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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF LOCAL GOVERNMENT,
RURAL DEVELOPMENT AND COOPERATIVES (MLGRD&C)
LOCAL GOVERNMENT ENGINEERING DEPARTMENT (LGED)

THE MASTER PLAN STUDY ON SMALL SCALE WATER RESOURCES DEVELOPMENT FOR POVERTY ALLEVIATION THROUGH EFFECTIVE USE OF SURFACE WATER IN GREATER MYMENSINGH OF BANGLADESH

FINAL REPORT

ANNEXES

FEBRUARY 2006

PACIFIC CONSULTANTS INTERNATIONAL (PCI), JAPAN

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FINAL REPORT (ANNEXES)

TABLE OF CONTENTS

PART I: Supporting Documents

ANNEX 1

SOCIO-ECONOMIC BACKGROUND

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TABLE OF CONTENTS

A 1 SOCIO-ECONOMIC BACKGROUND

1.1 Background

1.1.1 Social Conditions

(1) People and Population National Social Development Plan

People in Bangladesh mostly share a common culture named as *Bengali Culture*; and which have a tradition of about two thousand years or so. Bangladeshis are from different stream of religions; such as Muslims (88.3%), Hindus (10.5%), Buddhists (0.6%), Christians (0.3%); and the rests are the Indigenous religions practiced by different indigenous people (*1.2 million*), such as *Chakma, Marma, Shantal, Garo* etc.

As shown in the table, Bangladesh has 123.2 million people (Population Census 2001 Preliminary Report BBS) with an annual growth rate of 1.48% [1991-2001]; and with a highest density of 834 heads/km^2.

Most of the people live in the rural areas (*94.3 million / 76.6%)*. The male-female ratio is 104:100. The life expectancy at birth is estimated at 68.8 (*Year: 2000*).

There are different religions in Bangladesh such as Muslims (88.3%), Hindus (10.5%), Buddhists (0.6%), Christians (0.3%); and the rests are the Indigenous religions practiced by different indigenous people (*1.2 million*), such as *Chakma, Marma, Shantal, Garo* etc.

(2) Social Development

1) General

Bangladesh has achieved substantial progress in mass literacy, public health, reduction of population growth and self employment support for rural poor. Primary education is compulsory and female education is free through the first eight years. The strong commitment to primary education and to gender equity means that three out of four girls now enter primary education.

In the area of health, over 80% of the country's children are immunized against the six `killer` diseases. Infant mortality has decreased significantly. There has been a sharp decline in the fertility rate.

The increased participation of women in poverty alleviation programmes as well as in Bangladesh's ready-made garments sector, which provides jobs for more than 1 million women, has helped to create an awareness of women's issues at all levels.

An unparalleled concentration of innovative and committed NGOs has brought about a micro-credit revolution and guided countless indigent women and landless households into income generating activities. The safety net programmes initiated by the government in improving the condition of the poorest to a level of survival are proving effective.

2) Poverty

Since its independence in 1971, Bangladesh has reduced poverty, as measured by head count index, from more than 70% in the early 1970's to 50% in 2000. And 90 % of poor live in the rural areas.

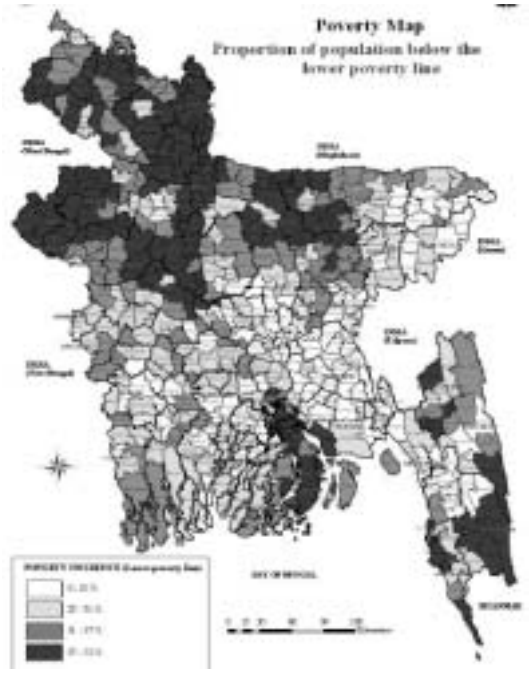
Source		1983/84	1985/86	1988/80	1991/92	1995/96	2000*
World Bank	National	58.5	51.7	57.1	58.8	53.1	49.8
	Rural Area	59.6	53.1	59.2	61.2	56.7	53.1
	Urban Area	50.5	42.9	43.9	44.9	35.0	36.6
Gini Coefficient*	National	0.360	0.379	0.379	0.388	0.432	0.417
	Rural Area	0.350	0.360	0.368	0.364	0.384	0.366
	Urban Area	0.370	0.370	0.381	0.398	0.444	0.452

Source: World Bank, and * Household Expenditure Survey, 2000, BBS

As shown in the map in "Local Estimation of Poverty and Malnutrition in Bangladesh 2004", BBS/WFP, a large portion of poor people live in upazilas in northern central to west, which is a part of

the Study Area.

3) Gender



Bangladesh like other developing countries of the world has the vision to accelerate growth, alleviate poverty, take advantage of new opportunities and meet the challenges for the future. Bangladesh is also fully committed to ensure equality for all citizens and to eliminate all forms of discrimination against women and girls. As a reflection of this commitment, Bangladesh has made sustained and comprehensive efforts to address the special needs and interests of women and girls as well as bringing them into the mainstream of national development.

Since women are in a relatively disadvantaged position in terms of fulfillment of basic needs, such as food security, education, health, shelter and to enjoy human rights, the GOB placed more emphasis on ensuring women's advancement in various socio-economic aspects and declared "the National Women Development Policies" in 1997. Though the Ministry of Women and Children Affairs is considered as the leading agency for women's development, other line agencies and serving Ministries are also playing important role in implementing sector specific women's development plan and programs.

- Education

  Notable progress has been made in reducing gaps in the female education and gender disparity, such as (1) food for education, (2) free education up to primary, (3) stipends for girls up to grade eight, free education up to grade twelve, (4) sixty percent quota for female teachers, have contributed to increasing girls' employment and decreasing the dropout rate at primary education level. There is a greater awareness among the people involved in education.

- Economy

  There is steady increasing trend of women's participation in the economy. A greater number of women are involved in non-farming activities, export oriented industries and informal sector, women have proved to be efficient users of micro credit and engaged themselves in different self – employed occupations. Various initiatives have been taken by both government and non-government agencies to develop the capacity of women as entrepreneurs and increase women's access to credit and technology.

  Various credit programs undertaken by GO/NGOs also significantly contribute to the economic empowerment of women. Millions of women all over Bangladesh have been benefited from their programs in terms of raising the standard of living for them and their children.

  A large stream of female labor is directly contributing to the export oriented industries e.g. garment, tea and frozen fish. The female labor force is increasing at a faster rate than the male labor force. A private organization with the help of Telephone and Telegraph Board has introduced the mobile telephone for rural women.

  This has become a major source of income for many rural poor women. This measure has improved the communication network in remote areas. Ninety percent of the telephone operators are women. This will benefit the semi-skilled women labor force.

- Political Participation and Decision Making

  The importance of women's participation in political and decision-making processes is well recognized. The present government took a major step in 1997. Through enactment of Local Government Legislation, three seats by direct election are reserved for women in all four tiers of

local government. Beside local level, forty five seats were reserved for women at the national parliaments. The government has also introduced lateral entry for women to increase the number of women in decision-making position.

- Violence Against Women

  To ensure a violence free environment is still a great challenge for the government. Enactment of new laws with appropriate institutional measures and social mobilization for establishing women's human rights is important. There is increasing information and understanding on this with various governments and NGOs consciousness of their responsibilities towards combating violence.

- Environment

  Increasing awareness to incorporate concerns and needs of environment with particular attention to women in every development agenda is crucial. Different line agencies, non-government agencies and human rights organizations have undertaken need-based programs.

  Different project undertaken by different ministries in the environment and social forestry sector considered women's relations with environment as one of the key areas for intervention.

- Women's Human Rights

  There has been brightened awareness of the difficulties women have in accessing justice and judicial reform and judicial training are giving increasing importance to women's needs and concerns.

  NGOs, women organizations and human rights organizations continue to play an active and important role in the above critical areas of concern. Their programs range from providing direct services to raise awareness, which also included services as for street children, domestic helpers and sex workers.

The Government of Bangladesh fully committed for achieving gender equity and equality to accelerate progress and the government has approved the national policy for advancement, which emphasizes the main-streaming of women issues at national, local and family levels. The following strategies have been identified to achieve the objectives of the policy:

Gender Development

Items	1980	1990	1995	2000
Life expectancy at birth (years) Male	49	55	58	61
Life expectancy at birth (years) Female	48	55	59	62
Adult illiteracy rate (% of people aged 15+) Male	60	55.7	53.2	50.6
Adult illiteracy rate (% of people aged 15+) Female	82.8	76.3	73.1	69.8
Total labor force (millions)	40	51	59	69
Female labor force (% of total)	42	42	42	42
Unemployment Total (% of total labor force)		1.9	*2.5*	3.3
Unemployment Female (% of female labor force)		1.9	*2.3*	3.3
Youth illiteracy Rate (% of people aged 15-24) Male	55.3	49.3	46.4	43.3
Youth illiteracy Rate (% of people aged 15-24) Female	74.1	66.8	63.7	60.3
Total fertility rate (births per woman)	6.1	4.1	3.4	3.1
Contraceptive prevalence (% of women aged 15-49)		*31*	*45*	*54*
Births attended by skilled health staff (% of total)			*10*	12

Note: Data in italics refer to the most recent data available within two years of the year indicated
Source: World Bank Gender Statistics

- Strengthening/introducing institutional measures at national, district, upazila and grassroots levels.
- Strengthening national machinery.
- Building stronger collaborative ties with NGOs and broader level of society.
- Commissioning research on gender issues.
- Developing gender disaggregated database and information system.
- Building capacity at all levels to develop and implement programs and projects for facilitating gender mainstreaming.
- Taking up advocacy and lobbying at all levels to raise awareness about gender concerns and mass mobilization.

- National and international networking.
- Financial arrangement etc.

Future strategic plans and actions for women's advancement will be formulated and implemented on the basis of experience and lessons learned from the best practices.

Despite the efforts of Government of Bangladesh, NGOs, and people, there are several issues related to gender and development which need to be given attention to:

- Micro credit by the Gramin Bank and NGOs has contributed a lot to raise the position in the family, the social status and also dignity of women, yet, social constraints and violence against women remain.
- Nine union *parishad* members from nine constituencies in the union are elected, three woman union *parishad* members from each of three constituencies. More poor women have chances to participate local politics this way, however, they also might be parts of the politics of influence peddling. Also this system might discourage women to become regular union *parishad* members.
- Despite many credit systems and promotion of income generating activities for women, nation-wide extension of activities and sharing of information among women are still not enough.

> "We are representatives of local people. Our rural women face various forms of violence and discrimination. They need advice and assistance. We must help them. Many of their problems are private, and they want to discuss them with us confidentially. The separate sitting arrangement is very important for us to transact business to help our women constituency."
> Female member, Uchakhila Union Council, Mymensingh District.

(3) Unemployment

Employment is a big issue in the economy of Bangladesh. Wage is very low as there is more than excess supply of labor in the agricultural sector; and also due to the rural-urban migration many people in the urban area is getting very low wages; even though many of them are working in industries with the minimum wages. There are about 1.8 million people reported to be unemployed (Male: 1.1 million & Female: 0.7 million). In broad sectors, about 20.0 million people (51.3% of total labor force) are employed in agricultural sector, and about 19.0 million (48.7% of total labor force) people are employed in non-agricultural sector.

Condition	Ratio
Do not work	28.40%
Looking for work	1.8%
Household work	32.4%
Agriculture work	19.2%
Industry	1.30%
Water/ Gas/ Electricity	0.10%
Construction	0.90%
Transport	1.50%
Business	5.50%
Services (self employed)	0.80%
Others	8.10%

(4) Social Development Plan

1) Interim PRSP

The GOB formulated "National Strategy for Economic Growth, Poverty Reduction and Social Development (NSEGPRSD)" as an interim Poverty Reduction Strategy Paper (I-PRSP) in March 2003, which seeks to reduce by half the incidence of income poverty by 2015. And GOB is now in the process of preparing the full PRSP by December 2004. I-PRSP composed with four main policy piers; i) macroeconomic stability, ii) improving governance, iii) investing in human development, and iv) social protection for reducing vulnerabilities and improving income generating opportunities. The I-PRSP long-term social targets to be achieved by the year 2015 are as follows:

(i) Remove the 'ugly faces' of poverty by eradicating hunger, chronic food insecurity, and extreme destitution
(ii) Reduce the number of people living below the poverty line by 50%
(iii) Attain universal primary education for girls and boys of primary school age
(iv) Eliminate gender disparity in primary and secondary education

(v) Reduce infant and under five mortality rates by 65%, and eliminate gender disparity in child mortality
(vi) Reduce the proportion of malnourished children under five by 50% and eliminate gender disparity in child malnutrition
(vii) Reduce maternal mortality rate by 75%
(viii) Ensure access of reproductive health services to all
(ix) Reduce sustainability, if not eliminate totally, social violence against the poor and the disadvantage groups, especially violence against women and children, and
(x) Ensure disaster management and prevent environmental degradation for overcoming the persistence of deprivation.

2) Draft PRSP

Following the I-PRSP, the Government drafted the full PRSP in December 2004, titled "Unlocking the Potential". It is expected to be approved by the Parliament after reviewing of donor agencies/nations.

It proposed seven-point agenda; 1) employment, 2) nutrition, 3) maternal health, 4) sanitation and safe water, 5) quality education, 6) criminal justice, and 7) local governance. Interim macro-economical frameworks during 2004 to 2007, is summarized in Table 1.1.1. Also policy matrix of water resources development & management and agriculture sector growth are shown in Table 1.1.2 and 1.2.3, respectively.

1.1.2 Economic Conditions

(1) National Development Plan

After the independence of Bangladesh in 1971, the GOB started the 1st Five Year Plan in 1973. With some interruptions, the 5th Five Year Development plan completed the term in 2002. Achievements of previous Five Year Development Plans are shown as follows:

Five Year Development Plan (FYDP)	Period	GDP Growth Rate (%)	
		Planned	Actual
1st FYDP	1973-1978	5.5	4.00
2 Years Plan	1978-1980	5.6	3.50
2nd FYDP	1980-1985	5.4	3.80
3rd FYDP	1986-1990	5.4	3.80
4th FYDP	1990-1995	5.00	4.15
5th FYDP	1997-2002	7.00	

After the 5th Five Year Development Plan ended in 2002, the Interim Poverty Reduction Strategy Plan (I-PRSP), titled "A National Strategy for Economic Growth, Poverty Reduction and Social Development 2003", is the only development strategy document of the GOB at the present.

(2) Recent Economic Development

Bangladesh has marked considerable progress since independence in 1971 despite its dire initial conditions. From a mainly feudal agrarian base, the economy of Bangladesh has undergone rapid structural transformation towards manufacturing and services. The contribution of the agriculture sector to GDP has dwindled from 50 % in 1972-73 to around 20 % in 1999-2000. The agricultural sector is, however, still the main employment provider. The staple crop is rice, with paddy fields accounting for nearly 70% of all agricultural land. GDP by industrial sectors are shown in Table 1.1.4.

Balance of Trade

Unit: Tk.. 10 million

Year	Export	Import	Balance
1986/87	3,368.2	6,849.6	-3,481.4
1987/88	4,116.1	9,158.8	-5,042.7
1988/89	4,268.6	9,507.5	-5,238.9
1989/90	5,141.5	11,330.5	-6,189.0
1990/91	6,027.2	11,187.7	-5,160.5
1991/92	7,419.8	13,275.6	-5,855.8
1992/93	8,821.5	13,819.8	-4,998.3
1993/94	9,873.9	13,754.0	-3,880.1
1994/95	13,692.0	21,856.4	-8,164.4
1995/96	14,452.1	25,464.6	-11,012.5
1996/97	17,155.4	29,018.7	-11,863.3
1997/98	22,940.8	31,891.6	-8,950.8
1998/99	24,561.9	34,101.7	-9,539.8
1999/00	24,741.5	37,202.2	-12,460.7
2000/01	30,647.6	43,694.9	-13,047.3

Source: Foreign Trade Section, BBS

(3) Foreign Trade

AS shown in table, foreign trade balance is constantly negative in Bangladesh. These deficits of balance are mostly covered by transfer by Bangladesh nationals abroad.

Industrial production growth has averaged more than 6% over the last 5 years. The export sector has been the engine of industrial growth, with ready-made garments leading the way, having grown at an average of 30% over the last 5 years. Primary products constitute less than 10 % of the country's exports; the bulk of exports are manufactured/processed products, ready-made garments and knit wears in particular.

(4) Government Budgets, and Foreign Economic Assistance and External Debt

As shown in Table 1.1.5, more than 30 % of the total government expenditure covered by foreign economic assistance every year. And external debts are accumulated at US$ 14.7 billion at the end of June 2001. Among the creditors, IBRD shares 43.1%, followed by ADB at 27.2%, Japan 19.5% and others.

1.2 Brief Description of Socio-economic Conditions in the Study Area

1.2.1 General

The Study Area occupies 11.3 % of the country with 16,672 km^2 of land area, and holds 12.6 % (15.62 million people) of the total population. The local administration comprises of 6 Districts, 58 Upazilas (sub-districts) and 558 Unions. Sherpur district was a former sub-division of the greater Jamalpur Region. It was upgraded to a district on 22nd February 1984. Also, Kishoreganj district was one of the sub-division of former Mymensingh district. It was upgraded to a district in 1984.

The average area of one Union is approximately 3,000 ha with about 2,800 residents. An overview of the characteristics of the six districts is shown in Table 1.2.1.

