpose. The requirements for fisheries and municipal, domestic and industrial supplies, while significant, are smaller and less concentrated by area than that for either irrigation or control of salt-water intrusion.

The aggregate demands for the various purposes must be met over time and space from rainfall, surface water or groundwater. The time distribution of rainfall and surface water poses problems because of the huge excess of water during the monsoon and lack of rainfall and surface water during winter and spring. Surface storage potentials are virtually nill within Bangladesh.

Table 1, 2 and 3 give the availability of water in major and minor rivers in Banglades.

TABLE - 3 : WATER AVAILABILITY IN MINOR RIVERS IN BANGLADESH

	Cultivable Area (MAC)	Surface Water Availability in Minor Rivers	
		March (MAF)	April (MAF)
Northwest	6.10	0.387	0.428
Central	4.04	0.211	0.454
Eastern	4.00	0.118	0.359
Southwest	6.66	0.140	0.140
Total:	20.8	0.856	1.381

1/ H.R. Khan, Irrigation Water Requirements in Bangladesh, National Symposium on River Basin Development, Ministry of Irrigation, flood Control and Water Resources, December 1981.

GROUNDWATER

Groundwater is expected to provide irrigation water to a significant portion of the cultivable area by 1985. Most of the drinking water is also derived from underground.

Recently UNDP(1982)[1/] published a report which describes the results of several years of groundwater investigations in Bangladesh. Some of the conclusions are given below.

The geologic, hydrologic and climatic conditions of Bangladesh are favourable for the occurrence and development of large quantities of ground water.

Two of the world's largest rivers flow through Bangladesh. Up-stream diversion of surface water from these rivers would effect ground-water levels in Bangladesh and increase salinity in shallow aquifers in the coastal area due to decreased outflow.

Floods, in normal years, cover almost a third of Bangladesh but in years of high floods almost half of the country may be under water. Flood waters contribute a significant, but undetermined, amount to ground-water recharge.

1/ Groundwater survey, Department of Technical Cooperation for Development, UNDP 1982.

Bangladesh is mostly underlain by unconsolidated to poorly consolidated sediments ranging in age from Tertiary to Recent. The sediments are generally thick over most of the country.

The role of geologic structure in controlling the occurrence and movement of ground water in Bangladesh is not clearly difined but is probably of minor significance in most of the country.

On a regional basis, three aquifers have been identified: an upper aquifer, herein called the composite aquifer; the main aquifer; and a deep aquifer which lies below the main aquifer and is separated from it by clay layers of varied thickness. In most areas the upper two aquifers are probably hydraulically interconnected.

The main aquifer, in most of the country, is either semi-confined and leaky or consists of stratified, interconnected, unconfined water-bearing zones which are subject to delayed drainage. The main aquifer occurs at depths ranging from less than 16 ft in the northwest to more than 250 ft in the south.

Based on pumping tests, the transmissivity of the main aquifer ranges from 8,000 to 665,000 US gdp/ft. Highest transmissivities occur adjacent to the Brahmaputra-

Jamuna River in north-central Bangladesh and lowest transmissivities occur in the Chittagong Hill Tracts and Sylhet District in the eastern section of the country. Excluding the Tertiary sediments, the areal average transmissivity is about 161,000 US gpd/ft with 56 per cent of the area having transmissivities greater than 80,500 US gpd/ft. Transmissivities in the main aquifer generally decrease southward.

The storage coefficient of the aquifer, computed from pumping test data, ranges from $3x10^{-4}$ to $7.2x10^{-3}$ with the average value being $2x10^{-3}$. These values are representative of leaky, confined aquifers in Bangladesh. However, in the stratified, unconfined aquifers which occur in most of the country's alluvial system, the computed storage coefficients are the results of the initial response owing to the elastic propoerties of the aquifer. The actual storage coefficients or specific yields of the stratified aquifer could not be computed owing to the relatively short duration of pumping in such type of aquifer exhibiting delayed drainage conditions. Analyses of pump tests of longer duration indicate that the specific yields of the aquifer range from 0.03 to 0.2.

The regional ground-water flow is from northwest to southwest. The ground-water gradient ranges from about 1:1,000 in the northwest, about 1:12,000 in central Bangladesh, to about 1:25,000 in the coastal area.

Ground-water levels are highest from August through October and lowest in April and May. A sharp rise in water-levels generally begins in May and continue until July. The range of fluctuation is from 10 to 20 ft in most areas of the country. After July the rate of rise decreases and, in many areas, ground-water levels remain almost stationary from August to October, indicating rejection of recharge because the aquifer is filled to capacity. The rejected recharge varies from place to place and depadds upon several factors including permeability of surficial materials, rainfall amount and intensity and the time factor. Rejected recharge does not occur at all places.

Depth to ground water in the dry season is generally within 20 ft of the surface. In a few areas, particularly in Dhaka District and the Barind area in Rajshahi District, the depth to ground-water levels exceed 40 ft.

Long-term hydrographs show a regular pattern of rising and falling water levels. Almost the same maximum and minimum water levels are reached each year. Expeptions to

this are in the Dhaka and Chittagong areas where there have been long-term ground-water declines related to large withdrawals.

Recharge to ground water occurs primarily through direct infiltration of rainfall. Actual recharge is considerably less than potential recharge. Highest potential recharge occurs in Dinajpur, Mymensingh, Sylhet, Noakhali and Chittagong Districts where it is more than 24 in. The lowest potential recharge occurs in western Bangladesh in Rajshahi, Kushtialand Pabna Districts were it is less than 12 in.

The ground-water reservoir is hydraulically connected to the major streams of Bangladesh. At high-stream stage there is direct lateral and vertical recharge into the composite aquifer and at low-stream stage there is discharge from the aquifer into the stream. From the data available, it appears that ground-water levels are higher than corresponding stream levels for 7 to 9 months each year in most areas of Bangladesh.

In 1979, ground-water extraction was estimated to be 2,784,300 acre-ft, mostly from the main aquifer. Extraction from the composite aquifer is principally for

rural domestic supplies or shallow tubewell irrigation. Extraction from the deep aquifer occurs mainly in the coastal area and in the vicinity of Dhaka city. Eighty two per cent of the total ground-water extraction was used for irrigation.

Ground-water extraction for agriculture is greatest in Dhaka, Dinajpur, Rangpur, Bogra and parts of Pabna, Kushtia, Jamalpur, Mymensingh and Comilla Districts. Extraction in these areas is estimated to be more than 0.20 acre-ft/acre annually. In a few areas, mostly in Dhaka District, extraction exceeds 0.33 acre-ft/acre annually.

Annual municipal extraction for the cities of Dhaka and Chittagong is 3.69 and 2.13 acre-ft/acre, respectively. A result of this relatively high rate of extraction has been the long term decline in ground-water levels beneath both cities.

Ground-water quality in most areas of Bangladesh is suitable for agricultural, domestic, municipal and industrial purposes. Iron and hardness are locally excessive. Water quality generally deteriorates southward.

The country has been divided into 15 potential groundwater development zones, based on aquifer characteristics, land development units and estimated potential recharge. Each zone has been classified according to its development potential in relation to the other zones. Eight zones are classified as good, one zone is, classified as good to fair, two classified as poor, one zone is limited to development of the deep aquifer and one zone is suitable only for development of small domestic water supplies. Considering only the minimum average potential recharge from rainfall, groundwater may irrigate about 20 to 40 per cent of the total land area when planted with HYV rice paddy crop. For the irrigagation of other crops whose water requirements are less, a greater percentage of the area could be irrigated.

Considering the constraints of thickness of the upper clay/silt layer (depth to aquifer), depth to water level and water quality, areas where shallow tubewells are feasible have been identified. Using 0.5 cfs discharge as a criteria, it appears that shallow tubewells of that capacity can be developed only in Rangpur, Dinajpur, Bogra and Rajshahi Districts. In other areas discharges less than 0.5 cfs can be obtained and MOSTI wells may be feasible.

When shallow tubewells are planned in the same area as deep tubewells, water level drawdown must be carefully

considered. In most areas, the main aquifer is hydraulically connected with the overlying composite aquifer. Therefore, significant lowering of water levels on the composite aquifer, thereby increasing the suction lift of shallow tubewell pumps. If large scale ground-water development projects become widespread, shallow tubewells will eventually be impractical in much of the country. Shallow tubewells should be considered as an interim step in the long-term, large scale, ground-water development of Bangladesh.

FLOODS AND DRAINAGE

The flat, low-lying topography impeds drainage and causes flooding under the heavy monsoon rainfall pattern. The hydrological regime of the rivers is determined mainly by the huge run-off of monsoon rainfall outside Bangladesh, and snowmelt in the Himalayas. During the early part of the monsoon, enormous amounts of water flow in via the Brahmaputra, the Ganges and the Meghna system, causing adjoining rivers to rise rapidly. The rise in river levels blocks drainage outlets, causing increased ponding of local rainfall. Most of the land is flooded in this way. Only relatively narrow bolts, adjoining the major rivers and their distributaries are flooded dirdctly by river water.

In particular, in the moribund Ganges delta occupying most of Kushtia, Jessore and Khulna districts, where local rivers are not connected with the major rivers, flooding occurs when runoff from excessive local rainfall is unable to drain rapidly enough because of the congested condition of the old river channels. Elsewhere, in areas adjoining the northern and eastern hills, flash floods occur following periods of heavy rainfall. Similar flash floods occur, but less frequently, on the Tista floodplain following exceptionally heavy rainfall in adjoining areas of the Himalayas. In coastal areas, flood levels fluctuate with the tide, except where tidal effects are cut off by embankments.