District	Area (km^2)	Population 1996, (,000)	Number of		
			Upazila	Union	Mauza
Jamalpur	2,032	2,111	7	68	757
Kishoregonj	2,689	2,573	13	105	946
Mymensingh	4,363	4,450	12	146	2,172
Netorokona	2,810	1,938	10	85	1,591
Sherpur	1,364	1,279	5	51	446
Tangail	3,414	3,371	11	103	1,954
Study Area Total	16,672	15,722	58	558	7,866

Source: Census of Agriculture 1996, BBS, 2003

1.2.2 Socio-economic Conditions

(1) District Gross Domestic Products (DGDP)

DGDP by industry activity of districts in the Study Area is shown in Table 1.2.2. Comparing with national GDP per capita in 1999/2000 at current cost of US$ 363 or Tk. 18,269, the districts figures show a lower GDP as shown below:

District	Regional GDP 1999/2000	Share of District	Regional GDP per capita		Growth rate for year average	Rank based on per capita
			In Tk.	In US$		
Bangladesh	2,370,740	100%	18,269	363	5.36	Total 64
Jamalpur	31,429	1.3%	13,834	275	5.97	50
Kishoreganj	38,266	1.6%	13,903	276	4.96	43
Mymensingh	73,117	3.1%	15,430	307	5.58	33
Netrokona	32,020	1.4%	15,410	306	4.99	30
Sherpur	18,842	0.8%	13,748	273	5.61	55
Tangail	47,986	2.0%	13,297	264	4.81	56
Project Area	241,660	10.19%	14,270	284		40

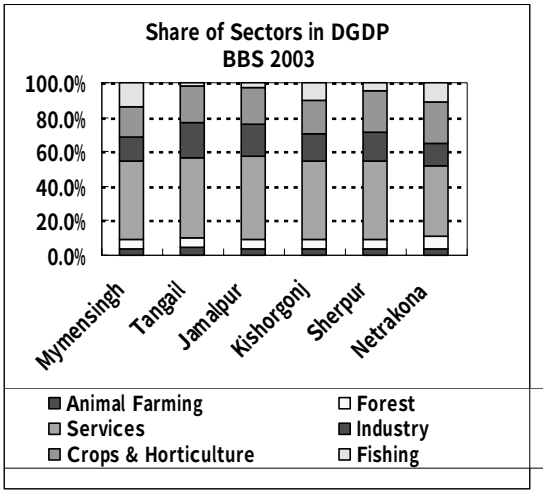
Sources: Statistic Yearbook of Bangladesh 2001

This table indicates that the Study Area is one of the poorer regions in Bangladesh.

(2) Major Industrial Sectors in District GDP

As shown in figure on the right, major industrial sector in the Study Area is services sectors covering more than 40%, agriculture and fisheries sector covers 30 to 43%, and followed by industrial sector.

Among agriculture and fisheries sector, crop and horticulture occupy major parts. Fisheries sector comes to the second in Mymensingh, Kishorganj and Netrokona districts, especially fisheries sector in Mymensingh district cover more than 13% of district GDP. Industrial sector in Tangail district shows the largest share of district GDP at 21%.



1.2.3 Rural Infrastructure

According to the Zila Profile of BBS homepage as shown in Table 1.2.3, social infrastructure data in 1998 is available in the Study Area.

(1) Utilities

Totally 5,839 roads with 32,276 km length are installed up to 1998, and 86% of them are categorized a kutcha road. Most part of them is submerged during monsoon season and cause the damage of pavement and embankment. Also line 29 of rail road run in the Study Area operated by Bangladesh Railway. Most of them are submerged by flood and intercept the traveling during monsoon season. Navigation in inland water mainly the river coarse of the Jamuna and old Brahmaputra rivers is operated.

(2) Social Facilities

There are 1,358 hat bazaars, 40 of flood centers, and 443 community centers in the Study Area. As religious facilities, 17,413 mosques, 1,542 mandirs, 128 churches, and 2 pagodas exist in the Study Area.

(3) Educational institutions

There are 19,478 educational institutes including primary to high education; 1/3 of them was primary schools, and there area 2 universities in the Study Area in 1998. Teachers and students were estimated as 80,650 and 3,360,688, respectively.

(4) Health facilities

There are 994 doctors together with 2,300 nurses/health assistances deployed at health care facilities from primary healthcare to hospitals. Also, a total of 4,024 beds were installed in these healthcare facilities in the Study Area

Table 1.1.1 Mid-term Micro-economic Framework of Draft PRSP

Triangle	Strategic Blocks/Supporting Strategies		Contents of Strategy
Economic Growth	Accelerating Growth for Pro-Poor	Employment	Assets of poor, Education, labour productivity, working environment, labour market
		Investment & Saving	Increase investment and saving ratio
		Macroeconomic Stability	Macro-economic stabilization financing and banking policies for investment promotion
		Promotion of Trade	Countermeasure for MFA(Multinational Fiber Arrangement) cancellation, export diversification and trade liberalization
		Facilitating Fair & competitive business	Legal improvement, renovation of banking sector, privatization, direct investment, development of private enterprise,
		Promotion of employment	Increase employment ratio, support for entrepreneur, vocational training and emigrant workers
	Critical Sectors for Pro-poor economic growth	Agriculture/rural development	Diversification of production, increase productivity, value-adding
			Development of fishery, livestock and forestry
			Technical extension, marketing & processing, rural non-farm activities
			Food security
			Micro-credit
		Water resources development and management	Implementation of NWPo and NWMP
		Small & medium size enterprises	
		Informal sector	
		Infrastructure development	Electricity (rural & urban), gas, new energy, and communication transportation
		ICT (information communication technology)	Expansion to rural area, high-tech park
	Effective Safety nets		Integration of various programs, comprehensive policy and expansion of coverage
Social Development	Human Development	Education	Qualified education, Non formal education (NFE) and increase literacy rate
		Health	Maternal health, female health, infectious disease, improvement of governance through the Health, Nutrition & Population Sector Program (HNPSP).
Governance	Social inclusion & Empowerment		Support female, children, tribal people, disable and other disadvantage group
	Promoting good governance		Capacity building, promotion local governance, tackling corruption, criminal justice reform
	Service Delivery		Public-private partnership
Environment	Caring for the environment & Sustainable development		Conservation of nature, combating pollution

Table 1.1.2 Policy Matrix of Water Resources Development & Management

Strategic Goal	Key targets	PRSP Policy agenda (FY2005-FY2007)	Responsibilities
1. Expand utilization of Surface Water.	• Creation of additional irrigation facilities • Supply of safe water for domestic use.	• Abstraction from main rivers: • Undertake studies to determine utilization of the flow of the main rivers, • Identify suitable locations for dual purpose pump houses (to be used both for irrigation and flood reduction). • Include irrigation components in large flood control projects.	MOWR (JRC, BWDB, WARPO) MOA (DAE, BADC), MOFA, **MOLGRD & Co. (LGED, DPHE.)**
2. Rationalize utilization of ground water.	Ensuring: - Supply of safe water for domestic use - Regulate Industrial & agricultural use - Ensure conjunctive use of water.	• Monitor quality & quantity of groundwater regularly. • Promote private investment under regulatory framework. • Undertake of New FCDI Projects Start construction of Ganges Barrage and Bromoputra Barrage.	**MOLGED & Co (DPHE, LGED)**, MOEF, MOWR (IWM, WARPO) MOA, IWMU, (Integrated Water Management Unit of DAE), BADC.
3. Protect flood, improve drainage and reduce vulnerability.	• Protection of lives and properties. • Rehabilitation of 123 polders for protection of 1.28 million ha land from tidal flood and salinity intrusion.	• Fixed-agency-wise responsibilities • Gradually handover O & M of the existing projects to the beneficiaries. • Replicated Mechanism developed under Command Area Development (CAD) Projects.	MOEF (PWD), M/O. Commerce (R & H). MOWR (BWDB), MOFDM
4. Enhance access of the poor to water and common properties resources.	• Creation of Income Generating Activities (IGA) for the poor through water resources management program. • Protection of 0.28 million hectares from	• Promote community participation in multipurpose use of water & other facilities like irrigation canal, fish pass, regulators, irrigation inlets, cross dams, embankment slope, etc.	**Local Government Division (LGED)**, MOWR (BWDB, WARPO), MOEF, MOFL, MOA (DAE)
5. Augment surface water utilization (retention) in rivers, creeks and khals.	• Re-excavation of rivers, canals, derelict ponds and rainwater harvest.	• Undertake desiltation and re excavation of small rivers and canals using human labour • Initiate construction of Ganges Barrage, augmentation of flow in the Gorai river, • Replicate Tidal River Management (TRM) Programme in the (South West region) coastal zone. • Divert surface water through small barrage and large Water Control Structure (WCS). • Take up performance evaluation of the rubber dams projects.	MOWR (BWDB, WARPO), MOA, MOH, DPHE, **LGD (LGED)**.
6. Protect wetland/ Sundarban, saline water intrusion and promote accretion of land from the sea.	• Environmental protection, habitation for the poor people on the raised platforms and in the char areas.	• Undertake co-ordinated efforts to make the accreted land habitable and suitable for crop production. • Implement Integrated Coastal Zone Management Plan (ICZMP).	MOWR (BWDB, WARPO), MOL, MOA (DAE.).
7. Make Institutional Development of water sector agencies.	• Development of knowledge and capability for design of future water resources management plans & monitoring.	• Strengthen capacity of Disaster Management Bureau (DMB) and other organizations, i.e. BWDB, SPARSO, IWM, CEGIS, and WARPO.	**LGD**, DMB, BWDB, MOWR (BWDB, WORPO, IWM, CEGIS), BWDB.
8. Control Erosion of major rivers and protect large and small towns	• Save property worth Tk. 50000/- million • Generate employment for 470 million person day annually for construction works.	• Protect vulnerable areas from erosion, specially saving places of economic importance and densely populated areas. • Protect wet lands.	MOWR. (BWDB. WARPO, IWM)

Table 1.1.3 Policy Matrix of Agriculture Sector Growth in Draft-PRSP

	Strategic Goal	Key targets/Activities
Agriculture	Increase productivity and profitability in crop sector	・ Narrow yield gap ・ Increase rice production to 29 million tons by 2006 ・ Increase production of other field crops including horticultural and plantation crops
	Ensuring food security through increasing production for food crops	・ Increase production of rice, wheat, maize, potatoes, pulses, oil-seeds, fruits and vegetables ・ Improve nutrition intake of the poor through promotion of crop diversification
	Encouraging production of cash crops	・ Increase production of jute, cotton, sugar cane, tea, and plantation crops
	Accelerating production of high value crops for domestic and export market	・ Increase production of vegetables, fruits and flowers ・ Increase production of medicinal ornamental and aromatic plants
	Improvement of land resource base	・ Protect crop land from non-agricultural uses ・ Improve soil fertility through increasing organic content from 1% to 5%
	Strengthening agricultural research	・ Development improved crop technologies for quik dissemination ・ Increase bio-technology research for crops
	Strengthening agriculture extension service	・ Give pro-poor focus on extension service ・ Cover all categories of farmers, landless households and women in the extension service ・ Raise income of the rural households
	Expansion of irrigation with emphasis on efficient management of water resources	・ Increase irrigation coverage, especially to less developed area ・ Increase use of surface water for irrigation ・ Improve on-farm water management ・ Increase profit margins from rice irrigation
	Promoting quality seed development	・ Increase availability of quality seeds for rice and non-rice crops ・ Expedite private sector participation in seed development
	Improvement of agricultural marketing	・ Reduce producer-consumer price spread ・ Reduce marketing costs of various crops
	Promoting agro-processing and agribusiness development	・ Increase opportunities for value addition to crops ・ Strengthen linkage among farmers, traders, processors and business service provider
	Promoting investment in agriculture	・ Making provision for appropriate financial support to farmers to ensure level playing fields for them
	Mainstreaming women in agriculture sector	・ Increase and improve women's participation in crop agriculture
Livestock & Poultry	Increasing productivity in livestock sector	・ Increase production of livestock products, i.e. meat, milk and egg ・ Increase income of the livestock and poultry
	Promoting poultry sector development	・ Raise poultry production ・ Raise income of the poor
	Promoting milk and meat production	・ Increase milk production ・ Develop milk and meat processing facilities
	Strengthening livestock research and extension	・ Boost up production of livestock products ・ Develop new breeds ・ Develop improved animal husbandry practices and veterinary services
Fisheries	Increasing productivity in inland aquaculture	・ Increase fish from pond poly-culture ・ Cover 90% of ponds for fish culture
	Increasing productivity in inland capture fishery	・ Increase output from semi-closed and closed water bodies ・ Reclaim and improve fish habitats and sanctuaries
	Raising income of the poor fishers	・ Increase income from cage, pen, seed and fry production
	Promoting rice cum fish culture	・ Introduce fish production in rice land concurrently and alternately
	Strengthening fisheries research and extension	・ Accelerate fish production

Source: Draft-PRSP, Annexure 2 Policy Matrix

Table 1.1.4 GOP at Constant Price (1995/96=100) by Sector

unit: million Taka

		1993/94	19934/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02
1	Agriculture and Forestry	324,200	317,932	324,382	342,458	348,080	359,368	384,251	405,514	417,847
2	Fishing	74,551	79,613	85,500	91,997	100,257	110,240	120,019	114,582	116,978
3	Mining & quarrying	14,119	15,482	16,691	17,286	18,281	18,522	20,277	22,254	23,860
4	Industry	209,554	231,517	246,351	258,795	280,908	289,882	303,679	323,976	340,176
5	Electricity, gas and water supply	21,628	22,772	24,009	24,473	24,965	26,463	28,258	30,349	32,680
6	Construction	92,525	101,372	109,993	119,500	130,833	142,503	154,590	167,959	181,228
7	Wholesale and retail trade	182,433	196,948	206,076	217,374	230,382	245,377	263,282	280,212	295,988
8	Hotel and Restaurant	8,876	9,318	9,782	10,269	10,936	11,664	12,473	13,346	14,214
9	Transport, storage and communication	131,241	137,739	144,831	152,798	161,490	171,019	181,422	195,798	207,605
10	Financial intermeditation	22,838	24,001	25,171	26,465	27,860	29,365	30,980	32,697	34,404
11	Real estate, renting and business services	141,159	146,065	151,036	156,385	162,328	168,528	174,990	180,959	187,147
12	Public Administration and defence	36,911	38,561	40,165	42,375	44,874	47,432	50,262	53,216	56,950
13	Education	30,831	32,214	33,042	34,618	37,422	40,304	43,424	46,511	50,012
14	Health & social services	34,436	35,431	36,388	37,807	39,542	41,361	43,346	45,480	47,748
15	Community social & personal services	136,345	139,073	142,943	146,929	151,117	155,575	160,332	165,378	170,729
16	GDP at constant producers price	1,461,647	1,528,038	1,596,360	1,679,529	1,769,275	1,857,603	1,971,585	2,078,231	2,177,566
17	import duty	54,492	61,724	66,880	73,318	75,202	76,687	77,689	79,121	83,324
18	GDP at constant market price	1,516,139	1,589,762	1,663,240	1,752,847	1,844,477	1,934,290	2,049,274	2,157,352	2,260,890
19	net primary income from abroad	47,372	48,482	49,536	56,707	59,867	66,203	75,098	80,880	84,447
20	GNI at constant market price	1,563,511	1,638,244	1,712,776	1,809,554	1,904,344	2,000,493	2,124,372	2,238,232	2,345,337
	population (in million)	117.7	119.9	122.1	124.3	126.5	128.1	129.8	129.2	131.2
	Per capita GDP	12,881	13,259	13,622	14,102	14,581	15,100	15,788	16,698	17,232
	Per capita GNI	13,284	13,663	14,028	14,558	15,054	15,617	16,367	17,324	17,876

Source: Statistical Yearbook of Bangladesh 2001, BBS

Table 1.1.5 Consolidated Receipts and Expenditure of the Bangladesh

Unit: Tk. million

Items	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02
Revenue Receipts	151,380	172,705	188,987	204,668	213,450	241,730	284,560
tax	121,241	142,614	153,900	161,671	170,957	194,900	220,230
non-tax	30,139	30,091	35,087	42,997	42,493	46,830	64,330
Development Receipts	81,120	80,440	81,470	119,630	145,890	178,220	175,260
Project	46,780	50,107	51,390	59,250	69,430	76,060	85,030
Food & Commodities	22,380	16,030	14,170	28,285	18,890	13,160	17,190
Internal Resources	11,960	14,303	15,910	32,095	57,570	89,000	73,040
Total Receipts	232,500	253,145	270,457	324,298	359,340	419,950	459,820
Revenue Expenditure (gross)	120,833	123,729	138,450	168,783	185,820	206,619	220,379
Wages & Salaries	41,834	43,255	49,747	53,671	59,327	60,973	66,782
Commodities & Services	24,017	26,917	19,819	29,023	32,533	37,095	42,872
Transfer	45,809	44,016	60,251	78,091	85,118	99,337	101,219
Other Services	9,173	9,541	8,633	7,998	8,842	9,214	9,506
Development Expenditure	99,957	110,410	110,370	125,090	79,659	161,508	136,000
Agriculture, Flood Control, Water Resources and Rural Development	20,365	25,719	29,355	27,530	36,760	36,828	27,031
Industry	1,763	1,762	593	980	2,560	5,410	2,397
Transport & Communication	27,008	24,519	20,175	26,360	32,000	37,566	32,868
Other Services	50,821	58,410	60,247	70,220	8,339	81,704	73,704
Total Expenditure	220,790	234,139	248,820	293,873	265,479	368,127	356,379
Balance	11,710	19,006	21,637	30,425	93,861	51,823	103,441
Real Public Expenditure (deflated)	220,990	227,123	238,478	258,737	294,347	313,220	296,365
Share of Foreign revenue at real expenditure	31.3%	29.1%	27.5%	33.8%	30.0%	28.5%	34.5%

Resource: Statistic Yearbook Bangladesh 2001 Table 9.01, BBS

Table 1.2.1 District General Profiles

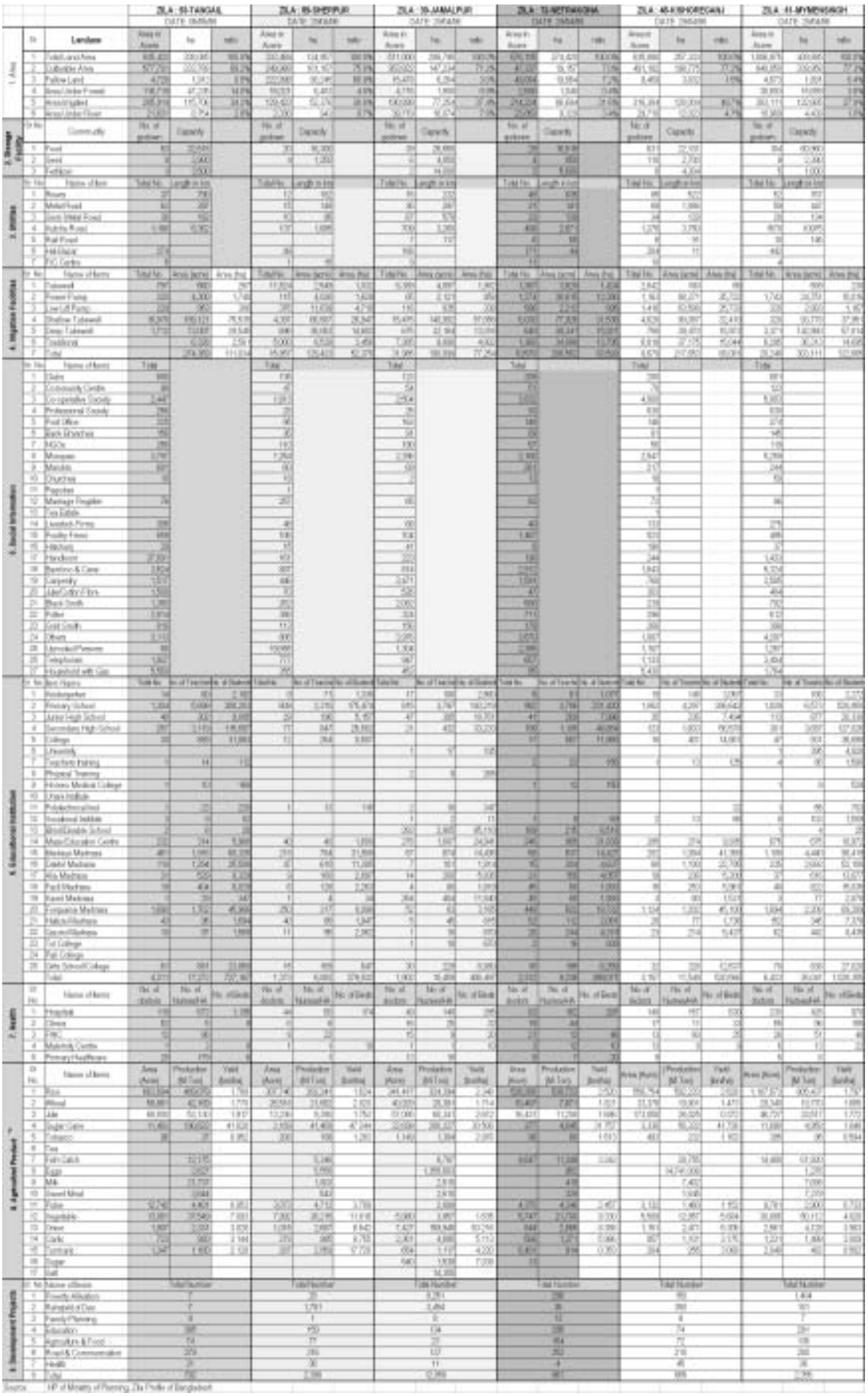


Table 1.2.2 District GDP of Current and Constant (1995/96) Price in the Study Area