Although the annual flood-affected area varies between about 5.9 million to 9.6 million acres, the area subjected to floods over a period of years in much larger. This occurs because the localities affected from year to year are not the same and different areas are inundated depending on the distribution of rainfall, coindidence and magnitude of river peaks and tides in some areas. The "flood vulnerable area", that which has been floods in one year or another, comes to nearly 17 million acreas, out of which 14 million acres are cultivated.

It means that at one time or another, close to half of the 55,000 square mile area of Bangladesh is flooded. Although the floods supply water for aman and boro rice crops in some areas and the people have adapted their living and farming habits accordingly, the floods still in other areas damage crops and property and curtail crop production and sometimes cause loss of life. The impact of flooding results not only from the actual flooding event but also from its uncertainty whether in terms of area, depth, duration or time of recurrence. Because of its overriding impact, a better knowledge of floods and associated drainage problems, and of means to manage them is essential to the long-term development of Bangladesh.

The villagers are used to the "normal flood" and the crops grown are adapted to it. However, it does restrict the cropping in many areas and, in some years, there are abnormal floods, which do a great deal of damage either because of their timing, duration, or extent. If there is an early flood, it can ruin young rice and jute plants in the fields or destroy seed beds.

If there is a long flood just after the summer-sown rice has flowered there is often a sharp fall in yield. These floods rise and fall fairly quickly, but if they last over four days, a great many rice plants are destroyed.

Moreover, floods of unusual height drown short-stemmed rice plants on intermediate and relatively high lands. Apart from crop damage, floods also knock down houses, erode road embankment, accelerate river bank erosion and result in loss of life.

TIDES

The tides are important in that tidal levels regulate river discharge through the estuaries along the coast, cause saline inundation of the coastal areas during the high tide period of the day, and enable land drainage during the low tide period.

The tide along the coast originates from the Indian Ocean. It travels very fast through the deep Bay of Bengal and arrives at Hiran Point and at Cox's Bazar at the same moment. The line between these two stations is roughly the ten-fathom contour which thus demarcates the end of the deep part of the Bay.

Surface water levels rise and fall with the ocean tides throughout southern Bangladesh. During winter months when river flows are low, tidal effect extends up the Ganges-Padma River as far as Faridpur in the west and up the Meghna River past the confluence of the Surma and Kusiyara rivers in the northeast. River flows dampen these effects during

periods of heavy runoff. Tides are semidiurnal with a normal period of 12 hours 25 minutes. Two high tides and two low tides occur every 24 hours 50 minutes with a pronouced diurnal variation between the heights of two consecutive high tides. The tides appraach Bangladesh from the southwest and occur along the westerly side of the Bay about three hours earlier than on the east side.

Normal tide-water levels are subject to influence by meteorological effects such as wind, variations in barometric pressure, and rainfall. The increase in water levels due to cyclonic storms is generally from 10-20 ft. but has been reported to be more than 42 ft. River flood flows also increase tidal heights, particularly the low tides.

CYCLONES

Cyclonic storms are also important feature in Bangladesh climate and can cause even more damage than the annual river floods. Tropical storms usually form in the southeast portion of the Bay of Bengal, move in a northwesterly direction and often turn northeasterly or easterly to the east coast of the country. Reports of property damage and loss of life, caused by recent cyclones have been greater than those of earlier cyclones. This is partly due to increases in population density and property development and more complete reports on damage. The time of occurrence of a cyclone as related to the stage of planting or growth of rice influences markedly the amount of crop damage.

ADJUSTMENTS OF TRADITIONAL CROPPING PATTERNS TO WATER REGIME

More than any other environmental factor, hydrological conditions determine the present and future agriculture use of Bangladesh's cultivated land. These conditions determine which crops can be grown and which rotations can be practised. In general, rice and jute are grown in the monsoon season on seasonally flooded or wet land, and dryland crops are grown in the dry season on land that drains quickly enough and has soils with good enough moisture retaining capacity. Because of slow drainage and consequent soil saturation or flooding, 85% of all agricultural land is suitable only for rice and jute production during the monsoon season. Dryland crops, including permanent crops (such as orchards and sugarcane) and annual crops (including groundnuts and summer vegetables) can be grown on the remaining land, the best drained highland soils during the monsson. Rice can also be grown in the dry season where land remains flooded throughout the year, or on impermeable soils with irrigation.

The three main rice crops - aus, aman and boro are grown in the early monsoon, late monsoon and dry seasons, respectively. Their cultivation, together with that of jute, is largely determined by land levels in realation to flooding.

High yielding transplanted aman rice varieties can be grown on land flooded not more than about 3 feet deep, whereas only low yielding deepwater aman varieties are grown on more deep flooded land. Even these varieties cannot be grown safely on land flooded too deeply or rapidly. The general relationship between land levels, flood depths and cropping patterns is given below in Table 4.

TABLE - 4 : LAND TYPE AND CROP ROTATION

Land Type	Main crop rotation or land use
Permeable highland	Broadcast aus, rabi crop 1/
Permeable medium highland (0-3 feet flodd depth)	Broadcast aus or jute, rabi crop 1/
Poorly drained highland	Transplanted aman, broadcast aus 1/
Poorly drained medium highland (0-3 feet flood depth)	Broadcast aus or jute-transplanted aman, rabi crop 1/
Medium lowland ridges and basin margins (3-6 feet flood depth)	Mixed aus and deepwater aman. rabi crop 1/
Lowland (6-feet flood depth) medium lowland basin centers	Deepwater aman or boro; locally aus and rabi crop (Khesari) on grazed grass-land.

LAND

Land is the major constraint to expanding agricultural production in Bangladesh. Data on land utilization are shown in Table 5. Over the years, as population pressure

1/ Indicates that the following crop may or may not be grown in rotation, usually determined by soil moisture conditions.

has increased, more land has been brought under cultivation each year and that land has been used more and more intensively. Increase in cultivated area have come about by a decrease in area classified as "cultivable waste" (land suitable for cultivation by lying fallow for more than a year) from an average about 1.95 million acres over the last half of the 1950's to only 0.62 million acres in 1978-79. Further change in this category of land is likely to take place only slowly as much of the remaining cultivable waste is probably very marginal land, and some fallow lands will be needed for cattle grazing, shifts in cropping patterns, etc. Moreover, increases in area "not available for cultivation", which have been substantial in the past, are likely to continue as urban demands like requirements fro rural housing grow.

TABLE - 5 : LAND UTILIZATION

	Particulars	5-year Average ending 1959-60	5-year Average enging 1964-65	1969-70	1978-79	1980-81
1.	Forest	5.46	5.46	5.54	5.42	5.41
2.	Not available for cultivation	5.59	5.97	6.50	6.67	6.71
3.	Cultivable waste	1.95	1.82	0.74	0.62	0.62
	Total :	13.00	13.25	12.78	12.71	12.74
4.	Current fallow	1.32	0.98	0.73	1.76	1.40
5.	Net cropped area	20.33	20.93	21.76	20.80	21.16
	Total cultivable area :	21.65	21.91	22.49	22.56	22.56
6.	Total cropped area	25.91	27.88	32.84	31.85	32.52
7.	Cropping intensity percentage	120%	127%	147%	153%	144%

Source: Bangladesh Bureau of Statistics.

More significant than the increase in cultivated area has been the growth in "cropped area". As Table 7 indicates, this was achieved by a dramatic increase in multiple cropping, raising cropping intensity from 120 per cent to 153 per cent. While the temperatures and daylights are sufficient to permit year-round cropping, when one considers that about one-third of the land is flooded every year, that drought threatens nearly every farm during November-April, and that cyclones and shifts in river beds are a frequent threat, this achievement is remarkable.

While there has been an increase in cultivated and total cropped area over the past years, in no way has it kept pace with population growth. Thus, total cropped area per person declined from about 0.57 acres in 1949/50 to 0.46 acres in 1969/70 and 0.37 acres in 1978/79. The relationship between population and land is very uneven throughout the country, with population density in the thickly populated eastern areas of Comilla and Chittagong districts being about twice that of the less crowded districts in the northwest.

CHAPTER II

VARIOUS GOVERNMENT AGENCIES

There are several government agencies dealing with minor irrigation development and exploitation of groundwater for drinking purposes. These are:

Name	Ministry	Functions
Bangladesh Water Development Board (BWDB)	Ministry of Agriculture and Forests	Major and minor irrigation; flood control and drainage projects; surface and ground water data collection and processing; and research.
BARC		
Bangladesh Agricultural Development Corporation(BADC)	Ministry of Agriculture and Forests	Minor irrigation, ground water studies.
Bangladesh Rural Development Board (BRDB)	Ministry of Local Government, Rural Development and Cooperatives(MLGRDC)	Minor irrigation.
Directorate of Public Health Engineering(DPHE)	Ministry of Local Government, Rural Development and Cooperatives(MLGRDC)	Drinking water and sanitation outside Dhaka.
Dhaka water and Sewarage Authority (DWASA)	Ministry of Local Government, Rural Development and Cooperatives(MLFRDC)	Drinking water and Sewarage in Dhaka.
Chittagong Water and Sewarage Authority(CWASA)	Ministry of Local Government, Rural Development and Cooperatives(MLGRDC)	Drinking water and sewarage in Chittagong
Municipalities	Ministry of Local Government, Rural Development and Cooperatives(MLGRDC)	Drinking water and sewarage disposal.

Name	Ministry	Functions
Upa-Zilla Parishads	Ministry of Local Government, Rural Development and Cooperatives(MLGRDC)	Minor and small scale irrigation and flood control.
Bangladesh Krishi Bank (BKB)	Ministry of Finance and Planning.	Minor irrigation.
Bangladesh Bank	Ministry of Finance and Planning	Minor irrigation.
Department of Agricultural Extension(DAE)	Ministry of Agriculture and Forests	Agriculture extension

The functions of BWDB, BADC, BKB and BRDB - which have major roles in developing physical facilities for deep and shallow tubewells and low lift pumps - have been described in the next few pages.