		Current Prices					Constant Prices (1995-96)				
		1995-96	1996-97	1997-98	1998-99	1999-2000	1995-96	1996-97	1997-98	1998-99	1999-2000
Mymensingh	Agriculture	20,081	19,694	22,777	25,443	27,720	20,081	19,315	20,498	21,713	24,695
	Crops and horticulture	8,927	8,936	11,015	12,694	13,166	8,927	8,670	9,600	10,452	12,193
	Animal farming	2,249	2,343	2,517	2,672	2,836	2,249	2,300	2,359	2,417	2,478
	Forest and related services	1,306	1,419	1,551	1,758	1,870	1,306	1,358	1,420	1,493	1,567
	Fishing	7,599	5,996	7,695	8,320	9,628	7,599	5,784	7,120	7,350	8,997
	Industry	6,842	7,623	8,628	9,442	10,494	6,842	7,367	8,006	8,544	9,217
	Service	22,752	23,957	26,540	29,406	32,546	22,752	23,184	24,385	25,795	27,549
	Import duty	1,829	1,848	1,940	2,057	2,356	1,829	1,839	1,923	2,028	2,199
	GDP at market prices	51,504	53,122	59,884	66,348	73,117	51,507	51,736	54,813	58,080	63,859
	Growth rate (%)		3.14	12.73	10.79	10.25	-	0.45	5.95	5.96	9.95
	Per capita GDP (Tk.)	11,477	11,665	12,983	14,183	15,430	11,477	11,361	11,886	12,416	13,478
	Per capita GDP (US$)	261	273	295	295	307	261	266	261	256	268
	Share of Agriculture in DGDP	39.0%	37.1%	39.0%	39.3%	37.9%	39.0%	37.3%	37.4%	37.4%	39.0%
Tangail	Agriculture	10,069	11,222	12,194	13,819	14,463	10,069	10,953	10,893	10,539	11,054
	Crops and horticulture	6,979	7,722	8,513	9,714	10,101	6,979	7,578	7,267	8,900	7,977
	Animal farming	1,651	1,745	1,838	1,945	2,074	1,651	1,690	1,731	1,773	1,818
	Forest and related services	921	1,001	1,093	1,240	1,319	921	958	1,001	1,053	1,105
	Fishing	518	754	750	920	969	518	727	694	812	854
	Industry	6,561	7,274	8,213	8,990	9,778	6,561	7,022	7,568	8,011	8,582
	Service	15,724	17,009	18,612	20,397	22,360	15,724	16,452	17,066	17,828	18,816
	Import duty	1,112	1,263	1,249	1,260	1,383	1,112	1,257	1,238	1,242	1,290
	GDP at market prices	33,466	36,768	40,268	44,366	47,986	33,466	35,683	36,566	37,620	40,343
	Growth rate (%)	-	9.87	9.52	10.18	8.16	-	6.63	2.47	2.88	7.24
	Per capita GDP (Tk.)	9,803	10,608	11,446	12,454	13,297	9,803	10,296	10,394	10,500	11,179
	Per capita GDP (US$)	240	249	262	259	264	240	241	229	220	222
	Share of Agriculture in DGDP	30.1%	30.5%	30.3%	31.1%	30.1%	30.1%	30.7%	29.2%	28.0%	28.9%
Jamalpur	Agriculture	6,630	7,250	7,889	9,005	9,552	6,630	7,098	7,404	7,898	8,494
	Crops and horticulture	4,415	4,890	5,475	6,321	6,651	4,415	4,824	5,159	5,465	5,901
	Animal farming	983	1,039	1,093	1,171	1,248	983	1,005	1,028	1,053	1,078
	Forest and related services	558	606	662	751	799	558	580	606	638	669
	Fishing	674	715	659	842	959	674	688	610	743	846
	Industry	3,794	4,207	4,778	5,218	5,771	3,794	4,076	4,422	4,712	5,064
	Service	10,383	11,225	12,375	13,742	15,037	10,383	10,859	11,368	12,041	12,887
	Import duty	661	740	761	819	889	661	736	755	809	829
	GDP at market prices	21,467	23,423	25,804	28,665	31,249	21,467	22,769	23,949	25,458	27,074
	Growth rate (%)	-	9.11	10.17	11.08	9.26	-	6.07	5.18	6.30	6.35
	Per capita GDP (Tk.)	10,056	10,802	11,716	12,945	13,834	10,056	10,500	10,876	11,417	11,998
	Per capita GDP (US$)	246	253	258	269	275	246	246	239	238	239
	Share of Agriculture in DGDP	30.88%	30.95%	30.57%	31.47%	30.57%	30.88%	31.17%	30.92%	31.02%	31.37%
Kishoreganj	Agriculture	9,799	10,273	11,399	12,836	13,658	9,799	9,972	10,455	10,779	11,806
	Crops and horticulture	5,456	5,797	6,241	7,123	7,369	5,456	5,656	5,678	5,753	6,349
	Animal farming	1,053	1,116	1,185	1,275	1,358	1,053	1,081	1,109	1,139	1,171
	Forest and related services	690	751	820	930	989	690	718	751	789	828
	Fishing	2,599	2,609	3,152	3,510	3,922	2,599	2,518	2,918	3,097	3,468
	Industry	4,053	4,530	5,120	5,595	6,167	4,053	4,386	4,742	5,031	5,419
	Service	12,358	13,172	14,374	15,787	17,256	12,358	12,758	13,204	13,959	14,600
	Import duty	919	997	1,033	10,778	1,184	919	992	1,024	1,091	1,105
	GDP at market prices	27,139	28,972	31,927	35,266	38,268	27,139	28,107	29,425	30,729	32,930
	Growth rate (%)	-	6.76	10.20	10.46	8.51	-	3.57	4.69	4.43	7.16
	Per capita GDP (Tk.)	10,400	10,948	11,899	12,960	13,903	10,400	10,621	10,967	11,310	11,964
	Per capita GDP (US$)	255	256	262	270	276	255	249	241	235	239
	Share of Agriculture in DGDP	36.11%	35.46%	35.70%	36.40%	35.69%	36.11%	35.46%	35.53%	35.06%	35.85%
Sherpur	Agriculture	4,492	5,007	5,769	6,511	6,734	4,492	4,917	5,251	5,443	5,593
	Crops and horticulture	3,029	3,448	3,907	4,525	4,606	3,029	3,416	3,537	3,700	3,746
	Animal farming	584	619	666	701	747	584	597	612	626	642
	Forest and related services	369	402	439	497	529	369	384	402	422	443
	Fishing	510	538	758	787	852	510	519	701	694	752
	Industry	2,084	2,313	2,613	2,858	3,171	2,084	2,243	2,426	2,587	2,783
	Service	5,648	6,340	7,031	7,753	8,403	5,648	6,133	6,449	6,788	7,091
	Import duty	399	456	482	510	535	399	454	476	503	499
	GDP at market prices	12,822	14,196	15,896	17,632	18,842	12,822	13,747	14,605	15,321	15,948
	Growth rate (%)	-	10.09	12.61	10.93	6.86	-	7.21	6.24	4.90	4.09
	Per capita GDP (Tk.)	9,883	10,725	11,896	13,033	13,748	9,883	10,445	10,931	11,324	11,635
	Per capita GDP (US$)	242	251	262	271	273	242	245	240	236	231
	Share of Agriculture in DGDP	35.03%	35.47%	36.29%	36.93%	35.74%	35.03%	35.77%	35.95%	35.53%	35.01%
Netrakona	Agriculture	9,969	10,203	11,256	12,741	13,614	9,969	9,960	10,242	10,624	11,997
	Crops and horticulture	5,529	5,827	6,402	7,285	7,543	5,529	5,740	5,741	5,811	6,594
	Animal farming	1,040	1,101	1,163	1,238	1,313	1,040	1,057	1,095	1,124	1,154
	Forest and related services	745	810	895	1,003	1,087	745	775	810	852	894
	Fishing	2,653	2,465	2,806	3,215	3,682	2,653	2,378	2,596	2,837	3,256
	Industry	2,655	2,949	3,315	3,637	4,049	2,655	2,882	3,090	3,301	3,561
	Service	9,370	9,927	10,901	12,075	13,315	9,370	9,613	9,997	10,579	11,258
	Import duty	814	858	870	924	1,061	814	853	862	911	972
	GDP at market prices	22,806	23,936	26,342	29,377	32,020	22,806	23,289	24,191	25,413	27,678
	Growth rate (%)	-	4.96	10.05	11.52	9.00	-	2.12	3.87	5.05	8.91
	Per capita GDP (Tk.)	11,596	11,990	13,004	14,322	15,410	11,596	11,888	11,943	12,389	13,320
	Per capita GDP (US$)	284	281	290	298	306	284	273	263	259	265
	Share of Agriculture in DGDP	43.71%	42.63%	42.73%	43.37%	42.52%	43.71%	42.77%	42.34%	41.81%	42.96%

Source: Statistic Yearbook of Bangladesh 2001, BBS; Table 11.63, 64, 68, 71, 74, 75, 76

Table 1.2.3 Summary of Local Road in the Study Area

District	Upazila	Upazila Total Area (km2)	Total Length (Km)	Surface Type-Wise Break-Up (Km)				Structure		Existing Gap		Total No.	Local Road Density (km/km2)	Structures per Road Length	Average Span of Structures
				Earthen	Flexible Pavement	Brick Pavement	Rigid Pavement	Number	Span (m)	Number	Span (m)				
Jamalpur	Dewanganj	266.59	430.61	355.92	59.51	15.18	0	117	943.57	101	2,810.00	140	1.62	0.27	8.06
	Islampur	343.02	521.73	438.86	77.36	5.51	0	398	4,141.62	327	8,306.50	141	1.52	0.76	10.41
	Jamalpur Sadar	489.56	829.69	646.75	104.57	78.36	0	601	1,741.82	257	2,218.77	144	1.69	0.72	2.90
	Madarganj	225.38	319.60	242.21	74.19	3.2	0	280	3,842.49	49	1,748.10	77	1.42	0.88	13.72
	Melandah	239.65	551.94	429.28	111.55	11.11	0	297	3,541.75	131	3,819.60	164	2.30	0.54	11.93
	Sarishabari	263.48	445.37	315.82	98.09	31.46	0	159	1,548.07	-	-	125	1.69	0.36	9.74
	Bakshiganj	204.30	378.74	337.65	38.39	2.7	0	142	1,863.98	151	3,481.00	143	1.85	0.37	13.13
	Total	2,031.98	3,477.68	2,766.49	563.66	147.52	0	1,994	17,623.30	1,016	22,383.97	934	1.71	0.57	8.84
			100.0%	79.5%	16.2%	4.2%	0.0%								
Kishoreganj	Ashtagram	355.53	308.85	303.98	0	0.5	4.37	103	401.39	78	1,527.50	74	0.87	0.33	3.90
	Bajitpur	193.76	275.15	205.15	67.08	1	1.93	223	734.24	86	485.30	91	1.42	0.81	3.29
	Bhairab	139.32	169.27	113.31	42.06	0.76	13.14	186	2,789.37	12	257.00	80	1.21	1.10	15.00
	Hossainpur	121.29	256.11	207.27	47.34	1.5	0	435	802.47	82	208.70	81	2.11	1.70	1.84
	Itna	401.94	285.89	277.13	1	0.2	7.56	104	352.24	177	842.20	60	0.71	0.36	3.39
	Karimganj	200.52	549.36	510.56	34.6	1.99	2.21	681	1,902.36	766	2,945.97	218	2.74	1.24	2.79
	Katiadi	219.22	413.98	326.75	84.38	2.85	0	502	1,154.89	11	48.10	129	1.89	1.21	2.30
	Kishoreganj Sadar	193.73	492.20	408.66	78.9	4.65	0	1,044	1,654.97	548	913.25	259	2.54	2.12	1.59
	Kuliarchar	104.01	201.26	144.27	50.02	5.93	1.05	290	1,075.21	70	339.60	71	1.94	1.44	3.71
	Nikli	214.40	202.66	177.23	7.6	6.8	11.03	115	550.58	75	967.03	72	0.95	0.57	4.79
	Pakundia	180.52	440.33	373.42	60.46	6.45	0	853	1,316.44	124	552.00	166	2.44	1.94	1.54
	Tarail	141.46	305.31	261.62	41.65	2.03	0	192	1,177.23	163	1,212.20	150	2.16	0.63	6.13
	Mithamain	222.92	287.86	279.81	0	1.22	6.84	112	163.68	233	1,802.35	83	1.29	0.39	1.46
	Total	2,688.62	4,188.23	3,589.16	515.09	35.88	48.13	4,840	14,075.07	2,425	12,101.20	1,534	1.56	1.16	2.91
			100.0%	85.7%	12.3%	0.9%	1.1%								
Mymensingh	Haluaghat	356.07	1,674.07	1,556.61	81.71	35.76	0	942	4,250.20	1,107	5,621.61	372	4.70	1.78	4.51
	Ishwarganj	286.19	401.10	295.47	97.84	7.79	0	518	1,663.56	62	58.71	72	1.40	0.77	3.21
	Nandail	326.13	615.48	478.58	60.71	76.19	0	738	1,486.59	274	451.40	196	1.89	0.83	2.01
	Phulpur	580.21	1,110.48	1,039.60	68.17	2.71	0	360	1,731.94	42	827.50	291	1.91	3.08	4.81
	Gouripur	274.07	732.21	684.37	47.24	0.6	0	643	1,626.00	234	1,149.10	211	2.67	1.14	2.53
	Bhaluka	444.05	752.08	633.51	82.93	35.65	0	816	1,672.26	82	702.46	174	1.69	0.92	2.05
	Fulbaria	402.41	778.59	697.24	77.58	3.77	0	654	1,786.52	535	1,367.11	169	1.93	1.19	2.73
	Gaffargaon	401.16	847.06	752.16	88.00	5.5	1.4	689	1,937.16	632	2,103.84	180	2.11	1.23	2.81
	Mymensingh Sadar	388.45	676.43	577.28	87.36	11.69	0.1	754	1,399.42	18	1,023.20	239	1.74	0.90	1.86
	Muktagacha	314.71	941.31	882.88	52.59	5.85	0	801	1,837.19	256	629.55	226	2.99	1.18	2.29
	Trisal	338.98	877.02	767.75	95.82	13.46	0	1,356	2,420.21	442	1,081.36	285	2.59	0.65	1.78
	Dhobaura	251.05	379.58	349.47	23.35	6.76	0	370	2,375.28	267	2,505.79	83	1.51	1.03	6.42
	Total	4,363.48	9,405.83	8,365.45	839.95	198.97	1.5	8,271	21,811.05	3,684	15,015.84	2,415	2.16	1.14	2.64
			100.0%	88.9%	8.9%	2.1%									
Netrokona	Atpara	195.13	272.60	238.25	31.20	3.15	0	378	1,356.81	65	601.50	92	1.40	1.39	3.59
	Barhatta	221.50	486.03	446.94	26.23	12.86	0	337	1,513.95	347	2,432.57	126	2.19	0.69	4.49
	Durgapur	293.42	337.70	261.69	57.10	18.91	0	258	2,164.99	61	2,008.44	92	1.15	0.76	8.39
	Khaliajuri	297.64	205.83	200.57	4.00	1.06	0.2	1	4.00	12	155.00	49	0.69	0.00	4.00
	Kalmakanda	377.41	491.65	440.32	44.32	7	0	316	2,570.76	126	3,028.50	121	1.30	0.64	8.14
	Kendua	303.60	466.91	399.69	65.17	1.85	0.2	1,421	2,618.57	493	1,450.41	163	1.54	3.04	1.84
	Madan	225.85	306.96	264.88	22.75	17.33	2	202	848.36	82	1,228.60	84	1.36	0.66	4.20
	Mohanganj	243.20	221.33	188.84	13.90	13.82	4.8	134	933.84	23	513.30	77	0.91	0.61	6.97
	Netrokona Sadar	340.35	591.94	530.89	53.71	7.34	0	682	1,377.30	231	2,010.28	173	1.74	1.15	2.02
	Purbadhala	312.30	491.10	447.98	37.96	5.17	0	390	981.55	59	352.24	106	1.57	0.79	2.52
	Total	2,615.27	3,872.05	3,420.05	356.34	88.49	7.2	4,119	14,370.13	1,499	13,780.84	1,083	1.48	1.06	3.49
			100.0%	88.3%	9.2%	2.3%									
Sherpur	Jhenaigati	231.00	333.35	290.57	40.79	2	0	266	1,703.58	375	2,218.19	124	1.44	0.80	6.40
	Nakla	174.80	314.32	214.75	94.10	5.47	0	216	1,869.81	50	1,286.00	111	1.80	0.69	8.66
	Nalitabari	327.61	508.32	396.64	81.24	29.71	0.75	220	3,042.05	84	2,054.38	132	1.55	0.43	13.83
	Sherpur Sadar	360.01	474.41	384.77	83.29	6.36	0	394	2,808.28	73	1,851.50	139	1.32	0.83	7.13
	Sreebordi	270.34	449.86	375.85	69.89	4.12	0	371	1,628.41	194	1,626.50	137	1.66	0.82	4.39
	Total	1,363.76	2,080.26	1,662.58	369.31	47.66	0.75	1,467	11,052.13	776	9,036.57	643	1.53	0.71	7.53
			100.0%	79.9%	17.8%	2.3%									
Tangail	Basail	157.78	360.14	328.56	27.58	4.02	0	191	1,989.82	132	2,155.60	129	2.28	1.21	10.42
	Bhuapur	225.02	372.39	326.55	40.43	4.31	0.3	195	1,208.40	121	1,604.50	224	1.65	0.87	6.20
	Ghatail	451.30	818.86	750.50	59.69	8.67	0	487	3,019.28	239	2,390.72	184	1.81	1.08	6.20
	Gopalpur	193.37	461.42	374.47	85.69	1.26	0	390	3,055.30	99	1,103.00	199	2.39	2.02	7.83
	Kalihati	301.22	639.30	534.89	90.83	13.61	0	241	2,631.11	202	4,302.50	174	2.12	0.80	10.92
	Madhupur	500.67	800.10	642.72	130.84	26.56	0	547	2,929.40	7	165.00	159	1.60	1.09	5.36
	Mirzapur	373.89	892.75	834.26	51.00	7.14	0.35	160	1,113.01	59	1,051.22	302	2.39	0.43	6.96
	Nagarpur	262.70	662.49	615.23	45.57	0.75	0.95	184	1,714.28	315	6,783.51	186	2.52	0.70	9.32
	Sakhipur	429.63	633.24	568.76	58.62	5.87	0	409	927.27	142	467.54	115	1.47	0.95	2.27
	Tangail Sadar	334.26	345.43	259.30	84.85	1.29	0	293	2,919.90	130	3,451.00	87	1.03	0.88	9.97
	Delduar	184.54	282.40	240.94	41.12	0.35	0	202	1,594.93	66	1,639.00	81	1.53	1.09	7.90
	Total	3,414.38	6,268.52	5,476.18	716.22	73.83	1.6	3,299	23,102.70	1,512	25,113.59	1,840	1.84	0.97	7.00
			100.0%	87.4%	11.4%	1.2%									
Study Area Total		16,477.49	29,292.57	25,279.91	3,360.57	592.35	59.18	23,990	102,034.38	10,912	97,432.01	8,449	1.78	5.60	32.41
			100.0%	86.3%	11.5%	2.0%	0.2%								

ANNEX 2

NATURAL CONDITIONS AND WATER RESOURCES

ANNEX 2: NATURAL CONDITIONS AND WATER RESOURCES

TABLE OF CONTENTS

A 2 NATURAL CONDITIONS AND WATER RESOURCES

2.1 Physiography

2.1.1 Physiography in Bangladesh

Physiography of Bangladesh is shown in Fig. 2.1.1. In total, there are 31 physiographical classes including urban, water and unclassified class. Table 2.1.1 presents the percent (%) of area lying in each physiographic class along with their distribution in each of the six district of the Study area which was extracted from the NWRD of WARPO GIS database. In Bangladesh, the highest area (13.14%) is covered by the Northern and Eastern Hills. The Ganges Tidal Floodplain (10.95%) and the High Ganges River Floodplain (9.52%) constitutes a large portion of the area. In the Study area, which is about 11.3% of the country area, the Old Brahmaputra Floodplain (4.46%) and the Young Brahmaputra and Jamuna Floodplain (2.87%) constitutes more than half of the Study area. Madhupur Tract lying inside the Study area (1.35%) constitutes almost half of the total Madhupur tract area (3.02%) in the country.

2.1.2 Physiography in the Study Area

The Study Area is surrounded the Mrgaraya Mountaints at north, the Dhaleshwari rivers at east, the Meghna river at south, and the Jamuna River at west. The old Brahmaputra River pass through the center of the Study Area from the north-western boundary to the center of south boundary.

The northern boundary area is formed as the alluvial fan with the elevation 40 to 25 m a.s.l., the eastern boundary area is depression area, which is called haor with an elevation of 3 to 7 m a.s.l., central part of the area is the Brahmaputra floodplain with an elevation of 5 to 20 m a.s.l., and the western area is a part of Jamuna floodplain including charland. Between the old Brahmaputra and Jamuna floodplain, the Madhupur Tract, clayey river terrace, uplift on the plain with the elevation of more than 20 m a.s.l.

Geological classification of the Study Area is shown below:

Name of District	Area of Geological Unit (km^2)								Total
	Alluvium sand	Alluvium silt	Alluvium silt and clay	Chandina alluvium	Dihing & Dupi Tila undivided	Madhupur clay residuum	Marsh clay and peat	Young gravelly sand	
Jamalpur	63.09	1,768.68	194.71	27.55	-	-	4.84	12.76	2,064.63
Kishoreganj	-	380.01	676.30	8.23	-	-	1,446.07	-	2,510.60
Mymensingh	-	1,083.55	637.36	1,034.94	11.40	528.72	582.50	392.97	4,271.44
Netrokona	-	171.50	980.08	-	-	-	1,399.38	314.80	2,865.76
Sherpur	-	382.28	148.37	16.30	-	-	279.25	490.68	1,316.87
Tangail	32.28	976.15	1,159.48	11.56	-	1,002.22	265.32	-	3,447.01
Total Area	95.36	4,755.16	3,796.29	1,098.59	11.40	1,530.93	3,977.36	1,211.21	16,476.31
Share	0.6%	28.9%	23.0%	6.7%	0.1%	9.3%	24.1%	7.4%	100.0%

Source: DFID Study

2.2 Climate

2.2.1 Climate of Bangladesh

Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, moderately warm temperatures, and high humidity. Regional climatic differences in this flat country are minor. In general, maximum summer temperatures range between 32 ^{o}C and 38 ^{o}C and April is the warmest month in most parts of the country. January is the coldest month, when the average temperature for most of the country is about 10 ^{o}C. Winds are mostly from the north and northwest in the winter, blowing gently at 1 to 3 km/hr in the northern and central areas and 3 to 6 km/hr near the coast. From March to May, violent thunderstorms, called northwesters by local English speakers, produce winds of up to 60 km/hr. During the intense storms of the early summer and late monsoon

season, southerly winds of more than 160 km/hr cause waves to crest as high as 6 m in the Bay of Bengal, which brings disastrous flooding to coastal areas.

Climate plays a main role in determining temporal distributions of rainfall, evapotranspiration, surface and ground waters. In Bangladesh, the water year is defined as beginning on April 1 and ending on March 31 and is divided into four distinct seasons:

- Pre-monsoon season: April to May when the change of wind direction is from northeast to southwest via northwest.
- Monsoon/wet/rainy season: June through September when the southwest wind originating over the Indian Ocean brings warm moist air that produces some of the highest rainfalls of the world over Bangladesh and at the upstream catchments of the major rivers, particularly in the Indian states of Meghalaya and Assam. Upto 85% of the annual total rainfall occurs during the monsoon period. The timing of the beginning of the monsoon rains and the extent and duration of the rains are critical factors in agricultural production, particularly with respect to the grain or rice production. A delay of 7 to 10 days in the arrival of the monsoons can have an adverse dramatic impact on the total grain harvest.
- Post-monsoon season: October and November when the change of wind direction is from southwest to northeast via southeast.
- Dry season: December through March when the northeast wind brings dry air from China.

Mean annual rainfall ranges from about 1,200 mm in the west to almost 6,000 mm in the northeast. The average annual rainfall in the Himalayas and in the Meghalaya hills to the north of Bangladesh reaches about 10,000 mm.

Average annual rainfall of the country is about 2,360 mm (1960-1997 data). The rainfall over the whole country considering two seasons (wet from May to October and dry from November to April) is shown as follows:

Rainfall by Hydrological Regions (1960-1997) Unit: mm

Season	Hydrological Region							Average
	NW	NC	NE	SW	SC	SE	EH	
Wet	1,393	1,445	2,297	1,299	1,821	1,683	1,934	1,856
Dry	346	511	897	366	486	588	511	504
Annual	1,739	1,956	3,194	1,665	2,307	2,271	2,445	2,360

The table indicates that northwest and southwest regions receive less rainfall compared to other regions. Also, almost 80% of annual total rainfall occurs during the wet season.

In Bangladesh, temperature is the highest in April/May. It decreases slightly in the monsoon period and rises again in September/October when the rain begins to diminish. Temperature starts lowering down from November. It is the lowest in January and rises up from February onwards. Within this generalized situation, there are local variations which have pronounced influence on crop production.

In 1975, Bangladesh Rice Research Institute and International Rice Research Institute (IRRI) made a study on Agro-Climatic Survey of Bangladesh. The study considered those climatic determinations which might prohibit, limit or facilitate crop production. Rainfall (main) and temperature were the two factors considered. The study defined a wet month as one having a rainfall of 200 mm or more. The study prepared a map termed as Climatic Map of Bangladesh as shown in Fig. 2.2.1. In order to emphasize that there is at least one month with more than 500 mm of rain, certain areas of the map were dotted. Type 3.3 (dry for 5-6 months and wet for 5-6 months) covers the largest part of the country including the Study Area.

2.2.2 Climate in the Study Area

As shown in Table 2.2.1, there is only one BMD meteorological station at Mymensingh in the Study Area. The monthly average data are summarized in table shown below:

General Climate Data at BMD Mymensingh Station (ID 10609)

Month	Total Rainfall (mm)	Total Evaporation (mm)	Temperature (°C)			Average Relative Humidity (%)
			Maximum	Mean	Minimum	
Jan	8	69	25	18	12	73
Feb	20	88	27	21	15	68
Mar	41	140	31	25	19	67
Apr	144	157	32	27	22	74
May	347	151	31	27	23	80
Jun	390	129	31	29	26	85
Jul	472	124	31	29	26	86
Aug	343	128	32	29	26	85
Sep	362	117	31	28	25	86
Oct	208	112	31	27	23	81
Nov	22	85	30	24	18	76
Dec	10	71	26	20	13	76
Annual	2,365	1,382	30	25	21	78
Period	1970 - 2003	1987 - 2002	1970 - 2002	1970 - 2002	1970 - 2002	1969 - 2001

Source: BMD daily data supplied by RDEC-JICA

- Annual total rainfall is 2,365 mm with maximum and minimum rainfalls occurring in the months of July (472 mm) and January (8 mm) respectively.
- Annual total evaporation is 1,382 mm with maximum and minimum evaporations occurring in the months of April (157 mm) and January (69 mm) respectively.
- Annual average temperature is 25°C with maximum and minimum temperatures occurring in the months of April (32°C) and January (12°C) respectively.
- Annual average relative humidity is 78% with maximum and minimum relative humidity occurring in the months of March (67%) and September (86%) respectively

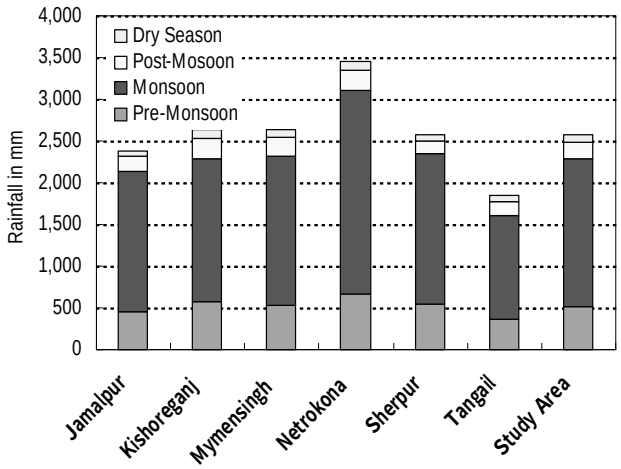
2.2.3 Rainfall in the Study Area

Location of rainfall stations and their annual mean rainfall are plotted in Fig. 2.2.2. The annual total rainfall, pre-monsoon rainfall, monsoon rainfall, post-monsoon rainfall and dry season rainfall in the Study Area are summarized in Table 2.2.2 which presents rainfall by month and by season of all the rainfall stations in the Study area. Maximum and minimum monthly total rainfalls are observed in July and January respectively. Among the stations, maximum and minimum annual total rainfalls are observed at Khaliajurii in Netrokona district (3,902 mm) and Kalihati in Tangail district (1,621 mm) respectively. In terms of seasonal variation among the rainfall stations, the findings are:

- Pre-Monsoon: Maximum of 830 mm at Khaliajuri in Netrokona and minimum of 312 mm at Gopalpur in Tangail district.
- Monsoon: Maximum of 2,679 mm at Khaliajuri in Netrokona and minimum of 1,079 mm at Kalihati in Tangail district.
- Post Monsoon: Maximum of 274 mm at Bhaluka in Mymensingh and minimum of 144 mm at Kalihati in Tangail district.
- Dry Season: Maximum of 142 mm at Mohanganj in Netrokona and minimum of 45 mm at Sharishabari in Jamalpur district.

Table 2.2.3 presents historical annual total rainfall by station in the Study area. During the period from 1981 to 2002, maximum and minimum annual total rainfalls were observed in 1991 at Kendua in Netrokona district (5,949 mm) and in 1984 at Kalihati in Tangail district (803 mm) respectively.

Seasonal variation of rainfall by district. Maximum and minimum annual total

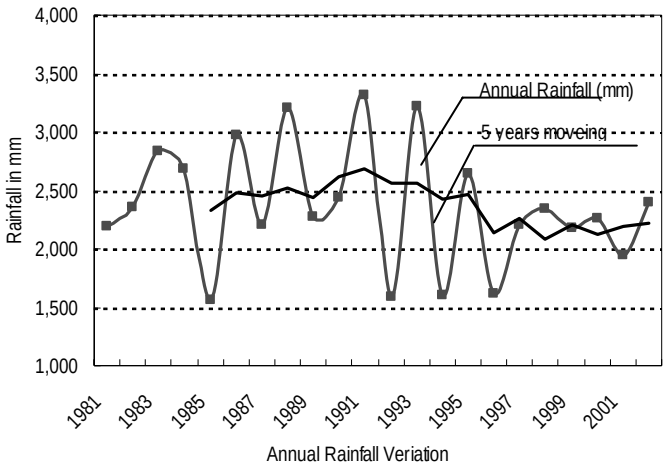


Seasonal Distribution of Average Rainfall by

rainfalls of 3,417 mm and 1,851 mm are observed in Netrokona and Tangail districts respectively. In terms of seasonal variation among the districts, the findings are:

- Pre-Monsoon: Maximum 668 mm in Netrokona and minimum 363 mm in Tangail district and 517 mm in the Study area.
- Monsoon: Maximum 2,439 mm in Netrokona and minimum 1,247 mm in Tangail district and 1,767 mm in the Study area.
- Post Monsoon: Maximum 247 mm in Netrokona and minimum 163 mm in Sherpur district and 207 mm in the Study area.
- Dry Season: Maximum 119 mm in Kishoreganj and minimum 64 mm in Jamalpur district and 90 mm in the Study area.

The figure shows historical variation in annual total rainfall at BMD Mymensingh station. The highest and lowest rainfalls were observed in 1991 (3,312 mm) and 1976 (1,541 mm) respectively. A 5-point moving average trend line indicates that during the mid-1980s to mid-1990s, there was an increasing tendency in annual rainfall whereas in the last decade, the annual rainfall has a decreasing tendency.



2.3 Water Resources and Flood

2.3.1 River System and Hydrological Regions in Bangladesh

(1) River System

Bangladesh is the biggest delta in the world, formed by 3 mighty rivers: the Ganges (catchment 907,000 km^2), the Brahmaputra (catchment 583,000 km^2) and the Meghna (64,000 km^2). Of the total area of the 3 catchments (1.55 million km^2), only 8% is in Bangladesh, 62% in India, 18% in China, 8% in Nepal and 4% in Bhutan.

The rivers of Bangladesh mark both the physiography of the nation and the life of the people. About 700 in number, these rivers generally flow towards south. The larger rivers serve as the main source of water for cultivation and as the principal arteries of commercial transportation. Rivers also provide fish, an important source of protein. Flooding of the rivers during the monsoon season causes enormous hardship and hinders development, but fresh deposits of rich silt replenish the fertile but overworked soil. The rivers also drain excess monsoon rainfall into the Bay of Bengal. Thus, the great river system is at the same time the country's principal resource and its greatest hazard.

(2) Hydrological Regions

Previously, Master Plan Organization (MPO) defined five hydrological regions which were: Northwest, Northeast, Southeast, South Central and Southwest, plus the Active Floodplain. Also, Flood Action Plan (FAP) defined five hydrological regions which were: Northwest, Northeast, North Central, Southeast, and Southwest, plus Charlands. The boundaries of MPO exactly covered the entire country but the boundaries of FAP didn't cover the entire area of the country, and overlapped in two areas. Even where MPO and FAP regions had a common name, the boundaries were not the same.

In accordance with National Water Policy (NWP), WARPO has delineated eight hydrological regions covering the entire country, based on appropriate natural features for planning the development of water resources. Fig. 2.2.3 shows the WARPO defined hydrological regions which are: Northwest (NW), North Central (NC), Northeast (NE), Southeast (SE), South Central (SC), Southwest (SW), Eastern Hills (EH), plus the active floodplains and charlands of the Main Rivers and Estuaries (RE).

Within each hydrological region there are significant sub-regions, defined by parameters such as agro-climatic zone, landform, river salinity and degree of urbanization.

The hydrological regions as defined above are inappropriate for presentation and analyses of many types of non-water data because the RE region comprises the major rivers, charlands and land within the active flood plain. A set of seven Extended Hydrological Regions (EHRs) have therefore been defined in which the RE region has been absorbed into the other regions. The boundaries of the EHRs have also been adjusted to follow, where possible, district or thana boundaries in order to facilitate analysis and presentation of data based on administrative units.

The Study Area falls within the NC and NE hydrological regions bordered by the Old Brahmaputra River.

2.3.2 River System and Hydrological Regions in the Study Area

(1) River System in the Study Area

In the Study Area, there are around 250 rivers including the major river of Jamuna, the old Brahmaputra. River length in each district is summarized as follows:

River Length and Area in the Study Area

District Name	River Length by Width Range (Unit: km)					River Polygon Area (>>100m) (ha)
	Below 25m	25m - 50m	50m - 100m	Above 100m	Sub-Total	
Jamalpur	315.40	91.55	290.14	-	697.09	9,761
Kishoreganj	463.38	310.09	89.20	0.06	862.72	11,355
Mymensingh	642.73	851.14	268.52	12.77	1,775.15	3,548
Netrokona	771.21	835.61	170.69	1.14	1,778.65	2,300
Sherpur	179.87	220.11	83.85	-	483.82	594
Tangail	488.24	317.50	326.71	-	1,132.46	10,751
Total	2,860.82	2,626.00	1,229.12	13.97	6,729.90	38,309

Source: NWRDB (WARPO)

(2) Hydrological Analyses

The annual average water levels at BWDB non-tidal water level stations on rivers flowing through the Study area is shown in Fig. 2.3.1. The data are summarized in Tables 2.3.1. The tables indicates that water levels are high during the months of July-September and low during the months of March-May. During the period 1981-2002, maximum water levels were observed in 1988 and then in 1998 whereas no specific year(s) could be identified in terms of lowest water levels.