BANGLADESH WATER DEVELOPMENT BOARD (BWDB)

BWDB was established by a Presidential Order published in the Bangladesh Gazette on May 31, 1972. The order resulted in bifurcation of the former East Pakistan Water and Power Development Authority (EPWAPDA) into a Water Development Board (BWDB) and a Power Development Board (BPDB). BWDB is responsible for providing surface water irrigation, drainage, flood control, erosion control, town protection and river training throughout Bangladesh. It is the major water planning agency for the nation.

The functions and responsibilities assigned to the Bangladesh Water Development Board may be outlined as follows:

(1) Prepare for approval of the Government a scheme for the control of flood in the development and utilization of water resources of Bangladesh.

(2) Frame a scheme or schemes for the whole of Bangladesh or any part thereof providing for all or any of the following matters, namely:

(a) construction of dams, barrages, reservoirs and other original works, irrigation, embankments and drainage;

(b) flood control including watershed management;

(c) prevention of salinity, water congestion and reclamation of land;

(d) maintenance, improvement and extension of channels including dredging of channels but excluding all such operations as may be assigned by the Government to any other agency;

(e) regulation of channels to concentrate river flows for more efficient movement of water, silt and sand, etc.

In the context of above functions, the order further stated that the Water Board shall:

(1) have control over the flow of water in all rivers and channels of Bangladesh subject to private right and the underground water resources of any region of Bangladesh;

(2) prescribe standards for the operation and maintenance of all irrigation embankment and drainage works;

(3) control and operate the dredger fleet, its ancillary crafts, appurtenances and equipments including launches, barges etc.

Thus, it may be seen that the most important mission of the Water Development is to develop water resources for increasing food production by providing irrigation, drainage and flood control facilities, the other important functions are erosion control and town protection, river training and maintenance of dredger fleet.

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION

The Bangladesh Agricultural Development Corporation (BADC) was established in 1961 in response to the recommendation of the Food and Agriculture Commission to assure expeditious distribution of agricultural inputs as well as to carry out various development functions in agriculture.

BADC is overwhelmingly the most important public agency concerned with the minor irrigation sector. It is responsible for over 90% of the supply and maintenance of LLP and DTW (BWDB handles the balance) has supplied and stocked spares

for about 50% of STW installed to date (the balance being for BKB and Bangladesh Bank), and has an ongoing project for HTW (IRDP executed earlier for about 90,000 HTW). BADC has over 14,000 staff employed in the sector. Although Government intends that much of BADC's present activity be transferred to the private sector, the transition will take several years. In view of this, and of the enormous increase in irrigation development proposed under the SFYP, BADC will clearly remain a critically important agency through the SFYP period.

Section 13 of the Bangladesh Agricultural Development Corporation Ordinance sets forth the functions of the Corporation:

(a) The Corporation shall (inter alia);

- make suitable arrangements on a commercial basis for the procurement, transport, storage and distribution to agriculturalists of essential supplies such as seed, fertilizer, pesticides and agricultural machinery and implements,
- promote the setting up of cooperative societies with a view to handing over the supply function,
- encourage the development of cooperatives in other spheres,

(b) The Corporation may (inter alia);

- organize the supply, maintenance and operation of low lift pumps and set up workshops for repairs,

- in conjunction with the Government, encourage the expansion and improvement of industries for the manufacture of diesel engines used in agriculture,
- make arrangements for servicing machinery, and
- provide and maintain transport facilities and assist other public or private agencies to provide such facilities for the use of the Corporation.

In "Project Areas" the Corporation has even wider powers to conduct agricultural extension programs and land reclamation and exploitation, to take over the functions of nearly all Ministries, to conduct surveys and research and to distribute irrigation water.

BANGLADESH KRISHI BANK

BKB was established in 1973 to provide credit facilities to all persons and corporate bodies engaged in agriculture and cottage industries. It is now the largest source of credit for agriculture. Its lending volume increased eightfold over the last six years, from Tk 176 million in 1974 to Tk 2097 million in 1981-82.

BKB's staff is large, experienced and well distributed. BKB has a staff of 5,000 and operates 22 regional offices and more than 800 branches. BKB's senior staff have long experience in agricultural banking. An Engineering Department has been added to provide technical support to its tubewell lending program. To cater for expansion, an aggessive training program has been established by its management.

BANGLADESH RURAL DEVELOPMENT BOARD (BRDB)

The BRDB which promotes the growth of TCCA/KSS system, was established in December, 1982. It (formerly IRDP) had its origin in what is Khown as the Comilla Model. An integral element of the model was the establishment of Thana Central Cooperative Associations (TCCA) located at the head quarters of the 450 thanas into which Bangladesh is divided administratively; and agricultural cooperative societies - Krishi Shamabay Samities (KSS) - located in the 68,000 villages of Bangladesh. Other components of the Comilla Model were: (a) Rural Works Program, planned and implemented through local councils for building local infrastructure; (b) Thana Training and Development Centre (TTDC) to bring together physically the various the government agencies, local councils and TCCA; and (c) Thana Irrigation Program to utilize irrigation equipment, and maintain them. After a decade of successful experimentation in 20 thanas, the Comilla concept of TCCA/KSS was expanded nationwide under the aegis of the Integrated Rural Development Program (IRDP), and agency of BDG's Ministry of Rural Development and Cooperatives; while other components were expanded nationwide under separate programs managed by other Government agencies. A joint review by the Government of Bangladesh and IDA reviewed the nationwide performance of

IRDP in 1980-81. The Review, the report of which was approved by the Cabinet in August, 1982, found that the TCCA/KSS system has been playing a useful - though far below potential - role in furthering agricultural and rural development plans and that it was a valuable resource to be used for achieving objectives of BDG's development plans.

As recommend in the joint Review, IRDP has been established as an autonomous Bangladesh Rural Development Board (BRDB) in 1982.

Under its charter, the role of BRDB is to:

(a) promote village based cooperatives and TCCA so that they become, in the shortest possible time, autonomous, self-managed and viable vehicles for increasing production, employment and rural development;

(b) encourage functional cooperatives for sponsoring income generating activities for the rural poor;

(c) promote intensive irrigated agriculture as a means of cooperative development as well as for efficient use of irrigation facilities;

(d) channel and ensure productive utilization of institutional credit through village cooperatives and TCCA system and promote members accumulation of deposits and savings;

(e) encourage financially viable TCCA to diversify activities, especially in marketing of agricultural inputs and produce;

(f) arrange for effective training of members;

(g) promote the growth of federations of TCCs at the district and national levels with a view to progressively hand over to them the promotional, motivational and educational functions relating to rural development;

(h) liaise with concerned agencies for mobilizing supplies, services and support for the cooperative system; and

(i) engage competent evaluation teams and research institutions to study and evaluate the progress made and effectiveness of the projects and programs of the Board.

CHAPTER III

ONGOING ACTIVITIES

Presently several donor assisted projects are under implementation for the development of minor irrigation facilities and related activities. Such major projects are described in this chapter.

RURAL DEVELOPMENT I (RD I) PROJECT

The First Rural Development Project, IDA Cr.631-BD(RD-I) was financed in 1976 to test the replicability of the Comilla's TCCA/KSS approach in seven selected thanas in two districts in northern Bangladesh. After an encouraging start on the training of field staff, and reorganization of existing KSS into the Comilla type TCCA/KSS by rescheduling of old debts of these KSS and other preparatory work, the supply of inputs like irrigation equipment, fertilizers and technical advice to the project's TCCA ran into serious problems. For example, procurement of minor irrigation equipment was delayed for three years due to BADC's inability to follow the Bank's procurement guidelines[1/]. Other inputs, which were not financed directly under the project, were also in short supply and priority was not given by BADC to the project area. As a result, the only service available to farmers for the

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1/ Staff Appraisal Report of Rural Development II project, The World Bank, May, 1983.

first three years under RD-I was short term (ST) credit which was of use basically only to larger farmers who already had irrigation facilities.

Important lessons have been learnt from RD-I. The first one is that if the principal objective is to create an institution to provide farmers, and in particular small farmers, with the means to adopt new technology and undertake efficient irrigation development, it is counter productive to package investments which are not directly relevant to the basic program, in this case, establishing viable TCCA/KSS. Attempts to implement a wide range of activities divert the attention of project staff from the priority task of institutional development. The second unsatisfactory aspect of RD-I design, which appears common to similar projects financed by other donors is the concentration on a relatively few thanas. This is unsatisfactory for two reasons, because operation of two programs - project and nonproject - is confusing to district officials because of the administrative problems involved; and further confining an intensive development program to a few favored thanas creates local tensions which in turn adversely affect implementation. Not least, other GOB departments expected to provide services to projects, in these cases directed by BRDB, seem to have found it difficult to equate the priority they had been expected to provide such areas with their responsibilities to provide such services nationwide. Finally,

it is evident from the experience of RD-I that institutional development cannot take place in the absence of an assured supply of inputs and services to farmers.

RURAL DEVELOPMENT II (RD-II) PROJECT

The primary objective of the Second Rural Development Project (RD-II) would be to strengthen and expand the TCCA/KSS cooperative system and improve the capability and performance of its promotional agency BRDB. The project would streamline procedures for (a) the purchase by TCCA of irrigation equipment, and (b) for the distribution of credit by Sonali Bank to the TCCA. Efforts would also be made to diversify the activities of a limited number of selected TCCA into crop and input marketing. Finally, the project would assist BRDB in providing a special package of inputs through TCCA for members, including women, of the special cooperatives (Bittaheen Samabaya Samity - BSS) of the rural poor. About 90 new TCCA, 8,000 new KSS and 3,000 new BSS are expected to be formed during the project's four year implementation period.