There are 7 non-tidal and 3 tidal stations along the old Brahmaputra river which are:

- Non-tidal stations: 223, 225, 224, 226, 227, 228 and 228.5
- Tidal stations: 229, 230 and 230.1

Out of the 6 non-tidal stations, data have been collected at 4 stations which are: 223 at Goal Kanda, 225 at Jamalpur, 227 at Offtake of Sutia and 228.5 at Mymensingh. The findings are:

- Historical annual maximum water levels: 23.64, 17.81, 14.88 and 13.70 m in year 1998 at stations 223, 225, 227 and 228.5 respectively.
- Historical annual minimum water levels: 17.44, 10.97, 6.56 and 6.02 mm in years 2000, 2001, 1999 and 2001 at stations 223, 225, 227 and 228.5 respectively.
- Difference between historical annual maximum and minimum water levels: 6.20, 6.84, 8.32 and 7.68 m at stations 223, 225, 227 and 228.5 respectively.

2.3.3 Water Resources

(1) Bangladesh Water Resources Estimation in Bangladesh

The natural surface water resources in Bangladesh are mainly obtainable from the country's dense network of river system, which include a combination of upstream inflows and runoff generated from rainfall within the country. Almost 70% of these surface water resources concentrate in the monsoon season. Preliminary estimates at the inception phase of the NWMP indicated as follows:

- Cross-border flows: 1,010 BCM[1)]
- Generated from local rainfall (2,300 mm): 340 BCM
- Evaporation losses 190 BCM
- Available for use or flows into the sea 1,160 BCM

MPO estimated and suggested that the available recharge of groundwater was 21 BCM in 1991. After the estimate, several studies and analysis were conducted[1)]. They acknowledge that more information on groundwater is required to make reliable assessment. Some of the area already observed the declination of groundwater table caused by excess extraction for irrigation, domestic and industrial water supply. Particular attention also needs to be given to the issue of arsenic contamination of groundwater.

(2) Water Use

MPO projected a water demand for all purposes for the year 2018 at 24.37 BCM during the critical dry month of March. On the other hand, the FAOSTAT 2000 estimated the water use at 79.4 BCM in 2000, of which the irrigation water covering 3.7 million ha consumes 96.16 % followed by domestic water use at 3.19 % and industrial water use at 0.65 %.

(3) Surface Water Resources in the Study Area

Besides rivers and khals, another component of surface water resources is the perennial water bodies which is shown in Fig.3.2.5 and is summarized in the right side table:

Perennial Water Bodies in the Study Area

District		Perennial Water Body		
Name	Area (ha)	Number (nos.)	Area (ha)	(%)
Jamalpur	206,463	285	2,182	1.1
Kishoreganj	251,060	560	4,599	1.8
Mymensingh	427,144	635	4,943	1.2
Netrokona	286,576	813	5,380	1.9
Sherpur	131,687	159	2,415	1.8
Tangail	344,701	378	2,402	0.7
Total	1,647,631	2,830	21,921	1.3

Source: National Water Resources Database (WARPO)

Note: Actual number of water bodies in the Study Area is 2,802. However, due to sharing same water bodies by adjacent districts, total number of water bodies as shown in the above table is more than 2,802.

According to NWRD of WARPO, there are in total 2,802 perennial water bodies with 547 beels (with duplicate names in the NWRD) and the rest 2,255 are unnamed (ponds etc.) water bodies. The total area of perennial water bodies is 21,921 ha, which is 8.5% of the Study area. In terms of number, Netrokona and Sherpur districts have the highest (813) and lowest (159) numbers of perennial water bodies. In terms of area, Netrokona and Tangail districts have the highest (5,380 ha) and lowest (2,402 ha) areas of perennial water bodies comprising 1.9% and 0.7% of the Study area respectively. The overall inland surface water quality is said to be within tolerable limits, but in general, detailed data is yet to be collected.

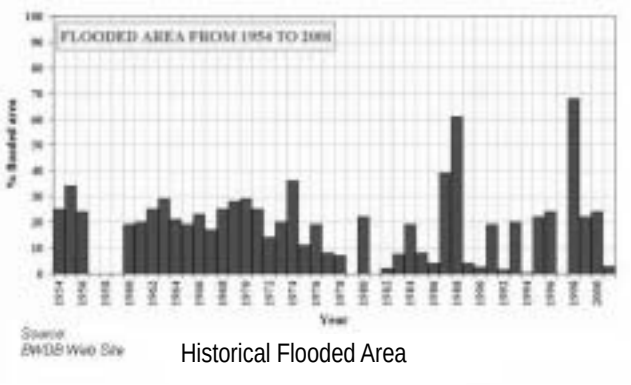
[1)] BCM: billion cubic meters

[1)] 19.6 BCM by BWDB/UNDP (1982), 36.6 BCM by BWDB/FAO (1983), 14.8 BCM by M.A. Karim (1984) and 25.7 BCM by MPO (1987)

2.3.4 Floods

(1) Floods in Bangladesh

The floods of the years 1954, 1955, 1974, 1987, 1988, 1998 and 2004 were catastrophic. Peak discharges in 1988 were of the order of 98,600 m^3/s in the Bhramaputra, 19,800 m^3/s in the upper Meghna and around 160,000 m^3/s in the lower Meghna. The historical flooded area (1954-2001) is shown in the figure.



Historical Flooded Area

According to the "Interim Report (August 14, 2004) of Rapid Assessment of Flood 2004" by the Centre for Policy Dialogue (CPD) under the program of Independent Review of Bangladesh's Development (IRBD), flood 2004 covered an area of about 20.72 % of Bangladesh's total land area till August 4, 2004 which is about a-third of flood 1998 inundated area of 67.76 % of Bangladesh total land area.

60% of the area of Bangladesh is at an elevation of less than 6 m above MSL. The average river gradient in the delta is only about 6 cm /km or 1/16,667. On an average, 20% of Bangladesh is flooded during the monsoon season. About 2/3rd of the agricultural land is classified as vulnerable to flooding. A considerable portion of the agricultural land is flooded to depths exceeding 90 cm (3 feet) in an average year.

Floods in Bangladesh are highly complex process. A key factor of flood in Bangladesh is that each flood is different. Numerous factors causing flood are listed in literature such as:

General	• Widespread heavy rainfall
	• High river discharge combined with heavy rainfall
	• Earthquakes and sediment transport
	• Greenhouse effect and sea-level rise
Inside Bangladesh	• Flat, low-lying topography
	• Geological depressions
	• Local heavy rainfall
	• High river discharge and over spilling of the rivers
	• Synchronization of high discharge peaks of the 3 major rivers
	• Backwater effects of the principal rivers at their confluences
	• Soil saturation
	• Siltation of river beds
	• Changing of river courses
	• Poorly planned embankments and flood control measures
	• Breaches of embankments
	• Water logging
	• Lack of planning for development works
	• Disappearance of wetlands (beels and swamps)
	• Rising sea level during monsoon
	• High tide
	• Cyclone and tidal bores
Outside Bangladesh	• Heavy rainfall in the upper catchments
	• Snowmelt
	• Immense extraterritorial inflows
	• Deforestation
	• Embankments and barrage in India

Fig. 2.3.2 shows areas by different types of flooding. The four major types of flooding are:

- River or monsoon flood of major rivers: The major rivers generally rise slowly and the period of rise and fall may extend over 10 to 20 days or more. Most extensive damages are caused by monsoon floods of the major rivers, particularly when the 3 major rivers rise simultaneously.

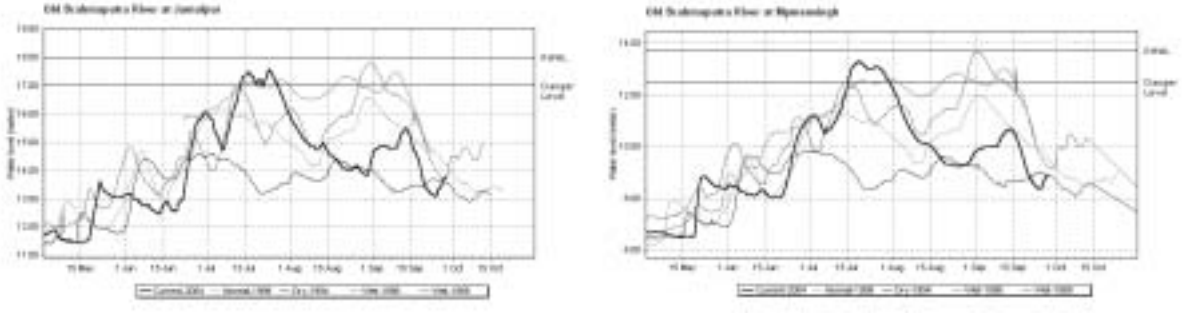
- Flash flood in the eastern and northern rivers: Flash flood is characterized by a sharp rise followed by a comparatively rapid recession. Duration of high flood stage may be a few days only. Rapid in river stage and associated flow velocity cause intensive damage to crops and properties.
- Tidal flood: The coastal area of Bangladesh consists of large estuaries and extensive tidal flood plains with elevations below high tide level in most places. Storm surges generated during tropical cyclones cause extensive damages to life and properties in the coastal areas.
- Rainfed local flood: During the monsoon, cyclonic storm due to passage of depression from the sea to land areas or due to land depression may cause heavy rainfall almost anywhere in Bangladesh. Such storms of 3 to 10 days duration may cause rainfall much excess of local drainage capacity and cause localized floods.

The floods usually start with flash floods in the northern and eastern hilly streams during pre-monsoon months of April and May followed by the onset of monsoon in June. The Meghna and the Jamuna normally reach their flood peaks in July and August and the Ganges in August and September. Severe flooding occurs when both the Jamuna and the Ganges are in flood stage concurrently.

(2) Floods in the Study Area

1) Hydrograph of previous Floods in the Study Area

Hydrograph of the several floods in the Study Area at Mymensingh and Jamalpur gauging stations along the old Bhramaputra river are shown as follows:



These hydrographs show the Flood in 1988 the most severe flood as the peak water level, but the flood in 1998 had the longest inundation period, which caused the serious damage to the aman rice cultivation. Also the flood in 2004 during the Phase 1 survey of the Study, is the 2nd largest flood on its peak water level

2) Inundation Land Types Classification

Inundation land classification prepared by BARC/UNDP/FAO in 1995, and the classified area in the Study Area is summarized as follows:

Inundation Land Type				Area of Inundation Land Type (km^2)						Total	
Code	Description	Flood Depth (m)	Suitablity to Rice Cultivation	Jamalpur	Kishoreganj	Mymensingh	Netrokona	Sherpur	Tangail	Area (km^2)	%
F0	High Land	0.00-0.30	HYV rice in wet season	229.87	5.66	983.78	450.45	401.73	1,051.78	3,123.28	19
F1	Medium High Land	0.30-0.90	Local varieties of Aus and T. Aman	1,674.16	713.20	3,186.28	1,576.27	828.20	2,047.44	10,025.56	61
F2	Medium Low Land	0.90-1.80	B. Aman in wet season	-	227.40	-	-	-	215.31	442.72	3
F3	Low Land	1.80-3.00	B. Aman can be grown	-	1,434.75	51.16	816.63	80.52	-	2,383.05	14
F4	Very Low Land	>3.00	B. Aman can't be grown	-	-	-	-	-	-	-	-
No Data	-	-	-	160.60	129.58	50.22	22.41	6.42	132.47	501.69	3
Total Area				2,064.63	2,510.60	4,271.44	2,865.76	1,316.87	3,447.01	16,476.31	100

Source: National Water Resources Database (WARPO)

2.3.5 Droughts

Agricultural drought is a common phenomenon in areas, particularly in the north-western regions of Bangladesh where water supply for irrigation in post monsoon and dry season falls short. Fig. 2.3.4 shows areas affected by drought. The main causes of drought are limited rainfall, high temperature associated with low humidity and withdrawal of water in the upstream. Droughts affect water supplies and plant growth leading to loss of production, food shortages and starvation. In comparison with floods and especially cyclones, droughts are slow to manifest themselves and are relatively more pervasive. Depending on the intensity of drought, estimated yield reduction of different crops varies from 10 percent to 70 percent. A severe drought typically affects crop production in about 30 percent of the country, reducing yields by an average 10 %. Drought normally affects kharif crops (e.g., *aus* and *aman*), but sometimes *rabi* crops (e.g., wheat and mustard), as happened in the very severe drought of 1978-80. This event directly affected about 42 % of the cultivated land and some 44 % of the population. Persistent drought is relatively rare, but has the potential to cause famine. Irrigation can help to reduce drought effects, but HYV varieties tend to be more drought-prone than indigenous species.

2.3.6 Groundwater

(1) Groundwater in Bangladesh

Groundwater is abundant in Bangladesh and the aquifers are highly productive. The sediments are predominantly non-inundated and easy to drill by hand, at least to shallow levels. Water tables vary across the country but are typically shallow at around 1-10 m below the ground surface. These factors have made groundwater an attractive and easily accessible resource and have led to a rapid proliferation in the use of groundwater over the last few decades. Today, 97% of the population relies on groundwater for potable supplies and groundwater is also an important source for irrigation and industry. Groundwater levels across Bangladesh become depressed during the dry season, but the aquifers replenish during the monsoon.

BADC initiated development of groundwater in the 1960s to enable seasonal irrigation of cereals. Study of the hydrogeology and groundwater resources of Bangladesh was begun in the 1970s by BWDB under the guidance of UNDP. UNICEF, recognizing that large quantities of groundwater existed at shallow depth, advocated the installation of large numbers of hand-drilled boreholes equipped with suction pumps. Some 6-11 millions hand-pumped tubewells are estimated to have been installed to date. At present, the extensive abstraction of groundwater for irrigation and domestic water supply is being questioned because of its extensive contamination with arsenic.

Groundwater abstraction takes place from a large number of hand-pump tubewells (HTWs) for domestic supply, shallow and deep tubewells (STWs and DTWs) for irrigation and public water supply (PWS), boreholes for domestic supply in cities and district towns. There are also an increasing number of hand-pump deep tubewells (HDTWs). ‘Deep’ here refers to the depth of the screened interval – the water table is invariably shallow which means that a simple suction hand pump can still be used even for these deep wells.

Considerable uncertainty surrounds the exact number of the various types of wells present in Bangladesh, but estimates are: HTW of 6-11 millions, STW of 0.5 million and DTW of 55,000. Data shows that high-density usage of STWs and DTWs could lower water levels in various parts of Bangladesh sufficiently to affect operation of HTWs during late dry season. Tara pumps are being installed in such areas where late dry-season water levels lie at 6m or more below ground level.

(2) Groundwater Resources in the Study Area

Fig. 2.3.5 shows maximum depth to groundwater in the Study Area. In summary, water-level fluctuations at a particular site reflect the aquifer, its proximity to major rivers and abstraction rates. In general, groundwater gradients over the country are low, typically between 1.0 m/km (1:1,000) in the north to as low as 0.01 m/km (1:100,000) in the south.

(3) Arsenic Contamination in Bangladesh

Arsenic contamination of groundwater was first detected in Bangladesh in 1993 by the DPHE in Chapai Nawabganj in the far west of Bangladesh in a region adjacent to an area of West Bengal which had been found to be extensively contaminated in 1988. Extensive contamination in Bangladesh was confirmed in 1995 when additional surveys showed contamination of shallow tubewells across much of southern and central Bangladesh. At the same time, cases of chronic arsenicosis were being recognized by health professionals. Since 1995, data pointing to the extensive contamination of Bangladesh groundwater have been collected by a large number of organizations. Fig. 2.3.6 shows the arsenic contamination area in Bangladesh analyzed by the DFID assisted study.

It is now generally agreed that the arsenic contamination of groundwater in Bangladesh is of natural origin, deriving from the geological strata underlying Bangladesh. The groundwater arsenic problem in Bangladesh arises because of an unfortunate combination of three factors:

- A source of arsenic (arsenic is present in the aquifer sediments),
- Mobilization (arsenic is released from the sediments to the groundwater) and
- Transport (arsenic is flushed away in the natural groundwater circulation).

The Bangladesh Standard for arsenic in drinking water is 0.05 mg/l (or 50 µg/l or 0.05 ppm or 50 ppb). This standard was based on World Health Organization (WHO) advice at the time when the regulations were drafted. In 1993, WHO lowered their guideline value for arsenic to 0.01 mg/l (or 10 µg/l or 0.01 ppm or 10 ppb). This value has not been adopted in either Bangladesh or India.

(4) Arsenic Contamination in the Study Area

Fig. 2.3.7 shows the result of arsenic contamination in the Study Area based on BGS-DPHE National Hydrochemical Survey assisted by U.K. Department for International Development (DFID). A total of 2039 sites were sampled in 1998 Phase I survey, and 1495 in the 1999 Phase II survey, 3534 sites in total. Out of that, 496 samples fall within the Study area. The findings are:

- There is no upazila with >80% arsenic contaminated tubewells.
- 3 upazilas have 60-80% arsenic contaminated tubewells.
- 4 upazilas have 40-60% arsenic contaminated tubewells.
- 9 upazilas have 20-40% arsenic contaminated tubewells.
- 22 upazilas have 5-20% arsenic contaminated tubewells.
- The rest 20 upazilas have almost no arsenic contaminated tubewell.
- West part of the Study area has high arsenic contamination whereas east part of the Study area has low arsenic contamination.
- Among the six districts, Kishoreganj has the most severe arsenic contamination.

Fig. 2.3.8 shows the types of wells surveyed in DFID Study. Out of the 496 wells in the Study area, 326 were STW, 151 were Tara wells, 14 were DTW and the rest 5 were other types.

Fig. 2.3.9 shows the depth distribution of wells surveyed in the DFID Study. The depth distributions of the wells were as follows:

- < 20 m: 53 tube wells
- 20 – 35 m: 106 tube wells
- 35 – 70 m: 207 tube wells
- 70 – 100 m: 109 tube wells
- 100 – 150 m: 19 tube wells and
- > 100 m: 2 tube wells

2.4 Water Resources Development

2.4.1 Historical Background of Water Resources Development

The most important study/reports/documents/activity which have guided the government policy on the water resources sector are as follows:

Sr.	Name of Study/Project	Contents
1	Water and Power Development in East Pakistan Report of United Nations Technical Assistance Mission, 1957 (Krug Mission Report)	The report was a product of a study on flood control and water management in East Pakistan after the disastrous floods of 1954, 1955 and 1956 that drew world attention. The most significant recommendation of the report was to create a new government corporation with comprehensive responsibilities and authorities to deal with all water and power development problems. Following the recommendation, East Pakistan Water and Power Development Authority (EPWAPDA) was created in 1959
2	East Pakistan Water and Power Development Authority Master Plan with the assistance of the International Engineering Company of USA (IECO), 1964	The Master Plan was designed to meet the agricultural demand of water through large-scale public sector development and water management in both dry season (irrigation) and wet season (flooding). The Master Plan identified 63 water development projects and grouped them according to geographic locations. Major outcomes of the plan were the initiation of the process of national level water sector planning and the eventual implementation of large-scale Flood Control Drainage (FCD) and Flood Control, Drainage & Irrigation (FCDI) projects including the protection of most coastal zones against tidal flooding.
3	Review of EPWAPDA 1964 Master Plan, International Bank for Reconstruction and Development (IBRD) 1966	Even though, the report indicated that the EPWAPDA 1964 Master Plan was based on insufficient data and was over ambitious, the report agreed with the general principles of regarding the importance of flood control, drainage and irrigation. The report, however, expressed reservations on the suggested strategy and specific proposals of the plan. The IBRD review of 1964 Master Plan played an important role in taking decision by many donor agencies for not to finance large, complex and long gestation schemes.
4	Joint Govt. of Bangladesh-World Bank Mission, 1970	The mission recommended that a new Master Plan (National Water Plan – NWP) was needed for assessment of availability and demands of each sector of water use.
5	Land and Water Resources Sector Study, Bangladesh IBRD, 1972	The Study emphasized the need for quick results from water development efforts to achieve food grain self-sufficiency. It attached high priority to small and medium sized, simple, low cost, labor intensive projects. Such schemes would involve low embankments and gravity drainage. It also proposed low lift pump irrigation and tubewell irrigation. The government, however, did not accept the study as a whole but its water development strategy was greatly influenced by its findings and recommendations.
6	Formation of the National Water Council and Master Plan Organization (MPO), 1983	NWC was constituted in February 1983 to guide and oversee the national water resources planning activities. The MPO was created at the same time and entrusted with the task of preparation of the NWP.
7	National Water Plan Phase-I MPO, 1986	In its first phase, the NWP identified 15 modes of development for the water sector with analysis in four major categories such as: (i) FCD (flood control, and gravity drainage); (ii) irrigation (major and minor irrigation); (iii) FCDI (flood control, drainage and irrigation); and (iv) additional modes. The investment priorities set by NWP included: (a) minor irrigation schemes such as low lift pump (LLP), shallow tubewells (STWs); (b) major irrigation schemes (FCDI); (c) deep tubewells (DTW); and (d) flood control and drainage scheme (FCD).
8	National Water Plan Phase-II MPO, 1991	It was updated NWP-I with a detailed investment program and a list of projects. The 20-year (1991-2010) public investment program gave more emphasis to FCD. Although the government did not formally either accept or reject the NWP reports, the NWP had in its two phases: (a) made important contributions to the knowledge; and (b) understanding of the water resources of Bangladesh. The NWP data provided the basis for subsequent water sector planning.

9	The Flood Action Plan FPCO, 1989-95	After the disastrous floods of 1987 and 1988, the attention of the government of Bangladesh, as well as its development partners (16 donor countries) was once again focused to floods in the country, especially in its urban areas. The Flood Plan Co-ordination Organization (FPCO) was created in 1989 and it undertook 11 main and 15 supporting studies (26 in total) including 2 pilot projects on FCD and river bank protection under a common umbrella known as the Flood Action Plan (FAP). Noteworthy among the features of FAP were: (a) the attention to urban FCD and non-structural flood proofing, though agriculture remained the main focus of regional plans; and (b) emphasis on social and environmental impact, effect on fisheries, and people's participation in flood control and water management.
10	Formation of Water Resources Planning Organization (WARPO) 1992	In June 1992, MPO was renamed as WARPO. The National Water Policy (NWP), published in January 1999, establishes a clear role for WARPO as an apex planning body in the water sector. WARPO will also act as a secretariat to the Executive Committee to the National Water Resources Council who oversees all water resources management activities in the country.
11	The Bangladesh Water and Flood Management Strategy, FPCO, 1995	The BWFMS report was a follow-up to FAP and became the working policy document for the water sector that presented a framework for the development and implementation of specific programs in water sector. It was approved by the government in 1995. It recommended a 5-year program involving: (a) preparation of a National Water Policy; (b) preparation of a National Water Management Plan; (c) strengthening of water sector organizations responsible for planning, construction, operation and maintenance; and (d) implementation of a portfolio of high priority projects.
12	Preparation of National Water Management Plan (NWMP) and a National Water Resources Database (NWRD) WARPO	organization. But after the adoption of the Water and Flood Management Strategy, the government decided to abolish FPCO and merge it with WARPO in January 1996 giving it a new lease of life and the responsibility of preparing a new NWMP and a NWRD. WARPO embarked on the preparation of the NWMP in March 1998 and completed the draft NWMP in March 2001. Finally, the Bangladesh Government on 31 Mar 2004 approved the 25-year NWMP which will be centrally monitored by WARPO. From 1990 to 1995 when FAP studies were being undertaken, WARPO remained a more or less dorman

2.4.2 National Water Policy (NWPo)

The National Water Management Plan (NWMP) has been approved by the National Water Resources Council (NWRC) headed by the Prime Minister of the People's Republic of Bangladesh on March 31, 2004. Final Report of the NWMP is not still available on the WARPO website. The extracts of this report are based on December 2001 publication by WARPO under Ministry of Water Resources.

In order to ensure continued progress towards fulfilling the national goals of economic development, poverty alleviation, food security, public health and safety, decent standard of living for the people and protection of the natural environment, the Government of Bangladesh declares the NWP which will guide management of the country's water resources by all the concerned ministries, agencies, departments, and local bodies that are assigned responsibilities for the development, maintenance, and delivery of water and water related services as well as the private users and developers of water resources.

Under the NWP, the Government of Bangladesh addresses 16 issues and corresponding policies to manage the water resources and protection of the environment of the country in a comprehensive, integrated and equitable manner. The 16 issues and the concerned policies are outlined as shown in Table 2.4.1.

NWP also addresses government’s policy towards institutional and legal framework aspects. The National Water Resources Council (NWRC) will coordinate all water resources management activities in the country. The Executive Committee of the National Water Resources Council (ECNWRC) will provide directives on all matters relating to the planning, management, and coordination of water resources across all sectors, as may be required by the NWRC. WARPO will be the exclusive government institution for macro-level water resource planning. It will also serve as the Executive

Secretariat of the ECNWRC. The government enacts a National Water Code revising and consolidating the laws governing ownership, development, appropriation, utilisation, conservation, and protection of water resources.

2.4.3 National Water Management Plan (NWMP)

The Bangladesh Government approved National Water Management Plan (NWMP) on 31 Mar 2004. The plan incorporates 84 programs covering the country's hydrological regions and will provide proper guidelines in utilizing the water resources. It will be implemented in three phases including 5-year first phase, 5-year second phase and 15-year third and long-term phase. It was approved at the seventh meeting of the National Water Resources Council chaired by the Prime Minister. The plan will be centrally monitored by the Water Resources Planning Organization (WARPO). The plan, which was finalized after holding 232 meetings of the council at different levels, will be reviewed after every five years and can be amended, if necessary.

(1) NWMP Preparation

The approach in preparing the NWMP was both structured and was highly participatory since Inception Phase (March 1998 to December 1998), Options Phase (September 1998 to March 2001) and Plan Preparation Phase (October 2000 to November 2001). Through the process of NWRMP preparation, National Water Resources Database (NWRD) was designed and formulated.

(2) NWMP Framework

The National Water Policy (NWP) and the Development Strategy constitute the main policy and strategic framework for the NWMP. Besides these, a wide range of policies for various sectors has direct or indirect bearing on the water sector. These include:

- National Environment Policy (1992)
- National Forestry Policy (1994)
- National Energy Policy (1996)
- National Fisheries Policy (1998)
- National Policy for Safe Water Supply and Sanitation (1998)
- National Agricultural Policy (1999)
- Industrial Policy (1999)

All these policies and the Development Strategy together provide an extensive framework for management of the water sector. However, a policy for land use planning had not been approved during the NWMP preparation.

The National Water Management Plan provides a framework within which all concerned with the development, management and use of water resources and water services in Bangladesh can plan and implement their own activities in a coordinated and integrated manner. The planned activity programs have been presented in 8 sub-sectoral clusters with each cluster comprises of a number of individual programs, with overall total of 84 sub-sectoral programs identified. Among the 8 clusters, 2 clusters address the structural constraints on the sustainable development and management of the water sector which are:

- Institutional Development (ID)
- Enabling Environment (EE)

The rest 6 clusters address capital needs and opportunities which are:

- Main Rivers (MR)
- Towns and Rural Areas (TR)
- Major Cities (MC)
- Disaster Management (DM)
- Agriculture and Water Management (AW)
- Environment and Aquatic Resources (EA)

The sub-sectoral programs under the clusters can be summarized in the following 3 broad categories:

- *Cross-Cutting Programs*: These programs relate to the actions necessary to evolve and strengthen the institutional framework and to create an enabling environment conducive to efficient and effective management of the sector.
- *National-Level Programs*: These programs mainly relate to long-term strategic security of water supplies to Bangladesh, pollution control, restoration of flood-plain and river fisheries, and other environmental management issues.
- *Regional Programs*: These programs fall into 2 sub-categories:
    - *Generic Programs*: These are generic in nature and applicable to all or most regions (eg rural water supplies and arsenic mitigation).
    - *Specific Programs*: These are specific to one or two regions only (eg cyclone protection).

  It is to be noted that WARPO has delineated eight hydrological regions of the country, based on appropriate natural features, for planning the development of water resources which are: Northwest (NW), North Central (NC), Northeast (NE), Southeast (SE), South Central (SC), Southwest (SW), Eastern Hills (EH), the active floodplains and charlands of the Main Rivers and Estuaries (RE).

The programs have been scheduled in a manner to improve the investment flows. Priority has been given to the institutional development, enabling environment, water supply and sanitation, rationalization of FCD&I management and key elements of the natural environment programs.

Table 2.4.2 summarizes programs that are within the NC and NE regions and for which local units (LGD, LGED and LGIs) have responsibility as either leading or supporting agency. In total, 20 programs can be identified which are: ID 001, 002 & 005; EE 002; MR 006, 008 & 009; TR 004, 005, 006 & 008; DM 003 & 004; AW 002, 003, 005, 006 & 007 and EA 006 & 008.

NWMP is a rolling 25-year plan in three phases:

- The Short-Term (2000-05) is considered a Firm Plan
- The Medium-Term (2006-10) an Indicative Plan, and
- The Long-Term (2011-25) a Perspective Plan.

The NWMP programs are to be implemented by line agencies and others as designated. Each organization is responsible for planning and implementing its own activities and projects within the NWMP framework. Implementation of the plan will be monitored regularly and it will be updated in every five years. Implementation of the Plan will bring multi-dimensional benefits to Bangladesh in consistent with national goals.

(3) Funding the National Water Management Plan

The overall capital cost of the NWMP has been estimated to be a little over one trillion Taka or US$ 20 billion. It is intended that these costs will be funded by a combination of traditional government allocations from Gross Domestic Product (GDP), beneficiaries, small - scale private sector and other sources. Other sources will include larger private sector instruments, public bond issues and water and environment funds, but will be highly dependent on the emergence of the enabling environment.

Inadequate provision for recurring is recognized as a major constraint on sustainable water sector management. The plan will facilitate increased cost recovery based on user pays principles and transferred responsibilities for scheme operation and maintenance. Furthermore, although the recurring costs will build up to considerable amounts by the end of the plan's lifetime, the greater part of them will comprise of service fees that can be sanctioned. In due course, and based on consultation and sensitization over a suitably protracted period, other recurring costs will gradually become the responsibility of users - leaving government with a small residue of recurring costs that it should rightly cover.

2.4.4 Water Resources Development in PRSP-draft

After Interim Poverty Reduction Strategy Paper (I-PRSP) in June 2004, the Draft PRSP (PRSP-D) was prepared in December 2004. The PRSP-D will be the medium term micro-economic framework of the Government after approval of the Government.

Implementation of the NWPo (1999) and NWMP (2004) is the basic strategy for the water resources development and management in PRSP-D, and eight strategic goals and their key targets are indicated. The detailed policy matrix in PRSP-D is shown in Table 2.4.4.

2.4.5 Water Resources Development Institutions

At present, the agencies or organizations which have relevant functions in water sector are of four categories:

(1) Government Agencies

The government agencies include 13 ministries and 35 organizations, the most important among which are:

- The National Economic Council (NEC)
- The National Water Resources Council (NWRC)
- The Planning Commission
- The Ministry of Water Resources (MoWR)
- Water Resources Planning Organization (WARPO)
- Joint Rivers Commission (JRC)
- Bangladesh Water Development Board (BWDB)
- Bangladesh Inland Water Transport Authority (BIWTA)
- Ministry of Agriculture (MoA) with its Department of Agricultural Extension (DAE)
- Bangladesh Agricultural Development Corporation (BADC)
- The Department of Fisheries (DoF)
- The Ministry of Local Government, Rural Development & Cooperatives (MoLGRDC) with its two divisions: the Local Government Division (LGD) and Rural Development and Cooperatives Division (RDCD)
- Department of Public Health Engineering (DPHE)
- The Local Government Engineering Department; (LGED)
- The Ministry of Environment & Forests (MoEF)
- The Department of Environment (DoE)
- The Soil Research Development Institute (SRDI)
- Bangladesh Haor & Wetland Development Board (BHWDB)
- The River Research Institute (RRI)
- The Department of Forest (DoForest)
- Institute of Water Modelling (IWM), formerly called Surface Water Modeling Centre (SWMC)
- Disaster Management Bureau (DMB)

(2) Local Government Institutions

The following local government institutions are involved fro the implementation of NWRMP:

- City Corporations: 4 nos. (Dhaka, Chittagong, Rajshahi and Khulna) among which 2 (Dhaka and Chittagong) have Water Supply and Sewerage Authorities (WASA)
- The Paurashava (Municipalities): 206 nos.
- Zila (District) Parishad: 64 nos.
- Upazila (Thana) Parishad: 464 nos.
- Union Parishad: 4451 nos. each comprising 1 chairman and 12 members including 3 nominated women members
- Gram Parishads: approx. 86,500 nos.

(3) Other Organizations and the Private Sector

1) Other Stakeholders

- Community Based Organizations (CBOs);
- Non-Government Organizations (NGOs);
- Cooperatives such as Water Management Organization (WMO) comprising the Water Management Group (WMG), Water management Association (WMA) and Water Management Federation (WMF); and
- Private sector organizations and institutions.

2) Donor Agencies

Development Partners: Noted among the development partners are:

- The World Bank (WB)
- The Asian Development Bank (ADB)
- The United Nations agencies (UNDP and UNICEF)
- Numerous bilateral development agencies of countries such as Japan, Netherlands, Denmark, UK, and Canada

2.4.6 Small Scale Water Resources Development Sector Project (SSWRDSP-1)

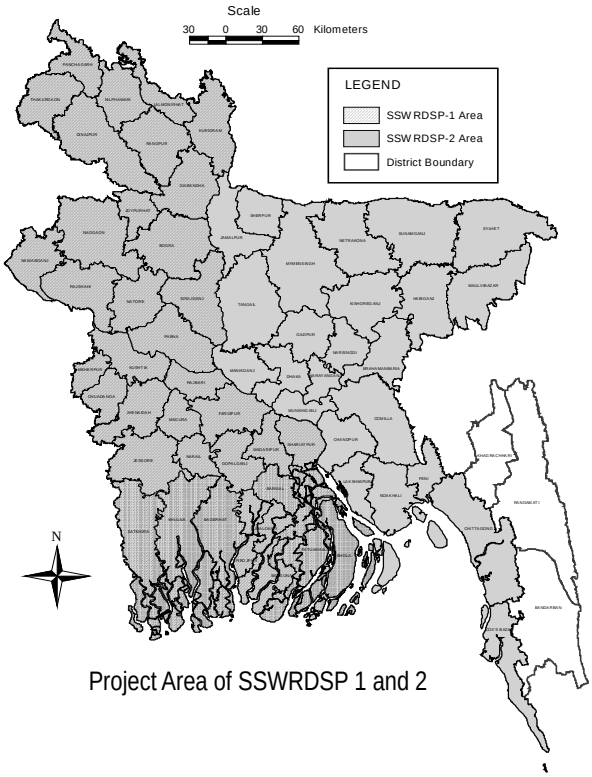
(1) Background

Water is the foundation for many rural livelihood activities of the rural poor, and effective water resource management is fundamental to addressing pervasive rural poverty problems while promoting economic growth in Bangladesh. Based on the Government of Bangladesh's main instrument to have the strategy implemented, the first SSWRDSP was launched in April 1996 to enhance rural incomes by developing community-based water management associations (WMAs) and community-managed small-scale infrastructure and this has proved to be an effective means to reduce rural poverty.

(2) Outline of the Project

1) Objectives and project area

The project aimed at sustainable growth in agricultural production and incomes of about 140,000 farm families in western Bangladesh through the establishment of about 300 small-scale water resources development schemes. In the Project, finally 280 subprojects were completed covering 165,000 hectares of cultivated land that benefited 192,600 farm families.



Project Area of SSWRDSP 1 and 2

2) Implementation period and executing agency

The Project was implemented from April 1996 and completed in December 2002. And, the Local Government Engineering Department (LGED) was the executing agency collaborating with other government agencies and NGOs.

3) Financial arrangement

The Project was implemented with funds from several stakeholders, and their shares are as follows:

Financial Sources	Finance amount	Share
Asian Development Bank (ADB)	US$ 28.3 million	52.9 %
International Fund for Agriculture Development (IFAD)	US$ 8.8 million	16.4 %
Government of the Netherlands	US$ 6.8 million	12.7 %
Government of the Peoples Republic of Bangladesh (GOB)	US$ 8.9 million	16.7 %
Total	US$ 53.5 million	100.0 %

Project beneficiaries also contributed US$ 3.5 million.

(3) Achievement of the Project

Major achievements of the 1st SSWRDSP are as follows:

- Total number of benefited districts = 37
- Total number of completed sub-projects = 280
- Total benefited cultivated land = 164,700 ha
- Total benefited farm families = 142,300
- WMCA membership = 119,400 persons with 24% female

Temporary employment of about 8.38 million person-days was generated from the works of 21 million m^3 of earthwork embankment (945 km) and re- excavation of canals (1,162 km).

2.4.7 Small Scale Water Resources Development Sector Project (SSWRDSP-2)

(1) Background

After the successful completion of SSWRDSP-1, the GOB requested the implementation of the SSWRDSP-2, expanding the project area to the entire country except three hill tract districts, and was agreed by ADB and the Government of Netherlands.

(2) Outline of the Project

1) Objectives

The Project aims to improve the development of the water resources sector through participatory rehabilitation and management of small-scale (less than 1,000 ha of benefited area) water resources infrastructure and supported by sector-wide policy and institutional reforms.

2) Project area

The Project will be implemented including 300 more subprojects in 61 districts of the country's 64 districts. The Project will not be implemented in the Chittagong Hill Tracts (3 Districts are located in this area) considering the different physical, institutional, and socio-cultural conditions.

3) Implementation period

The loan for this Project had become effective on 9 November 2001. Period of utilization of the Loan is until 31 December 2009 and estimated project completion date will be 30 June 2009.

4) Executing agency

Local Government Engineering Department (LGED) under the Ministry of Local Government, Rural Development and Cooperatives is implementing the Project.

5) Financial plan

Asian Development Bank (ADB) decided to provide a loan equivalent to $34.0 million from its Special Funds resources to finance about 44 percent of the total cost of the Project. The loan will finance foreign exchange costs estimated at $7.6 million (48 % of the total foreign exchange cost) and $26.4 million of the local currency cost. The Government of the Netherlands also decided that it would provide grant funds totaling $24.3 million (to cover $8.3 million of the foreign exchange cost and $19.8 million of the local currency cost) for NGO services, civil works, consulting services and training, etc. The Government of Bangladesh decided to provide the local currency cost estimated at $17.3 million equivalent (22 %t of total cost) for incremental project staff, taxes and duties, and land acquisition and compensation. In addition, the beneficiaries are expected to contribute approximately $2.4 million equivalent in the form of O&M costs incurred during the project implementation.