With the exceptions set out below, all TCCA would be eligible to participate in the project. Due to ongoing and proposed projects which are assisting TCCA in the districts of Kushtia, Pabna and Rajshahi (the ADB financed Northwest Development Project); Jessore and Faridpur (the IFAD

financed Noakhali Integrated Rural Development Project); and the Chittagong Hill Tracts (the ADB financed Chittagong Hill Tracts Development Project), it is anticipated that TCCA in the seven districts covered by these projects would not draw on the inputs and services made available under RD-II. However, it is expected that the institutional arrangements employed in the seven districts would be similar to those used under RD-II which themselves are consistent with the recommendations of the Joint Review of IRDP. Because of BRDB's currently limited implementation capacity the proposed rural poor and marketing components would be initially concentrated in six districts. Eligibility criteria for the participation of individual TCCA in project activities would take account of their needs, management capacity and availability of complementary infrastructure and other facilities. Other BRDB programs should not be affected adversely by RD-II; on the contrary, the strengthening of BRDB and the TCCA under the project should facilitate the implementation of a number of projects in which BRDB is involved, including some financed by IDA.

The principal components of the project would be[1/]:

(a) provision of medium term (MT) credit to TCCA/KSS members for the purchase of about 30,000 STW, 2,000 LLP, 2,300 tool kits, and 2,300 bicycles;

1/ Staff Appraisal Report, RD-II project, The World Bank, 1983.

(b) expansion of an ongoing Irrigation Management Program (IMP) to cover about 4,400 DTW and 1,100 LLP/STW clusters[2/];

(c) provision of medium term (MT) credit to about 3,000 TCCA/KSS, under a Rural Poor Program, for productive activities such as beef fattening, weaving, handicrafts, and pond fisheries;

(d) provision of short term (ST) credit to TCCA/KSS members for crop production;

(e) implementation of a TCCA/Crop and Input Marketing Program in a limited number of TCCA;

(f) construction of essential TCCA office facilities, at 100 thanas and the residential accommodation required for the staff of GOB agencies who would be essential for project activities in these thanas;

(g) strengthening BRDB and the audit capacity of the Registrar of Cooperatives by the appointment of additional staff and the provision of vehicles and office equipment;

(h) Training of BRDB staff, Cooperative Department auditors, TCCA/KSS/BSS staff and members, and thana irrigation teams in the wide range of activities essential to the success of the project. This component would include the construction of five new Thana Training Units and additional classrooms and staff accommodation at the Rural Development Training Institute (RDTI) at Sylhet; and

(i) technical assistance required for the Rural Poor Program, marketing, training, audit and accounts, and monitoring and evaluation - a total of 240 man months.

Purchase of STW and LLP: National demand of the TCCA/KSS system for STW is estimated conservatively at 15,000 per annum and that for LLPs at 1,500. The project would finance the purchase by eligible KSS on MT credit provided by TCCA, of 30,000 STW and 3,000 one-cusec LLPs. Installed units which would be mostly diesel engine driven would cost about Tk 33,000 for a STW and Tk 27,000 for a LLP. The balance of the TCCA demand for STW would be met from sources such as the IDA financed Agricultural Credit Project (Cr. 1147-BD) and projects financed by other sources. The TCCA will also require HTW and DTW, but this demand should be met fully by ongoing IDA and other donor financed operations. By 1987, 90% of 'A' and 'B' class KSS are expected to have some irrigation facilities compared to only 45% now. Project STW and LLP together with spare parts equivalent to at least 5% of the value of the engines would be imported, retailed installed and serviced by private dealers. TCCA would however have the option to purchase STWs in bulk from dealers and install these using private drilling contractors. Credit would also be made available to private mechanics sponsored by TCCA, for purchase of simple toolboxes and bycycles. Based

on irrigation equipment likely to be in operation, it is estimated that 2,300 such private mechanics would be required. These mechanics would operated as mobile private repairmen and would be suitably trained. Lending terms and conditions are specified in Schedule A. For this MT credit component to function smoothly, a number of improvements would be required in the credit mechanism used by BB, Sonali Bank and TCCA.

IDA - FINANCED AGRICULTURAL CREDIT I PROJECT

The first agricultural credit project for disbursement of US $ 62.4 million over a four year period, became effective in October 1981. Its main objective was to establish a replicable system for delivery of long term agricultural credit with a view to increasing agricultural production, rural incomes and employment opportunities. Based on its high development potential, a compact project area comprising the 5 districts (Rajshahi, Bogra, Pabna, Rangpur and Dinajpur) of the Rajshahi Division was selected for implementation of the project. This was done to allow a greater concentration of efforts to develop an effective organization for term lending, that could be extended to other parts of Bangladesh.

The project provided for financing 27,000 STWs, 50 private workshops, 500 mechanics kits and 20 grain stores of between 100 to 500 ton capacity. In addition lending for other diver-

sified lending, consultancies, and local and overseas training was also provided.

The Rural Credit Project Department (RCPD) of the Bangladesh Bank (BB) was entrusted with the responsibility of planning supervision and monitoring of the implementation of the project. The implementing agencies are the Bangladesh Krishi Bank (BKB), Sonali Bank, Agrani Bank, Janata Bank and the TCCA/KSS Cooperative System. Finally, the project introduced the system of using, on a relatively large scale, private dealers/importers for the procurement and distribution of STWs in Bangladesh.

STWs. The main emphasis of the project was on financing STWs. In line with the importance given by BDG to irrigation development and the considerable demand emerging for STWs, the phasing of the 27,000 STWs to be supplied under the project was revised by RCPD. As of January 1983, the number of STWs sunk in the project area totalled 6,716 of which 775 were sunk during 1981/82 and 5,941 during the current FY 1982/83 (up to 31.1.83). STWs sunk in the first year represent 39% of the appraisal estimates of 2,000 but only 20% of RCPD's target of 3,900. Those sunk during the first seven months of the second year have exceeded the appraisal estimates of 5,000 and it is likely that the RCPD's target of 13,400 would be reached ahead of

schedule. There is evidence of a considerable unsatisfied demand for STWs both from individual farmers and TCCA/KSS groups, and it is expected that the STW component of the project would probably be completed will ahead of schedule. In line with this, targets for 1982/83 have been revised in January 83 increasing the number of STWs to 29,700.

Workshops, mechanic's kit and grain storage; The progress of these components has been slow, due to limited demand. So far only two applications have been received for workshop loans; two loans totalling Tk 12,865 have been granted to mechanics; and eight loan applications have been received for grain stores of which two amounting to Tk 350,000 have been sanctioned while the others are under process.

Other diversified lending. No applications have been received for consideration under this component.

AGRICULTURAL CREDIT II PROJECT: The FAO/World Bank Cooperative Programme prepared a proposal for Agricultural Credit II Project. Meanwhile there has been a joint BDG/IDA review of the Agricultural Credit Sector which has identified problems in this sector and made various recommendations. There is general consensus that a follow up project should be a vehicle for the implementation of some of these.

The proposal of the project provides for:

1. Term loans for STWS. Term loans would be provided to farmers of farmer groups for the purchase and installation of 30,000 STWs. Installed units would be mostly diesel powered. With the progress in rural electrification, it is anticipated that some of these would be electrically powered.

2. Finance for the importation of spare parts. Funds would be provided to the Bangladesh Bank for the importation of spare parts, approximately equal to 25% of the cost of STW engines and pumps. Based on experience in NW Bangladesh, the most vulnerable parts are piston and piston rings, Nozzle, big-end bearing, plunger and liner.

3. Term loans for small village workshops. Private enterpreneurs would be encouraged to set up or improve workshops for servicing minor irrigation equipment and funds would be provided for 200 loans. It is expected that demand would develop as the project progressed and be principally for setting up small village-based establishments with a unit loan size of around Tk 125,000. To promote this investment, it would be necessary to extend adequate credit to make such workshops multipurpose, undertaking allied activities like the manufacture of minor accessories and general engineering. However, the project would be flexible

to allow investment in larger workshops if demand is forthcoming and found to be feasible.

4. Incremental short-term production credit. The project would provide Tk 904 million to meet the increased seasonal credit requirements arising as a result of additional areas coming under irrigation in the country. This would complement funds already available under current and proposed credit programs.

5. Line of credit for rural enterprises. Tk 50 million would be provided for this purpose. These funds would be earmarked for meeting credit demand for the purchase of farm equipment and setting up rural enterprises.

6. Training. It is estimated that an additional 1,000 field staff and 1000 senior and middle management level staff would be required to support the project lending programme. Funds would be provided for equipping the training centres at Bangladesh Institute of Bank Management and the four participating credit institutions. IDA has recently appraised the Rural Development II Project which is aimed at strengthening the TCCA/KSS cooperative system. In addition to short term credit (US $ 42 million) the project would finance 30,000 STWs and 3,000 LLPs; these would be available only to TCCA/KSS Cooperative.

ASIAN DEVELOPMENT BANK(ADB)

The second Agricultural Credit Project covering 3 districts, became effective in 1981. It provides credit through BKB for financing of 15,000 STWs and 70 medium and small-sized workshops (loan size - US $ 28 million). ADB appraised a third agricultural credit project which will finance cottage industires and rural enterprised, storage facilities, as well as transport US $ 60 million.

INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT (IFAD)

IFAD provided funds to the Grameen Bank project, of US $ 3.25 million in 1982-83 for providing credit support to the productive activities of the landless. A follow-up project is due for preparation in October/November, 1983.

US AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)

The USAID Rural Finance Experimental Project (RFFP) has now been completed. It provided US $ 7.0 million to finance an experimental credit and savings program. The purpose was to identify one or more replicable rural financial systems to meet the financial needs of the productive and potentially productive rural poor. As a follow-up, USAID is preparing a US $ 75 million Rural Finance Project, details of which have yet to be finalised and agreed with DDG.

USAID AGRICULTURAL RESEARCH II

This is an extension of the Agricultural Research Phase I project whose purpose was to "establish a functioning agricultural research system .....". The goal of the phase II is to increase domestic food production, small farm income, and rural employment. The purpose of the amendment of the phase II is to provide support to rice production research and expand the irrigation and water management research component. It is designed to strengthen Bangladesh's research capacity to develop improved rice varities and production practices, more efficient water lifting devices, and improved water use and distribution system.

Rice: Phases I (1977-80) and II(1981-86) of BRRI's Rice Production Research Project have been supported to date by a multi-donor consortium: the Australian and Canadian Governments and the Ford Foundation. During the preparation of the original USAID Agricultural Research II project paper documentation for Phase II of BRRI's rice project was still in progress. Subsequently, it became apparent that donor support would not be sufficient to fully meet BRRI's program needs. USAID was invited to join the consortium and contribute $ 3,000,000 toward BRRI's total $ 6,400,000 Phase II Project budget. The International Rice Research Institute (IRRI), through a host country contract with BRRI, will implement the project.

Irrigation: In the original Agricultural Research II project paper, irrigation and water management research represented one of the nine program areas. Subsequently, Bangladesh recognized that an expanded level of effort was necessary to improve the irrigation systems, presently operating at unacceptably low efficiency levels, which constitute a major constraint to increased food production.

BARC is not a research body per se; it is a coordinating body designed to consolidate and integrate the research activities conducted by more than 20 institutes. USAID's support for an expanded research effort in irrigation and water management as provided by the amendment will be directed through BARC-an arrangement similar to that for the current water management research support provided by the original project paper.

This amendment would add rice to the crops component of the Agricultural Research II project as well as expand the level of support for the water management component by $5,000,000. To accomplish these objectives, the project provides technical assistance, training and commodities as outlined in the summary budget below.

CONTRACT RESEARCH PROGRAM

BARC initiated a program in 1980 called the Contract Research Program (CRP) through which it contracts with various research and educational institutions in Bangladesh to conduct research in designated problem areas that are important to agricultural development. It is a small but significant part of the total agricultural research effort in Bangladesh.

In December 1979, BARC published the "National Agricultural Research Plan", which is to be periodically reviewed and modified, as a framework for guiding agricultural research activities. The funds administered by BARC under the CRP give BARC a degree of influence regarding research to be carried out by informing research administrators and the scientific community of those priority areas within the National Agricultural Research Plan for which research proposals are invited and for which contracts may be let.

The objective of the CRP, which was initiated in 1980, is not to do basic research, Rather, its specific purposes are to (a) focus efforts on immediate practical agricultural production problems related to goals of the Five-Year Plan and to (b) foster interdisciplinary and interinstitutional research. A primary aim is to maintain

attention on field oriented questions for which answers will have wide applicability to major agro-climatic zones of the nation.

IDA FINANCED EXTENSION AND RESEARCH I (EAR I) PROJECT

IDA financed EAR I project represented the first substantial effort to address some of the basic problems of agricultural extension in Bangladesh. The project included components for:

- Extension and Training (US $ 9.8 million) principally for staff housing, transport (vehicles, motorcycles, bicycles) and incremental operating costs;

- Agricultural Statistics (US $ 0.2 million) for salaries and allowances for additional statistical field staff required as a result of extension staff dropping their responsibilities for statistical enurmeration;

- Research (US $ 1.6 million) for the development or improvement of agricultural research and field trials throughout the North West;

- Command Area Development (US $ 0.7 million) for minor engineering works and technical assistance to improve water utilization on farms served by about 1,500 DTWs.

The project became effective in FY 1977-78 for a period of more than 3 years.

IDA EXTENSION AND RESEARCH II PROJECT (EAR II)

The project will support the Bangladesh Medium Term Foodgrain Production Plan (MTFPP) objective of achieving self-sufficiency in foodgrain by increasing production of rice and wheat from about 15 million tons in FY81 to about 18-20 million tons in FY85. The project will ensure that the MTFPP investments of about US $ 5 billion in irrigation and agricultural inputs are utilized efficiently. In line with MTFPP strategy, the project will put major emphasis on:

a. adaptive research to refine recommendations for optimizing farmers return and minimizing risks under low cash input rainfed conditions.

b. cropping systems and command area development research on farmers' fields in irrigated areas.

c. intensive extension effort on improving yields of rice and wheat in irrigated areas through changes in cropping pattern, use of newer higher yielding varieties, optimal use of fertilizers, identification and solution of trace element deficiencies, increased pest control activities, and increased use of supplementary irrigation.

d. extension effort in rainfed areas to improve rice and jute yields basically through balanced fertilizer usage and some increases in area under the modern high yielding varieties.

The project objectives will be met by the following actions:

a. Improving agricultural extension effectiveness by merging and reorganizing five existing extension agencies.

b. Intensifying extension work by providing about 2,270 additional EA, upgrading about 200 EA as extension officers, and by hiring an additional 60 extension officers.

c. Providing specialized training of about 500 man-years to extension and research officers.

d. Improving extension and research staff mobility by providing 5,400 bicycles, 500 motorcycles, 23 other vehicles and by increasing extension staff travel allowance.

e. Improving extension offices through new construction in 20% of project districts and thanas and by rehabilitating 750 abandoned seed stores as housing-cum-offices for 1,500 EA.

f. Improving research facilities by expanding a BARI coconut research station into a regional station and filling in minor deficiencies at eight other stations.

g. Improving adaptive research by reorganizing BARI regional research and by providing one million dollars in research grants through BARC.

h. Providing about 21 man-years of technical assistance.

CHAPTER IV

FACTORS AFFECTING UTILIZATION OF DTWs, STWs, AND LLPs

Before suggesting the possibilities for USAID's programms to improve the utilization of DTWs, STWs and LLPs, it would be proper to discuss the various factors associated with them. Some of these have direct effect on the efficient performance of the equipments and others affect indirectly. These are summarized and described in this chapter.

1. Development of appropriate pumps and engines for Bangladesh conditions.

2. Zoning of country for various types of pumps and engines.

3. Maintenance and servicing

   BADC
   Private dealer contractors(PDCs)
   Private mechanics

4. Repair

   (a) Mechanics - BADC
   PDCs
   Private mechanics

   (b) Spares - Imported by BADC
   Imported by PDCs
   Manufactured locally
   Standardization of equipment

(c) Workshop facilities - BADC
PDCs
Private

5. Manufacture of pumps and engines.

(a) Imported
(b) Domestic manufacture

6. Farmers organization

(a) BRDB

7. Agricultural credit

(a) Government

(b) Private

8. Extension

(a) Government

9. Research

(a) Government

10. Water distribution system

11. Monitoring of the minor irrigation system

(a) Discharge of tubewells
(b) Elevation of water tables
(c) Interferences among tubewells
(d) Spacing of tubewells
(e) Assessment of the tubewell potential based on available informations.

12. Studies

    (a) Groundwater models
    (b) Surface water sources

        i. minor rivers
        ii. water bodies

    (c) Effects of flood control efforts on recharge and croping pattern.

    (d) Possibilities of increasing LLP by heading up dry-season water levels in medium-sized rivers by barrages or weirs.

13. Post harvest facilities

14. Storage and marketing

1. DESIGN OF PUMPS AND ENGINES

In STWs, water is extracted by a diesel powered centrifugal suction pump at the surface.

It is extremely important to match engine and pump. Under IDA Shallow Tubewell Project it was specified to use a single cylinder four stroke diesel engine developing 6 bhp at 1500 rpm driving a centrifugal pump with 4 inch suction and delivery diameters. The static suction head was expected to be 12-15 feet and it was anticipated that the pump would deliver 0.75 cfs. Allowing for friction in the screen, the pressure drop in the well pipe, losses at bends and velocity head at exit, the total head might be of the order of 30 feet. Assuming a pump efficiency of 60% this would need 4.25 bhp so that engine would be running at 70% load, almost an ideal condition.

But engines were purchased which would produce 9 bhp at 2200 rpm to drive the original 1,500 rpm pumps. No reduction gear was proposed. What might happen for such speeding up of pumps? The discharge will increase causing greater drawdown and higher static suction head. The increased discharge will mean increased velocity in the pipe and increased friction losses. For example, if the discharge is increased to 1.25 crs, the friction loss in 50 feet of pipe will be 12 feet or 80% of the anticipated static head. The total head at the higher velocity would be of the order of 30 feet, a 1.25 cfs discharge would require nearly 9 bhp. These tentative figures suggest a much higher fuel consumption per unti of water pumped. Also the efficiency of the pump will undoubtedly deteriorate as the higher speeds cause wear on the impellor, causing further increase in fuel consumption. It is not possible to be more specific without reference to pump characteristic curves which are not easily available. However, it is important to stress the importance of matching pump and engine with high and rising fuel prices.

Moreover centrifugal pumps are efficient for higher heads and the mix flow types are efficient at lower heads. So it may not be proper to use centrifugal pumps throughout Bangladesh. Groundwater level fluctuates more than 20 feet over a dry season. We need pumps which would perform reasonably well throughout this range.

2. ZONING THE COUNTRY FOR VARIOUS TYPES OF PUMPS AND ENGINES

Groundwater lowerings are not uniform throughout Bangladesh. Lowering of water level will depend on extraction rate, storage coefficient, recharge and the interaction with surface water sources. The country can be zoned giving the suitability of various designs of pumps and engines.