Financial Plan of SSWRDSP-2

Unit: US$ million

Source of Financing	Foreign Exchange	Local Currency	Total Cost	Share
ADB	7.6	26.4	34.0	44%
Government of Netherlands	8.3	16.0	24.3	31%
Government of Bangladesh	0.0	17.3	17.3	22%
Beneficiaries	0.0	2.4	2.4	3%
Total	15.9	62.1	78.0	100%

2.4.8 Rubber Dam Project

(1) Rubber Dam Project

Rubber dam constructions have been implemented by LGED in Bangladesh after two rubber dams construction in Cox's Bazar, as the pilot basis, in 1995. Upto now nine rubber dam were installed and four dam is under construction in Bangladesh. According to Rubber Dam Project Office LGED, winter crop area and production by rubber dam irrigation increased at 68% and 70%, respectively. Project list of the rubber dams are shown in Table 2.4.5.

Advantage and disadvantage of rubber dam to conventional regulator is summarized as follows:

Advantage	Disadvantage
a. Structure can be made lightweight. This lessens treatment of foundation soil to only nominal or none. b. Rubber dam can have spans as long as 100 m without dividing piers. This provides full width of active cross-section of the river channel to release flood flow. c. Construction and installation are quicker. d. Investment cost is roughly less than half regarding the unit cost*) e. No gates and hoisting gears make operation of the structure simple. The dam bag needs very little maintenance. Repair to damages of the dam bag is simple and can be done by ordinary skilled staff with simple tools	a. The soft rubber-nylon made shell of the dam body needs careful operation and maintenance. Large floating materials like logs, trees, bamboos etc. may be harmful to the dam body. b. Repairs of dam bags are done only in dry condition. Underwater repair is not possible. c. Service life of dam bags is about 20 years. Replacement of the dam bag may be needed if design life of the dam is longer.

* Average unit cost of rubber dam (Total Cost / L x H) constructed in recent years is Tk. 200,000/m^2.

On the other hand, average unit cost of conventional regulator is estimated as follows from the results of SSWRDSP-1:

- Unit cost = Tk. 2,450,000/unit. (estimating the present cost)
- Average size = 1.5m(W) x 2 vents x 1.5m(H) = 4.5m^2
- Unit const = Tk. 550,000/m^2

(2) Prospect of rubber dam in Bangladesh

There is large potential for exploitation of surface water from small and medium rivers of Bangladesh for irrigation. Rubber dams would be ideally feasible water retention and conservation structures for such rivers which are characterized by low flows and water levels during post-monsoon and winter seasons when retention is needed and by high flood flows in monsoon season when unobstructed flood passage is desired.

(3) Collaboration with Department of Agricultural Extension (DAE)

Regarding the planning and implementation stage of rubber dam, LGED has been carried out the collaboration with DAE to estimate the effectiveness of and also to evaluate the project effect after implementation to grasp the accurate beneficiaries benefit.

2.5 Irrigation and Drainage

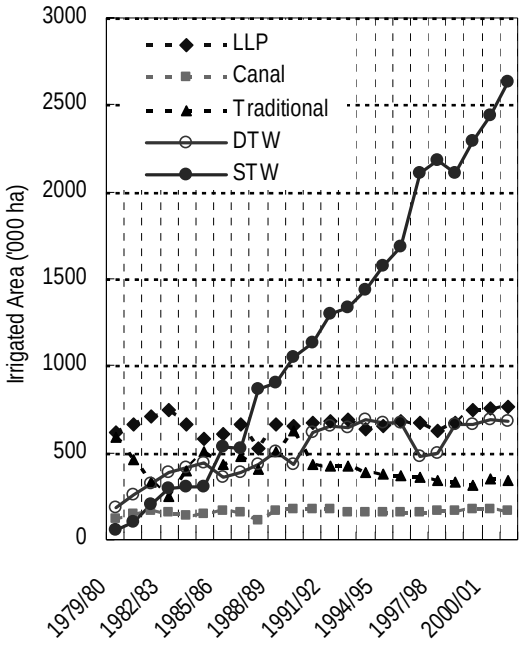
2.5.1 Irrigation

(1) Irrigated Area in Bangladesh

Significant development of the irrigated agriculture started by introduction green revolution in later 1960's by low lift pump where surface water available. In 1970's, irrigation by deep tube wells has initiated under the BADC.

According the data of Ministry of Agriculture, tube-well irrigation situations in the whole country are as follows:

From the above table, it is found that extreme increment of irrigation area by tubewell is owing to the increment of irrigation area by STW (shallow tubewell). The irrigation area by STW is continuously increment. On the other hand, the increment of irrigation area by DTW stops from Year 1991/92. This may imply that deep groundwater extract now reaches to upper limit in everywhere because of recharge capacity on groundwater.



Irrigated Area in Bangladesh by Means

Irrigated Area in Bangladesh

Unit: 1,000 ha

Year	Surface Water				Groundwater		
	LLP	Canal	Traditional	Total surf. water	DTW	STW	Total Tubewell
1979/80	621	122	590	1,333	181	55	236
1980/81	666	150	464	1,280	260	99	359
1981/82	704	163	333	1,200	323	202	525
1982/83	747	160	252	1,159	390	299	689
1983/84	667	134	400	1,201	415	304	719
1984/85	581	148	503	1,232	441	300	741
1985/86	609	163	433	1,205	359	535	894
1986/87	660	156	475	1,291	388	521	909
1987/88	527	115	404	1,046	432	869	1,301
1988/89	658	170	509	1,337	502	899	1,401
1989/90	657	178	629	1,464	428	1,045	1,473
1990/91	675	173	434	1,282	616	1,131	1,747
1991/92	685	171	426	1,282	656	1,293	1,949
1992/93	686	159	426	1,271	645	1,338	1,983
1993/94	638	155	382	1,175	694	1,431	2,125
1994/95	657	159	373	1,189	668	1,573	2,241
1995/96	678	154	366	1,198	676	1,680	2,356
1996/97	670	156	363	1,189	475	2,104	2,579
1997/98	622	163	338	1,123	495	2,182	2,677
1998/99	669	167	330	1,166	662	2,111	2,773
1999/00	742	172	317	1,231	664	2,291	2,955
2000/01	757	177	354	1,288	694	2,437	3,131
2001/02	768	163	336	1,267	677	2,632	3,309

1) Surface Water Irrigation

According Ministry of Agriculture, surface irrigation covers 1,267,000 ha of which low lift irrigation covers 768,000 ha in Bangladesh 2001/02. It is found that application of surface water supply measures has been hardly changed during these 20 years. However, applications of LLP and canal system are slightly incremented. On the other hand, traditional method is gradually reduced its irrigated area. It seems that the reason of no change in surface water irrigation area is limitation of water source availability. If water source is available, farmers will use of those and irrigation area will be incremented.

2) Groundwater Irrigation

Also the groundwater irrigation become major comparing the surface water irrigation since 1987/88, particularly the irrigated area by Shallow Tube Well (STW) covers more than 57% (2,632,000 ha) of total irrigated area in 2001/02. The irrigation area by STW is continuously increment. On the other hand, the increment of irrigation area by DTW stops from Year 1991/92. This may imply that deep groundwater extract now reaches to upper limit in everywhere because of recharge capacity on groundwater.

(2) Effectiveness of Water Conservation (WC) Sub-project on SSWRDP

From the above data, there is a high possibility of drought year occurrence lately. It is fairly difficult to implement paddy cultivation or other crops by rain-fed. In this circumstance, implementation of water conservation (WC) sub-project utilizing stored flooding water in the khals that is located in the sub-project area is very effective and economic

2.5.2 Irrigation Water Requirement in the Study Area

(1) Drought Analysis

1) Annual Rainfall

Annual rainfall in Mymensingh observation station of BMD (ID 10609) from Year 1977 to Year 2003 as a reliable data duration is as follows:

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	
mm	2,847	1,924	958	2,321	2,187	2,354	2,840	2,679	1,559	
Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	
mm	2,971	2,209	3,209	2,274	2,439	3,312	1,584	3,213	1,604	
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	Average
mm	2,645	1,620	2,208	2,347	2,174	2,266	1,948	2,395	1,268	2,272

2) Analysis of Probability of Not Exceedance

From the result of analysis by Iwai method, each return period of annual rainfall is as follows:

Return Period	Rainfall (mm)
50	1,182
40	1,219
30	1,270
20	1,350
10	1,512
5	1,729
3	1,951

From this, the return period of annual rainfall below the average rainfall in recent 10 years are as follows:

Rainfall in Year 2003:	1/30
Rainfall in Year 2001:	1/3
Rainfall in Year 1994, 1996:	1/10

(2) Irrigation Water Requirement

1) Net Irrigation Water Requirement (NIR)

NIR is calculated by the following fomula.

NIR=ET(crop) – (Re + Ge + Se)

Et(crop) : Evapotranspiration of crop
Re : Rainfall
Ge : Groundwater contribution, if any
Se : Stored soil moisture at the beginning of each period

2) ET(rice)

ET(rice) is calculated by following fomula.

ET(rice) = Kc(rice) x ETo

Kc(rice) : Crop coefficient of Rice
ETo : Reference crop evapotranspiration

a) Kc(rice)

Regarding Kc(rive) value, followings are suggested by each organizations.

i) For Aus, T-Aman and Boro by BADC are as follows;

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aus				1.10	1.15	1.30	1.00					
T Amon								1.10	1.15	1.30	1.00	
Boro	1.15	1.25	1.00									1.00

Source: Net Irrigation Requirement of Rice and Evapotranspiration of Wheat and Potato for Different Locations of Bangladesh; BADC (December, 1982)

ii) Results of field experiments for Aus, T Aman and Boro by BRRI (Dec. 2004)

- In Aus season, the Kc values ranged from 1.05 to 1.15 between different varieties.
- In T. Aman season, the Kc values ranged from 1.03 to 1.09.
- In Boro season, the Kc values ranged from 1.13 to 1.17.

These showed that there were slight variations in Kc values from season to season and from variety to variety. The Kc values in Boro and Aus season were slightly higher than in T. Aman season.

iii) For Rice in humid Asia by FAO Irrigation and Drainage Paper are as flows;

	Planting	Harvest	1st and 2nd month	Mid-season	Last 4 weeks
Wet season (monsoon)					
- light to mod. wind	June-July	Nov-Dec	1.10	1.05	0.95
Dry season					
- light to mod. wind	Dec-Jan	mid-May	1.10	1.25	1.00

iv) Results

Considering the above information, it seems that Kc(rice) by BADC is suitable to apply into the calculation of NIR.

b) Reference crop evapotranspiration (ETo)

By the modified Penman method, ETo is calculated using Temperature, Sunshine, Relative Humidity and Wind Speed considering of the data availability of Mymensingh observation station

Year	Max. (month)	Min. (month)
1989	7.87mm/day (Apr)	2.48mm/day (Dec)
1990	6.43 (May)	2.58 (Dec)
1991	6.31 (Apr)	2.43 (Dec)
1992	7.89 (Apr)	2.47 (Jan)
1993	6.35 (Apr)	2.32 (Jan)
1994	6.99 (May)	2.61 (Dec)
1995	7.66 (May)	2.51 (Dec)
1996	7.05 (Apr)	2.65 (Jan)
1997	7.53 (May)	2.12 (Dec)
1998	6.64 (May)	2.31 (Jan)
1999	7.36 (Apr)	3.01 (Jan)
2000	6.42 (Apr)	2.55 (Jan)
2001	6.94 (Apr)	2.46 (Jan)

Through these years above, average ETo of each month is as follows:

Mon.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ETo	2.58	3.86	5.48	6.82	6.51	5.56	4.15	5.54	4.98	4.98	3.85	2.66

From the above, ET(rice) is calculated as follows. Regarding HYV Boro, cultivated duration and ETo is as follows considering the data of Ministry of Agriculture.

Unit: mm/day

Rice	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aus				7.5	7.5	7.2	4.2					
T Amon								6.1	5.7	6.5	3.9	
Boro	3.0	4.8	5.5									2.7
HYV Boro	2.6	4.4	6.9	6.8	6.5							

Total ET(rice) of each rice is estimated as follows supposing its cultivation duration as 4 months.

i) Aus : 800mm/season
ii) T. Aman : 680mm/season
iii) Local Boro : 480mm/season
iv) HYV Boro: 820mm/season

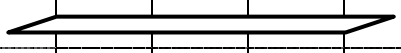
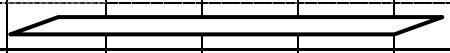
3) ET(crop)

For other crops, ET(crop) is calculated by following fomula as same as rice.

ET(crop) = Kc(crop) x ETo
Kc(crop) : Crop coefficient of other Crop
Eto : Reference crop evapotranspiration

a) Kc(crop)

As a representative crops of Rabi crop, Kc(crop) of Maize and Potato are calculated as follows following to the FAO Irrigation and Drainage Paper and results considering the growing period of each crop are as follows;

Crop	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Maize						
Potato						
Maize	-	0.45	0.75	1.05	0.55	-
Potato	-	0.45	0.75	1.05	0.70	-

b) Reference crop evapotranspiration (ETo)

ETo is same value as calculated for the rice.

c) ET(crop)

From the above a) and b), ET(crop) of Maize and Potato are as follows;

Crop	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Maize	-	1.2	1.9	4.1	3.0	-
Potato	-	1.2	1.9	4.1	3.8	-

Total ET(crop) of each crop is estimated as follows;

i) Maize : 290mm/season

ii) Potato : 330mm/season

(3) Irrigation Efficiencies

1) Conveyance loss

According to the results of field investigation at the four small scale irrigation projects by the Bangladesh Agricultural University Mymensingh, the average conveyance losses at each projects as per 100m length of canal is 17 – 34 % in main canal and 12 – 20 % in lateral/field canal.

2) Irrigation efficiency

On those 4 projects, the irrigation efficiency of 73 – 87 % are obtained from the field investigation.

(4) Possible Irrigation Area

Possible irrigation area for Boro cultivation on the case of water conservation (WC) subproject is calculated by water balance study considering the above results and other factors at the sample sub-projects those are identified as potential sub-project when implemented the inventory survey or the Union questionnaire verification survey. Hereunder, the conditions on water balance study and calculation method is mentioned.

1) Conditions on the calculation

a) Duration of calculation

Calculation is from the beginning of December to the middle of May of the next year.

- Starting time; As the time of water level in the khal becoming nearly equal to the paddy field level
- Ending time; as the time of finishing harvest of Boro rice.

b) Land preparation (LP)

Land preparation before transplanting the paddy is necessary. Water requirement for land preparation is assumed as follow considering other project's application:

LP=180 mm

c) ET(crop)

Total ET(crop) is calculated using ET(crop) mentioned above.

d) Evaporation (Ep)

Evaporation from water surface of the khal is considered as follows:

- Data: Mymensingh meteorological station of BMD
- Evaporation of each month is as follows (average of past data)

Month	Evaporation (mm/month)
November	85
December	71
January	69
February	88
March	140
April	157
May	76 (first half month Total)

e) Rainfall Data

Rainfall in the khal area is considered 100% effective to the irrigation.

Rainfall data of BWDB except Mymensingh district is used for calculation and rainfall data of BMD is

used for the Mymensingh district calculation.

Monthly rainfall data of which annual rainfall is equivalent to the 10-year return period annual rainfall as a design drought year is used.

f) Effective rainfall

Effective rainfalls of paddy and upland crops are calculated as follows.

i) For paddy

Rainfall falling on the paddy field will be considered to be effective to the irrigation.

Effective rainfall will be calculated by following method;

- Daily rainfall less than 5mm ----------effective rainfall = 0
- Daily rainfall between 5mm and 80mm ----------effective rainfall = (R*-5)x100%
- Daily rainfall over 80mm ----------effective rainfall = 80mm

R* : Daily rainfall

ii) For upland crops

Rainfall falling on the upland crop field will be considered to be effective to the irrigation.
Effective rainfall for upland crop will be calculated by following method;

- Daily rainfall less than 3mm ----------effective rainfall = 0
- Daily rainfall between 3mm and 50mm ----------effective rainfall = (R*-3)x 80%
- Daily rainfall over 50mm ----------effective rainfall = 50mm

R* : Daily rainfall

Daily rainfall data as same year as d) above mentioned is used to calculate the effective rainfall.

g) Field loss

Field loss of irrigation water should be considered. In case of water conservation (WC) sub-project, irrigation is done along the khal and irrigation water is directly supplied to the paddy filed from the khal or through the branch canal from the khal. Those branch canals are supposed to be not so long. Therefore, conveyance loss of canal should be disregard and application loss and percolation from the paddy field are only considered. Field loss is assumed as follow considering other project's application:

Field loss = 130 mm/month

(5) Trial water balance study at the sample sub-projects in each district

Trial water valance study for irrigation water at the sample sub-project in each district is as follows.

a) Selection of sample sub-project

To make the results more accurate, sample sub-projects are selected within the Sadar of each district in which the rainfall observation stations of BWDB are located and rainfall data are available. From the objectives of trial calculation, WC (water conservation) sub-projects or DI (drainage improvement) & WC sub-projects are selected. By the re-excavation of khals (drainage improvement), water in the beels adjacent to those khals are supposed to be utilized effectively in the paddy field along the khals. The location of beels is considered for the trial calculation from this viewpoint.

b) Jamalpur district

i) Actual rainfall

Annual rainfall of 1,753mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BWDB Jamalpur station (CL-67). As the annual rainfall of 1,750mm in Year 1999 is nearly same as the 10-year return period rainfall, the annual rainfall of 1,750mm in Year 1999 is considered to be the design rainfall.

ii) Effective rainfall for paddy and other crop

In this sub-project, calculations by the combination of crops cultivation will be done.

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	0	0	0	0	14.3	197.4
Effective R. for Paddy	0	0	0	0	6.5	155.9
Effective R. for crop	0	0	0	0	6.8	142.6

* In May, rainfall is total of first half of the month

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall + Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khal and connected beel respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 25 ha.
- In case of Boro and other crops (20% of total irrigable area) cultivation ; 28 ha.
- In case of other crop cultivation only ; 38 ha.

(In case of other crop cultivation only, irrigation area is 1.5 times bigger than the case of other crop cultivation only)

As the purposes of this sub-project are FM, WC & DI, benefits through project implementation are supposed to be more big considering the aspects of FM and DI effects.

c) Kishoreganj district

i) Actual rainfall

Annual rainfall of 1,700mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BWDB Kishoreganj station (CL-71). As the annual rainfall of 1,725mm in Year 1985 is nearly same as the 10-year return period rainfall, annual rainfall of 1,725mm in Year 1985 is considered to be the design rainfall.

ii) Effective rainfall for paddy

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	0	0	33.8	56.3	70.3	167.9
Effective R.	0	0	28.8	31.1	32.2	130.3

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall + Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khals and connected beels respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 2,240 ha.