3. MAINTENANCE/SERVICING:

The life of an equipment depends on maintenance and servicing. A properly maintained equipment will need fewer repairs and consequently the cost of irrigation would be cheaper. The farmers do not have the technical know how to service the tubewells and pumps.

The farmers don't have idea that right grade of lubrication oil, reasonably good quality fuel and clean water for radicator should be used. A very common example is that same lubrication oil is used several times after cooling.

There are not enough mechanics in the field to take care of routine servicing for the farmers.

4. REPAIR

Good repair service needs (a) adequate number of good mechanics, (b) readily available good quality spare parts and (c) workshop facilities.

Presently repair services are provided by (a) BADC (b) private dealer/contractors who also sell STWs and (c) private mechanics.

BADC virtually had the monopoly over the supply of spares, and maintenance and repair services with unsatisfactory results. Services were costly and poor. A direct result of the latter is excessive down time for equipment, and indirect result is that farmers' irrigate conservative areas to minimize the risk associated with breakdown and delayed repair. Government therefore decided to allow spares to be sold by private dealers and to encourage the establishment of private mechanics and workshops.

Private Dealers/Contractors(PDC) are supposed to provide repair services to the STWs sold by them for a period of 18 months. PDCs receive a fee of Tk 825 for this job payable in 3 six-monthly instalments from the banks which provided the loan for the STW. This may not be an adequate incentive for the PDCs to provide satisfactory repair services. Normally a PDC makes about Tk 4,000 from the honest sale of a STW. But his profit can go up significantly when a farmer gets 2 pipes[1/] instead of 3 (additional

1/ According to terms of contract, a STW dealer/contractor will provide 3 nos 4-inch dia 20 feet pipes; 3 nos 4-inch brass strainers-each 10 feet long; a tool box; and spare parts-a set of ring, V belt, 4 nos fuel filter, head gasket, a nozzle for Yanmar engines only; carry the STW to site and sink it.

Tk 1340 to a PDC), 2 strainers instead of 3 (additional Tk 1600 to the PDC), no tool box, not all the spares, and farmers are asked to get the delivery of STWs from the godown of the contractor and sink it (another Tk 1500 to PDC-Tk 300 for carrying the STW to site and Tk 1200 for sinking).

During the last 2 years PDCs of Bangladesh Krishi Bank and Bangladesh Bank sold more STWs than BADC. Most of these STWs were purchased by the farmers by utilizing the agricultural loans from BKB and various commercial Banks. PDCs employ agents who go to farmers and explain about the availability of STW and loans from banks for buying those. Farmers are told that they can get a STW for a small down payment of Tk 1000-2000 or sometimes it can be free. BKB demands a down-payment of Tk 2000 whereas Bangladesh Bank relaxed rules for small farmers[1/] to Tk 1000. These agents will be paid Tk 280-300 for each applicant.

Sometimes PDCs will put up the initial payment of Tk 1000-2000 on behalf of the farmers and they will compensate this by not supplying all the pipes, strainers tool boxes, spares and askingfarmers to sink it.

1/ Farmers who own less than 3 acres.

Sometimes farmers are told not to worry too much about loans from Government and this is how they get a 'free STW'. Bank Officials also welcome applicants brought by agents of PDCs, who also has a quota of STW to sell.

A PDC makes good amount of money from the sale of a STW-about Tk 4000-8000 so he does not find it profitable enough to look after a STW for 18 months for Tk 825. For repair, he needs to employ a good number of mechanics, maintain a network of spare parts stocks and workshops. Organizational aspects of it can be quite complicated.

There are not too many qualified mechanics available in the job market. It may be extremely difficulty to find mechanics who would be willing to look after regularly STWs in remote locations.

Private Mechanics are providing a reasonable service to tubewells and lowlift pumps. Number of trained private mechanics are not adequate. We do not have facilities to train required number of mechanics for tubewells and pumps.

The number of STWs increased greatly during the last 3 years - from 19,000 in July, 1980 to 110,000 in July, 1983. The number of trained mechanics did not increase at the same rate.

Presently BKB do not have mechanics to look after the STWs sold by them. Their PDCs did not provide the services expected from them. BADC do not have adequate number of mechanics. The BADC Executive Engineer at Bogra was responsible for 8095 STWs and had only 37 mechanics till March, 1983. This number was increased to 90 in June, 1983 which means one mechanic for 90 STWs now. BADC recommends that there should be one mechanic for 25 STWs or one assistant mechanic for 15 STWs. It is expected that the number of STWs will increase to 250,000 - 300,000 by June, 1985. If we want those to be functioning properly, there is a great need to train mechanics to look after them and keep them pumping water from underground. We need to train more than 1 mechanic for 25 STWs. There will always be a tendency for the mechanics to operate in better locations so that they will find other opportunities during off-season. Unless there are some surplus mechanics, they would not move to remote locations.

We also need to think about how to keep the mechanics busy throughout the year. There may not be enough willing candidates who would like to become trained mechanics unless there are assurances for reasonable income during off-season. One possibility would be to undertake routine maintenance, servicing and repairs needing workshop facilities during off-season.

Spare Parts: Over the next few years, the quantity of irrigation equipments in the field will continue to increase rapidly and the most of it will be privately rather than publicly owned as in the past. Furthermore it is expected that these equipments will be operating closer to optimum utilizatioh.

The recently commissioned STWs will need frequent repairs during next few years as those become older. Under these circumstances it will be imperative that a greatly expanded and reliable supply of spares and services be available. The overriding requirement is that there should always be an adequate supply of spares to maintain the current stock of equipment.

Presently a large number of farmers depend on certain spare parts manufactured locally. Such spare parts are cheap—a cylinder liner and piston for Tk 200 for a locally manufactured versus Tk 750 for important one. But the quality of these spares are poor, so the breakdowns are frequent. Arrangements must be made for the manufacture of quality spare parts locally.

Before taking up programmes for the manufacture of spare parts, it is important to standardize the equipments. Presently about 14 models of STWs are in use. Some of the models are performing very well and are popular with the

farmers. Examples are Yanmar 105, Kubota GA 96, Mitsubishi NM 90, Kirloskar. These are all 1500 rpm engines. There are models which are not providing satisfactory services. Examples are Mitsubishi NM 75, Daedong ND 85, Yanmar TS 70. These are all 2200 rpm engines. Performances of some of these engines were so poor that the Ministry of Agriculture stopped the sale of 2200 rpm engines in northwestern region of Bangladesh.

There is no reason why the number of models cannot be reduced to about six. We can choose only the good ones. These can be manufactured here and stock piling and distribution of spares would be brought within manageable capabilities of private distributers. Lot of discussions took place in the past about the need for standardization of equipments, but it was never done. Why? It would be impossible to keep the STWs operating at reasonable efficiency without the standardization of equipments and fewer models. With the reduction of number of models the mechanics don't have to acquaint themselves with too many models.

Workshop Facilities are provided by (a) BADC, (b) TCCAs (c) PDCs and (d) Private mechanics.

At present workshop facilities are meagre. The workshop owners in Bogra informed that STWs from as far as Rajshahi, Dinajpur are brought to them for major repairs.

We need new workshops, a large number of them and we need those quickly. World Bank, ADB and DANIDA are funding some workshops. Applications for loans for setting up of workshops are not forthcoming. Why private sector is not showing adequate interest? There may be several reasons. Do we have adequate number of trained mechanics to run these workshops? Mechanics needed to run workshops are better trained than those needed for engine repairing and are in demand in middle eastern countries. Will there be enough work load to keep the workshops busy throughout the year? Do we have reliable power supply in remote areas to keep these operating regularly? We should find out the answers to these questions.

Besides servicing the irrigation equipments, workshops in villages will train mechanics and will start developing and manufacturing traditional agricultural implements.

5. MANUFACTURE OF EQUIPMENTS IN BANGLADESH

Government is encouraging the manufacture of irrigation equipment as a means of ensuring a more reliable supply of equipment, as a means of achieving a measure of equipment standardization to enable much needed improvements to

supplies of spares and maintenance services, and as a means of saving foreign exchange. Fulfilment of this policy should be supported while also ensuring that domestic industry would be economically efficient. It is vital that this point not be lost sight of, as it has been in many countries in the nurturing of infant industry. Establishment of domestic manufacture of irrigation equipment is not an end; it is a means to further Government's overall development plans. Key to these in the immediate future is irrigation development. This will not be well served if domestic industry is over protected and allowed to become inefficient and high cost.

In that event either farmers would have to pay high prices or Government would have to pay high subsidies for equipment purchases. In either case this would necessarily impede the rate of development. From Bangladesh's economic point of it does not make sense to have too many manufactures producing at uneconomic scale and therefore at high unit costs, in a limited market (since there does not appear to be export prospects in the forseeable future)[1/]. Also, by the manufactures have set up facilities, the Government may feel compelled to set protection at a level which enables the

1/ Minor Irrigation Sector, A joint review by Government and the World Bank, Draft Report, April, 1981.

least efficient manufacturer to survive. The end result is a high cost domestic manufacturing industry producing high priced diesel engines. Equally important, there does not appear to be much interchangeability of parts between the different engines makes. Hence the proliferation of makes would inhibit the standardization of parts, components, and accessories and, consequently, the development of specialized ancillary industries. Conserversely, limiting the number of models would permit longer and more efficient production runs and better use of special purpose mechinery.

The economic benefits of establishing a domestic diesel engine industry would be of two types: linkage effects and external economics 1/. Linkages with engineering workshops and foundries supplying parts would be very beneficial to the development of Bangladesh's engineering industry which, in turn, is an important prerequisite for successful industrialization. Perhaps the most important linkage effect would be an increase in the greatly underutilized capacity of BMTF. Thisuunderutilized capacity represents a sunk capital cost so that the economic cost of BMTF produced parts would be low. External economics would be mainly

1/ Minor Irrigation Sector, A Joint review by Government and the World Bank, Draft Report, 1981.

from the spreading of scarce skills, as workers trained by engine manufacturers moved onto other jobs or perhaps established small workshops, and from technology transfer, as the engine manufacturers worked with suppliers to upgrade product quality and quality control.

6. FARMERS ORGANIZATION

BRDB is responsible for Organization of farmers for various activities including management of irrigation equipments. Presently IDA, ADB, DANIDA and USAID are funding several projects through BRDB.

7. AGRICULTURAL CREDIT

The volume of institutional agricultural credit has increased in the past 5 years. This increase has also been accompanied by an expansion in the range of crops eligible for credit and in the institutional net work disbursing credit in rural areas. In addition, innovative lending programs have been tried in order to reach small and marginal farmers and the landless. Despite these improvements, several problems remain unresolved. These inter-related issues are interest rates and refiance policy, overdue problem, weaknesses in the village level credit delivery system and overall credit management ADB, IFAD, IDA and USAID are funding several projects in this sector.

Despite eight decades of institutional credit, an effective village level credit disbursing agency has not been developed. All agricultural credit disbursing agencies in Bangladesh suffer from institutional witnesses leading to difficulties in supervising borrowers and improving their credit recovery position.

Still majority of the farmers depend on private money lenders who charge very high interest rates. I have seen farmers in Tangail who borrowed money from private money lenders at an interest rate of 50% for 3 month period in Boro season, annual interest rate becomes 200%.

Why they do not go to banks for loans who offer it at a very cheap interest rate in comparison to private loans? Most probably the private money lenders offer a 'One-Stop' 'One-Visit' loan system at the village level for which not more than ½ hour negotiation is needed. Banks should take lessons from them.in agricultural research or among progressive farmers is immaterial. The vast scale of production increases required to meet MTFPP towards the achievement of these goals, argues that Bangladesh requires an extremely strong and technically competent extension service. The experience obtained in the North-West under IDA funded Estension and Research I Project points to how such a service can be developed and operated on a large scale.

8. EXTENSION

The principal justification for an extension is that it should accelerate the rate at which innovations are adopted by farmers and spread throughout the farming community whether these innovations have their origins

Extension services in Bangladesh have been reorganized and streamlined under IDA funded Extension and Research II project.

The subject which did not receive adequate attention in Extension and Research II project is the development of materials to be used by extension agents. Farmers in Bangladesh are very poor. Loss of a crop will put him into debt for several years. So a farmer does not want to take risk of trying new methods unless he finds it working somewhere else. He does not trust the government system. So extension agents may find it a difficult task to transmit new ideas through conversations and use of leaflets only.

Videos and films can play a major role in the extension services. We should be careful about how to use the videos and films. Short films on selected topics can be made under farmers field conditions. That film should then be shown in that locality only. The viewers will see a farmer in the film who is familiar to them. Those who would have doubts may meet the farmer and ask questions. Initially the whole effort would be to develop farmers faith on the information/ messages transmitted through films. If this achieved, the rest would not be too difficult.

Films can be extremely useful for informing/training farmers about the importance of proper maintenance and servicing of the tubewells and lowlift pumps. For example there may be films on subjects like proper maintenance and servicing (need for proper lubrication, clean water for radiator, quality of fuel, importance of using good spare parts), proper repair (which jobs must be done by a qualified mechanics), how to buy a tubewell or pump (services to be provided by a PDC) etc. Such videos may be kept in Thanas and the farmers should have access to those during their spare times. To the illiterate farmers, those would be 'talking books.'

9. RESEARCH

Although there is a substantial gap between levels of crop performance obtained by farmers (on average) and the yields to be achieved by the proper application of known technology, there is a contining need for research to develop varieties and farming techniques offering the prospect of still higher yields, and to adapt general recommendations to the needs of particular agro-ecological zones. The more important technological gaps to be addressed through research appear to be the following:

- Varieties: the shortage of HYV and Local Improved Varieties adapted to the more difficult ecological

zones (e.g. saline and deep water areas) and offering high level of fertilizer response to moderate applications of nutrients;

- Fertilizers: the lack of fertilizer recommendations linked to the requirements of varieties and soils, and to the varied purchasing power of farmers;

- Water management: the absence of firm information on crop water requirements and on optimal irrigation system designs for different soil types, topographics and crops;

- Cropping systems: the limited knowledge of the effects of crop rotations on production levels and farm incomes;

- Crop drying and storage: an absence of low-cost techniques for drying grains and for storing all crops.

While some of these gaps can be filled by the importation of technology from other countries, a substantial national research programme, with a heavy emphasis on the localised testing of techniques, particularly on farmers' fields, is clearly warranted.

Presently there are ample assistance available to take care of the above mentioned research needs.

10. ONFARM WATER DISTRIBUTION

Various possibilities are:

(a) seepage reduction

i. by excavating canals of proper cross section and gradient and compating the bed and banks

ii. by using canal lining

(b) underground distribution system

(c) use of simple farm structures

(d) rotational system of water supply

The canal should be designed for the tubewell discharge. We have many under-sized and over-sized canals with and without proper gradient. In undersized canals, water is lost due to spillage. Whereas seepage losses are great in over-sized canals. Clearing the canal bed and compaction of bed and banks will reduce seepage greatly. Adequate extension efforts to overcome these problems will reduce seepage loss greatly.

Lining is expensive and needs maintenance. Under typical Bangladesh condition - human and animal walking on canal bed and banks, carts crossing canals - the maintenance cost would be great. Lining is not recommended unless soil is very light. Underground distribution system (UDS) is expensive. But is saves land. We need further study to determine its

popularity with farmer and appropriateness under Bangladesh condtion. Cost of UDSs can be reduced by using concrete pipes.

Further UDSs, even the experimental ones, should mainly be planned, designed and laid out by the farmers. Definitely much stronger farmer organizations would be needed. DTW with a UDS would be expected to irrigate at least 150 acres involving about 300 farmer plots. Initial investments would be high which will ask for greater effort to mobilize funds.

We need to know whether the farmers will make a long-term commitment to the system. More than half of the lands are farmed by landless farmers. A farmer may not farm same plots for a long time. He is not the owner. Are such farmers in a position to decide about committing lands to UDSs. Participation by farmers for one crop may not be economically justifiable for the system. Will the farmers agree to buy waters throughout the year or in other words will they participate in Aus and Aman seasons? How much the cost can be reduced by using concrete pipes? It may be difficult to transport pipes in remote areas. We would not know the answers to questions unless several such systems are installed and studied.

Use of simple farm structures will improve the efficiency of the water distribution system. Use of simple and inexpensive check structure instead of earthen barrier to raise the water level in a canal, simple turnant (6-inch concrete pipe) instead of cutting of embankment and the plugging with clay will reduce the wastage of water.

Rotational system of water supply also reduces conveyances loss. BRDB, through their Irrigation Management Program (IMP), are mobilizing farmers to adapt such methods.

MONITORING

The number of STWs increased greatly during the last 2 years. The DTWs also increased but not as fast as STWs. The number of LLPs reduced. How these irrigation equipments are performing? We do not have any information on performance. The standard figures are about 65 acres for a 2 cfs DTS, 12 acres for a 0.5 cfs STW and about 50 acres for a 2 cfs LLP. Total irrigated area is obtained by multiplying the above figures by the number of equipments. We need to monitor the performance of tubewells and low lift pump.

Monitoring program shouod cover following are as:

(a) discharge of tubewells and pumps

(b) water table lowering

(c) spacing of DTWs and STWs and their interference

(d) surface water sources for LLPs

(e) potential for additional equipments

Recent measurements of discharges of five DTWs in Joydebpur by diagnostic analysis team gave about 20% less than rated discharge[1/]. These DTWs were rated to give 2 cfs. 20% less discharge means 20% less irrigated area. These measurments were taken in February, 1982. The discharges would further be reduced in March, April and May when the water table is lowest. Normally the iirigation demand is highest in March and April. There is a great need to develop a program to measure discharge from these units and the total extraction of groundwater. Water table lowering would depend on the volume of extraction. Presently we are getting some reports of drying and reduced discharges of STWs from mostly Rajshahi and some in Bogra. Rajshahi received only little more than 20 inches of rainfall last year and less than 40 inchhs year before that against an average of about 55 inches. Quite an extensive embankment

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1/ Diagnostic Analysis of Five Deep Tubewell Irrigation Systems in Joydebpur, Bangladesh, Water Management Synthesis Report No. 15, June, 1983.

systems were constructed to provide protection against flood which eliminated surface flooding and most probably reduced recharge to the groundwater. Reduced discharges may be due to the one or combinations of the following reasons:

(a) excessive pumping rate lowered the groundwater table below the limits of centrifugal pumps.

(b) reduced recharge in certain locaties due to above mentioned reasons.

(c) local poor aquifer conditions

(d) poor design and construction of wells.

Interference among tubewells depends on rate of extraction, transmissivity and storage coefficient of aquifer and lateral recharge from surface water sources. Extraction/ withdrawal from the aquifer is controlled by tubewell discharge and spacing.

About 10%[1/] of the lowlift pumps cannot function towards the end of the season dur to depletion of the surface water sources. This is happening due to the insufficient information about the volume of water available in various sufface water sources.

As we do not have accurate informations on the volume of extracted groundwater and the area irrigated, it is very difficult to assess the impact of fielding of additional STWs and DTWs on the basis of available data. Presently

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1/ No survey was undertaken to determine this figure accurately.

there are about 110,000 STWs, 15,000 DTWs, more than 1,000,000 hand pumps and a large number of dugwells are in place and are pumping at rates varying between zero[2/] and about 50%[3/] above the rated capacities. How many of them are not working (zero discharge)? How many of them are pumping at 25% , 50% and 75%, of rated capacities? We do not have these informations. WE NEED THESE.

STUDIES

Besides the monitoring discussed above, there are scope for studies to assess the potential for minor irrigation equipment. These are:

(a) Groundwater models for various regions of Bangladesh relating groundwater level (lowerings) to extraction rate, river levels, rainfall in the previous monsoon season, and aquifer characteristics.

(b) Survey for surface water sources:

i. minor rivers
ii. water bodies

(c) Effects of flood control measures on recaharge and cropping pattern.

(d) Possibilities of increasing the number of LLPs and groundwater recharge (if necessary) through barrage type structures on minor and medium sized rivers.

2/ These are not working.

3/ Some STWs and DTWs are giving more than rated capacities. Some STWs are giving about 0.75 cfs.

(e) Effects of STWs and DTWs on domestic water sources like hand pumps, ponds and tanks, beels and minor rivers.

Groundwater is a major source of irrigation. With the existing 110,000 STWs and 15,000 DTWs, it is possible to withdraw 85,000 cfs water providing irrigation to about 2.55[1/] million acres, more than 12% of the cultivable area. With the proposed 250,000 STWs and 20,000 DTWs in 1985, it would be possible to withdraw 165,000 cfs irrigating 4.95 million acres, 24% of the cultivable area[2/]. It is considered that about 45,000 LLPs can be fielded with the available surface water sources. Assuming an average discharge of 1.5 cfs per LLP[3/] 45,000 x 1.5 = 67,500 cfs will irrigate about 2.02 million acres, about 10% of the cultivable area. Besides most of drinking water is drawn from groundwater. Moreover most of the irrigation wells are located in northwest and in Mymensingh, Tangail, Jamalpur, Dhaka and Comilla. So we have great withdrawl rates in certain areas of the country.

1/ 30 acres to a cfs of water, a very conservative figure.

2/ Hand pumps have the capacity to pump about 20,000 cfs, about 1/3 of that used for irrigation, which means another 250,000 acres.

3/ We have some LLPs rated at 1 cfs.

All STWs are fitted with centrifugal pumps. Such pumps can suck in from a depth of about 22 feet. If the groundwater table is lowered belows this limit, the centrifugal pumps may not operate. If the water table is lowered below 22 feet, the farmers have been observed to dig a hole cf about 6-7 feet deep and lower the STWs. Such STWs are lifted during monsson. Such lowering of water table will dry up all the sources of domestic water - all hand pumps, ponds and tanks and small rivers and khals. What would be the sources of drinking water in case of excessive lowing of water table? Water from DTWs can be used for drinking purposes. Normally DTWs are spaced at about 2,000 feet (more than 1/3 of a mile). It would be a long walk for people living in areas near the middle of 2 DTWs. Existing reciprocating hand pumps can be replaced by deep set hand pumps which can pump water from great depths. It would be a major task to replace the existing more than 1 million receprocating pumps by deep set hand pumps and will take long time.

We should study such sensitive system very carefully and intensively. Mathematical models are good tools for such studies. We need a model relating water table elevation changes to water withdrawal, river levels, aquifer conditions and rainfalls. Such models would be helpful

in locating appropriate pumps and engines in various parts of the country, will provide informations about effects on domestice sources of water and will give warning about crisis situations (excessive lowering of water table).

We do not have adequate informations on the discharges of minor rivers and the amount of water available for irrigation. These minor rivers are not gaged and most of them receive groundwater contributions during January-May period. For the rivers which are the distributaries of other rivers, the discharge depends on the groundwater contribution and the condition of the offtake. If the offtake is silted up in certain years, the discharge would be greatly reduced. Similarly adequate informations are not available about the volume of sufface water in beels, haors and oxbow lakes. The volume of water in beels depends on rainfall and river flooding. The flood control embankments eliminated flooding of many beels and changed cropping patterns in some areas. The once-famous Chalan Beel in Natore is almost flood free now.

In July, 1983, I saw farmers using STWs for land preparation for Aman in areas where normally 4 to 5 feet of flooding during monsoon in previous years would give them a very good Boro and a reasonable Aus. In March-April most of the minor rivers are dry. Discharges of some of the medium-sized rivers are also greatly reduced. Water levels

in the medium-sized rivers are lower than the bed levels of the small rivers. If the water level in the medium-sized rivers are headed up by barrages, water will be available in many of the distributaries (minor rivers) opening up the possibility of fielding larger number of LLPs.

Higher river levels will also preserve groundwater by reducing the discharge of groundwater into the rivers. We need studies/surveys to get informations on the above.

POSTHARVEST TECHNOLOGY

Drying and processing of Boro rice can be difficult if monsoon sets in early as it happened in 1978 and 1983. It may also be difficult for Aus. Do we have sufficient postharvest facilities? Are those facilities developing at the same rate as the increase in food production? Most of large number of rice mills set up during the last 3 years provide services to rice dealers. 85% of food grain procured by the food department come from rice dealers. Facilities developed for businessman. But how about farmers? Most probably not.

STORAGE AND MARKETING

Do the farmers have adequate storage and marketing facilities so that they get good price for their produce? Most of the small farmers are forced to seel their paddy

soon after harvesting because he needs money for himself and to repay the loan. The price is low immediately after the harvest because of large quantity of paddy in the market. He is also compelled to do it due to inadequate processing (boiling, drying), storage and marketing facilities. The best example is the price of potato this year. It's price was less than a taka per seer when those were in the hands of farmers. The present price is Taka 5 per seer and these are in the hands of middlemen and cold storage owners.

CHAPTER V

SUGGESTIONS FOR USAID INVOLVEMENT

The available minor irrigation equipments in 1985 will have the capacity to pump about 230,000 cfs and irrigate at least 1/3 of the cultivable area. Will those be functioning at or near the rated capacity at that time? Are we taking measures for developing facilities so that those will be functioing at or near optimum levels? Reply is 'NO'.

Though several donors are funding projects in minor irrigation sector, the following areas received either no or very little attention. USAID can make significant contributions in minor irrigation sector by taking up projects in some of the areas.

1. Develop pumps and engines suitable for Bangladesh situations-high fluctuations of groundwater table, smaller capacity and easy to maintain.

2. Present maintenance and repair facilities are inadequate. Reliable maintenance and repair facilities are the most important conditions for efficient performance of the tubewells and low lift pumps. Farmers must be given a reliable system otherwise they will drop out of the system. Efficient repair facilities depend on availability

of trained mechanics, workshop factilities and spare parts. In the past we depended upon the private sector to come up with these facilities without adequate response. There were provisions for training of mechanics and setting up of workshops in IDA's RD-I project. There are similar provisions in IDA's RD-II and Agricultural Credit II projects. Development of repair facilities should be monitored closely and in case of poor response from private sector, appropriate actions should be taken to develop these facilities.

Domestic manufacture of pumps, engines and spare parts should be undertaken as soon as possible. These should be standardized and fewer models should be allowed.

With the expansion of Rural Electrification Programme, there would be demands for electric motors. Government has also given emphasis on increased generation of power and improved distribution systems. So we should also consider the possibilities of manufacturing electric motors and training mechanics for them.

3. Farmers should be trained/informed about routine maintenances of irrigation equipments and advantages of improved On-farm distribution systems. Pamphets, films and [illegible]

radiator, use of good quality spares, using mechanics for repairs etc. Similarly farmers may be told about improved distribution system (no dead storage, proper section and gradient for canals, compaction of bed and banks etc.). Training materials can be developed and kept in the villages for farmers' use and the extension agents of DAE may use those for extension purposes. Similarly farmers may be told about better seeds, fertilizers, pesticides etc.

4. Improved distribution systems. Install 10 underground distribution systems and study them closely. Farmer groups can be organized to installthese and close studies will give informations on their feasibilities. These UDSs may not be economical now. But if we consider the facts that there may not enough surface water in dry seasons and groundwater may become a very major source of irrigation in about 5-10 years, there will a great need to improve the efficiency of water use. So tests on UDSs should continue.

These should be tried completely under 'farmers' control' conditions. Farmers should be encouraged to farm groups raise money, plan, design and instal the systems. They should collect water charges to keep the system operating and to repay the loans. Close

study of such systems, would provide informations about its feasibility and how those should be handled in future if found feasible.

Small farm structures may be developed and tried to improve water use. Presently no farm structures are used. Water is applied to various plots by cutting embankments, the cuts are plugged with clay after water application is over. In many cases, water will leak through improperly done plugs which causes over irrigation and loss. Similarly water is headed up earthen barriers across canals which may also leak.

5. Develop a monitoring system for the minor irrigation system. The following should be covered.

a. measurement of dischage of selected DTWs, STWs and LLPs and identify causes for less than rated discharges.

b. fluctuation of groundwater table.

c. spacing of DTWs and STWs and their interferences. The purpose is not to regulate the spacing but to see how farmers manage over a period of time and to assess the magnitude of interference.

d. potential for additional tubewells based on the present extraction rate, water table lowering.

6. Studies and surveys as discussed in last chapter.

a. Groundwater model: Groundwater would be a major source of water for irrigation, domestic and industrial use. This would be a huge and sensitive system. Mathematical models would be useful to determine how the system would behave. Groundwater models should be developed for various regions of Bangladesh relating groundwater level (lowerings) to extraction rate, river levels, rainfall in the previous monsoon seasons and aquifer charateristics.

b. Surface water sources

i. minor rivers

ii. water bodies

c. Effects of flood control efforts on recharge and croping pattern.

d. Possibilities of increasing LLP by heading up dry-season water levels in medium-sized rivers by barrages or weirs.

7. Studies and surveys to determine additional needs for potharvest facilities, storage and marketing at farm level for increased rice production.