Considering 1,909 ha of the gross area of this sub-project, this sub-project has a big potentiality for additional crop irrigation through effective use of the re-excavated khals and the beels adjacent to those khals.

d) Mymensingh district

i) Actual rainfall

Annual rainfall of 1,512mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BMD Mymensingh station (ID-10609). As the annual rainfall of 1,559 mm in Year 1985 is nearly same as the 10-year return period rainfall, annual rainfall of 1,559 mm in Year 1985 is considered to be the design rainfall.

ii) Effective rainfall for paddy

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	0	9.0	37.0	2.0	190.0	134.0
Effective R.	0	2.0	30.0	0	154.0	86.0

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall + Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khals and connected beels respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 104 ha.

As the purpose of this sub-project is DI & WC, benefits from the project implementation are supposed to be more big considering gross area of 692 ha and the aspects of DI effect.

e) Netrakona district

i) Actual rainfall

Annual rainfall of 2,608mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BWDB Netrakona station (CL-123). As the annual rainfall of 2,619mm in Year 1994 is nearly same as the 10-year return period rainfall, annual rainfall of 2,619mm in Year 1994 is considered to be the design rainfall.

ii) Effective rainfall for paddy

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	0	18.7	65.0	132.4	114.4	87.0
Effective R.	0	10.3	36.6	115.6	88.0	62.0

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall
+ Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khals and connected beels respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 12 ha.

Capacity of the khal after re-excavation and also capacity of the beel adjacent to that khal are not so big, therefore, possibility for increasing irrigation area is not big.

However, the purpose of this sub-project is DI & WC, so that the benefits from the project implementation are supposed to be more big considering the aspects of DI effect.

f) Sherpur district

i) Actual rainfall

Annual rainfall of 1,716mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BWDB Sherpur station (CL-78). As the annual rainfall of 1,718mm in Year 1985 is nearly same as the 10-year return period rainfall, annual rainfall of 1,718mm in Year 1985 is considered to be the design rainfall.

ii) Effective rainfall for paddy

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	10.9	0	35.0	4.1	95.3	153.8
Effective R.	5.9	0	22.0	0	78.8	127.0

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall
+ Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khals and connected beels respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 145 ha.

As the purpose of this sub-project is DI & WC, benefits from the project implementation are supposed to be more big considering gross area of 1,103 ha and also the aspects of DI effect.

g) Tangail district

i) Actual rainfall

Annual rainfall of 1,529mm as a not exceeding probable value of 10-year return period is obtained from the rainfall data of BWDB Tangail station (CL-2). As the annual rainfall of 1,502mm in Year 1989 is nearly same as the 10-year return period rainfall, annual rainfall of 1,502mm in Year 1989 is considered to be the design rainfall.

ii) Effective rainfall for paddy

Effective rainfall to the design rainfall on condition that was described before is as follows;

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May*
Actual Rainfall	3.6	0	55.8	1.3	86.5	53.6
Effective R.	0	0	45.8	0	63.2	40.3

iii) Water balance study

Water balance calculation formula in the khals and beels considering the above mentioned conditions is as follow:

Balance pondage = Initial pondage – LP – Total ET(crop) – Ep + Actual Rainfall + Effective rainfall

iv) Results of water balance study

The results of the water balance study considering the capacity of re-excavation of khals and connected beels respectively are as follows;

- In case of Boro cultivation only ; incremental irrigation area of 54 ha.

As the purpose of this sub-project is WC only, the benefited area of the sub-project is supposed to be the lower limit of SSWRDSP-2. From the above result, this sub-project must be more careful to set-up of the sub-project planning such as connecting the khals to the beels adjacent to those khals to make effective use of water widely.

2.5.3 Drainage

(1) Topography on Drainage

1) Highland

The areas classified as “Highland” (inundation depth less than 0.3m) are generally free of post-monsoon inundation. Potential for drainage may be found in small depressions at limited extent.

2) Medium highland/Lowland

This classification with the inundation depth of 0.3 to 1.8m is expected to have the highest potential for drainage activities. Excavation/re-excavation of drainage canals will have significant impact on agricultural production. Moreover, the area classified as medium highland/lowland covers about 60% of the area.

3) Lowland/Very lowland

Effectiveness of drainage at this area will also be limited. Similar to the haor areas, mitigation of early flood damages can be done.

(2) Drainage scheme on SSWRDP

1) Flooding water in the Study Area

At the beginning of flood season, only the rainwater that is concentrated into the khal flows down through the khal in the subproject area. (refer to the Fig.-2, Fig.-3)

Before long, the flowing water of major rivers, i.e. Jamuna river, Megna river, Old Bramaputra river, etc. are increasing its volume with heightening of its water level (Refer to Fig.-3).

Such major river water enters into the middle or small size river and flows backward in such rivers.

At the middle of flooding season, water flows of major rivers enter into the project area through the khals by flowing the water backward.

In the Study Area, flooding water flows slowly from north-west to south-east direction

2) Drainage situation in the sub-project area

Many places suffer from the water logging on the paddy field due to the poor drainage of the khals even though the downstream river water level becomes lower than the water level of those khals.

Riverbeds of these khals are heavily silted by the flooding water flowing into the khals for a long time. T. Aman or Boro cultivation is badly affected by this situation.

3) Application of drainage improvement (DI) sub-project

To dissolve the problem, application of Drainage Improvement project will be considered. Drainage improvement includes re-excavation of existing khals or small rivers and also excavation of new khals.

In case of the application of SSWRD, benefited area will be less than 1,000 ha, so that sub-project area should be within one Union from the viewpoint of getting the consensus of the stakeholders on the implementation of the project or O&M of the project after completion of such project.

However, khals usually lie between two or more Unions until inflowing into big rivers at the downstream of the khals If the Union intending to implement the DI sub-project locates at the middle reaches of such khal, the DI sub-project will be implemented not in one Union but in the Unions located at the down stream of the khal together considering the drainage effects. In case that the Union locates at the most downstream of khals and the khals flow into big river in such Union, the DI sub-project will be implemented independently because such DI sub-project will not be influenced by the downstream khal conditions.

4) Stage-wise development on drainage improvement (DI)

It is very essential to make grouping of each DI sub-projects by the drainage basin of khal or river. If some DI sub-projects locate within the same drainage basin of a khal, priority of the implementation of each sub-project must be carefully considered. In principle, development of DI sub-projects within the same drainage basin should be implemented from the downstream sub-project.

(3) Drainage conditions

On 2nd Small Scale Water Resources Development Sector Project (2nd SSWRDSP), following design guideline is set by LGED.

- Crop area flooded to above 0.30m for 3 consecutive days should be less than 5%.
- Average discharge required to drain basin runoff volume generated by a 5-day duration 10-year frequency storm.

- Average discharge calculation is based on the drainage rate and the drainage area at a given point of the channel.

Qm^3/s = [Drainage Rate (mm/day) x Drainage Area (ha)]/86,400

(4) Analysis of 5-day duration 10-year frequency storm

1) 5-day duration rainfall

From the reliable data obtained at Mymensingh meteorological observation station (BMD), 5-day duration rainfall in pre-monsoon season (April to June) is shown below.

Sl	Year	Total Rainfall (mm)	Duration	Sl	Year	Total Rainfall (mm)	Duration
1	1977	302	5 – 9 June	15	1991	303	4 – 8 June
2	1978	220	22 – 26 May	16	1992	92	9 – 13 June
3	1979	89	11 – 15 June	17	1993	296	9 – 13 June
4	1980	268	28 May – 1 June	18	1994	92	28 June – 1 July
5	1981	139	17 – 21 April	19	1995	286	17 – 21 June
6	1982	207	19 – 23 June	20	1996	132	30 May – 3 June
7	1983	195	17 – 21 May	21	1997	122	18 – 22 June
8	1984	207	14 – 18 June	22	1998	104	24 – 28 May
9	1985	146	20 – 24 April	23	1999	170	5 – 9 May
10	1986	203	9 – 13 April	24	2000	207	24 – 28 May
11	1987	201	31 May – 4 June	25	2001	214	3 – 7 June
12	1988	376	21 – 25 May	26	2002	437	13 – 17 June
13	1989	170	4 – 8 June	27	2003	138	8 – 12 June
14	1990	206	29 May – 2 June	-	-	-	-

2) 5-day rainfall height at 10-year frequency

According to the Gumbel method as giving the maximum distribution in hydrological statistic, 5-day rainfall height at 10-year frequency is calculated as 338mm. From average rainfall heights and ratio from the above data, 5-day distribution of rainfall height is as shown below.

Day	1st day	2nd day	3rd day	4th day	5th day	Total
Ratio	25%	15%	22%	23%	15%	100%
mm	83	52	74	78	50	338

Table 2.1.1 Physiography of the Entire Bangladesh and the Study Area

Physiographic Class	Area of Physiographic Class by District (km²)						Total Study Area		Bangladesh
	Jamalpur	Kishoreganj	Mymensingh	Netrokona	Sherpur	Tangail	(km²)	(%)	(%)
Active Brahmaputra-Jamuna Floodplain	359.12	33.51	114.42		0.72	384.49	892.26	0.65	1.95
Active Ganges Floodplain									2.04
Active Tista Floodplain									0.47
Akhaura Terrace									0.06
Arial Beel									0.11
Chittagong Coastal Plain									2.75
Eastern Surma-Kusiyara Floodplain									3.56
Ganges Tidal Floodplain									10.95
Gopalganj-Khulna Beels									1.46
High Barind Tract									1.21
High Ganges River Floodplain									9.52
Karatoya-Bangali Floodplain									1.86
Level Barind Tract									3.57
Low Ganges River Floodplain									5.48
Lower Atrai Basin									0.58
Lower Meghna River Floodplain									0.66
Lower Purnabhaba Floodplain									0.13
Madhupur Tract	54.45	17.09	721.42			1,041.09	1,834.05	1.35	3.02
Middle Meghna River Floodplain		81.44					81.44	0.06	0.93
North-eastern Barind Tract									0.78
Northern and Eastern Hills	13.26		5.89	22.05	85.80		127.00	0.09	13.14
Northern and Eastern Piedmont Plains	16.18		416.17	574.38	492.34		1,499.07	1.10	3.07
Old Brahmaputra Floodplain	699.61	446.67	2,051.96	1,620.32	646.27	612.19	6,077.02	4.46	5.12
Old Himalayan Piedmont Plain									2.97
Old Meghna Estuarine Floodplain		383.79					383.79	0.28	5.74
St. Martin's Coral Island									0.01
Sylhet Basin		703.29		623.34			1,326.63	0.97	3.03
Teesta Meander Floodplain									7.01
Young Brahmaputra and Jamuna Floodplain	838.23	712.64	910.87	5.47	81.67	1,363.47	3,912.36	2.87	4.10
Young Meghna Estuarine Floodplain									3.97
Urban, Water & Unclassified Class	83.77	132.15	50.71	20.21	10.07	45.77	342.68	0.25	0.75
	2,064.63	2,510.60	4,271.44	2,865.76	1,316.87	3,447.01	16,476.31	12.09	100.00

Source: National Water Resources Database (WARPO)

Note: Different physiographic classes are according to Land Resource Inventory Map of AEZ mapping

A 2 - 31

Table 2.2.2 Mean Month and Seasonal Rainfall in the Study Area

Sr	Station		Location	Agency	Average Rainfall (mm) by Month													Average Rainfall (mm) by Season			
No.	Code	Name	(District)	in Charge	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Dry
1	28	Pigna	Jamalpur	BWDB																	
2	32	Sharishabari	Jamalpur	BWDB	7	10	21	97	323	408	463	298	325	126	22	7	2,159	420	1,494	147	**45**
3	62	Dewanganj	Jamalpur	BWDB	8	15	26	139	333	449	522	347	357	196	13	8	2,440	472	1,674	209	57
4	66	Islampur	Jamalpur	BWDB																	
5	67	Jamalpur	Jamalpur	BWDB	8	22	33	119	346	495	516	378	400	164	17	16	2,526	465	1,788	181	80
6	61	Bajitpur	Kishoreganj	BWDB	8	27	70	146	378	365	383	308	313	183	34	14	2,248	524	1,369	217	119
7	71	Kishoreganj	Kishoreganj	BWDB	7	30	53	138	350	413	412	405	367	187	18	13	2,346	488	1,597	205	103
8	101	Bhairab Bazar	Kishoreganj	BWDB	4	31	60	165	403	324	417	326	295	172	28	11	2,235	568	1,361	200	106
9	112	Itna	Kishoreganj	BWDB	6	28	89	244	446	476	626	500	566	227	37	11	3,272	690	2,168	264	134
10	5	Bhaluka	Mymensingh	BWDB	8	34	67	188	364	439	530	351	392	230	44	23	2,644	552	1,713	**274**	132
11	27	Phulbaria	Mymensingh	BWDB	6	21	44	131	338	400	409	325	318	187	20	13	2,217	469	1,451	208	84
12	46	Rasulpur	Mymensingh	BWDB																	
13	64	Gafargaon	Mymensingh	BWDB	13	40	58	147	334	347	425	360	373	190	19	17	2,408	481	1,504	210	129
14	65	Gouripur	Mymensingh	BWDB	9	18	45	132	397	459	502	410	414	168	25	16	2,565	529	1,785	194	87
15	72	Muktagacha	Mymensingh	BWDB	9	22	29	135	326	397	485	345	419	176	20	13	2,424	461	1,646	195	74
16	73	Mymensingh	Mymensingh	BWDB	10	24	34	145	379	448	546	409	440	225	21	14	2,666	524	1,843	246	82
17	75	Nandail	Mymensingh	BWDB	6	22	50	151	421	468	553	445	481	208	37	13	2,861	572	1,947	245	92
18	77	Phulpur	Mymensingh	BWDB	8	21	37	136	385	458	649	408	442	188	39	10	2,749	521	1,957	227	77
19	63	Durgapur	Netrokona	BWDB	6	16	41	194	450	634	765	615	589	202	23	13	3,566	645	2,603	225	75
20	68	Jaria-Jhanjail	Netrokona	BWDB	7	21	44	189	483	607	755	611	576	209	22	10	3,515	673	2,549	231	82
21	113	Khaliajuri	Netrokona	BWDB	6	33	73	290	541	654	690	629	705	238	34	9	**3,902**	**830**	**2,679**	272	121
22	115	Kendua	Netrokona	BWDB	5	26	58	163	510	560	608	560	548	235	25	15	3,230	672	2,276	261	104
23	121	Mohanganj	Netrokona	BWDB	12	35	81	212	415	580	683	598	591	230	26	14	3,356	627	2,453	256	**142**
24	123	Netrokona	Netrokona	BWDB	8	23	48	200	429	544	708	509	534	213	32	17	3,242	629	2,295	245	96
25	74	Nalitabari	Sherpur	BWDB	8	20	28	163	427	487	565	355	402	144	15	14	2,668	591	1,809	159	70
26	78	Sherpur Town	Sherpur	BWDB	12	18	29	124	353	423	481	339	322	130	16	15	2,258	477	1,565	146	74
27	227	Nakuagaon	Sherpur	BWDB	13	23	47	137	559	638	810	449	595	168	14	20	3,471	697	2,492	182	103
28	2	Atia (Tangail)	Tangail	BWDB	5	22	34	120	258	344	375	306	345	161	22	13	2,014	378	1,369	183	74
29	13	Gopalpur	Tangail	BWDB	5	15	24	76	236	319	353	232	284	141	12	9	1,708	**312**	1,188	153	52
30	18	Kalihati	Tangail	BWDB	7	26	40	99	224	262	285	242	290	125	19	8	**1,621**	323	**1,079**	**144**	82
31	21	Mirzapur	Tangail	BWDB	3	20	44	145	235	284	361	239	261	144	24	11	1,757	380	1,146	168	78
32	10609	Mymensingh	Agri Unive., Mymensingh	BMD	8	20	41	144	347	390	472	343	362	208	22	10	2,365	491	1,566	229	79
33	41909	Tangail	Near Mosque	BMD																	
Maximum					13	40	89	290	559	654	810	629	705	238	44	23	**3,902**	**830**	**2,679**	**274**	**142**
Minimum					3	10	21	76	224	262	285	232	261	125	12	7	**1,621**	**312**	**1,079**	**144**	**45**

Definition of Season

Pre-Monsoon : *April – May*
Monsoon : *June – September*
Post-Monsoon : *October - November*
Dry : *December - March*
Source: BWDB and BMD rainfall data (1981 - 2002)

A 2 - 32

Table 2.2.3 Historical Annual Total Rainfall

Serial No.	Station Code	Station Name	Location (District)	Agency in Charge	Historical Annual Total Rainfall (mm)																					
					1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	28	Pigna	Jamalpur	BWDB																						
2	32	Sharishabari	Jamalpur	BWDB	1,497	1,204		4,335	2,915	1,533	1,718	3,175	3,050	2,274	2,841	1,197	2,236	1,320	2,212	1,597		2,201	1,837	1,639		2,241
3	62	Dewanganj	Jamalpur	BWDB	1,993	2,453	2,730	2,749	2,674	3,028	3,258	3,017	2,370	2,479	2,054	1,571	2,570	1,481	2,628	1,706		2,582	2,467	2,367		2,620
4	66	Islampur	Jamalpur	BWDB																						
5	67	Jamalpur	Jamalpur	BWDB	1,797	2,646	2,298	2,370	2,131	2,815	3,067	3,169	2,667	3,417	3,596	1,690	3,375	1,528	3,320	1,987		2,253	1,750	2,456	1,977	2,748
6	61	Bajitpur	Kishoreganj	BWDB	1,947	2,176	2,483	3,012	1,808	2,349	2,013	3,483	1,997	2,189	2,516	1,592	3,336	1,485	2,366	1,817	2,165	2,042	1,855			2,340
7	71	Kishoreganj	Kishoreganj	BWDB	1,913	1,948	2,590	2,648	1,725	2,330	2,093	3,510	2,631	2,486	2,504	1,725	3,679	1,416	2,291	2,579		2,005	2,913	2,009	1,920	
8	101	Bhairab Bazar	Kishoreganj	BWDB	2,409	1,534	2,469	2,373	1,665	2,027	2,271	2,969	1,844	2,334	2,541	1,608	3,010	1,512	2,397	1,969	2,629	2,230	1,721	1,598	2,916	3,155
9	112	Itna	Kishoreganj	BWDB	3,090	2,271	4,503	3,885		3,384	2,744	4,638	2,910	3,719	3,466	2,477	3,646	2,131	3,974	2,707	3,477	2,831	2,368	3,951	3,266	
10	5	Bhaluka	Mymensingh	BWDB	2,935	1,690	2,401	2,830	2,383	3,333	3,923		2,178	2,866	3,932	2,337	3,546	1,768	2,426	2,162		2,877	2,193	2,643	1,843	2,622
11	27	Phulbaria	Mymensingh	BWDB	1,715	1,637	2,586	2,482	1,733	2,761	2,406	2,208	1,564	3,492	2,946	1,347	3,208	1,676	2,298	1,593		1,948	2,020	2,068	2,653	
12	46	Rasulpur	Mymensingh	BWDB																						
13	64	Gafargaon	Mymensingh	BWDB	2,112	1,601	2,523	2,464	1,874	1,625	2,015	2,869	2,167	1,398	3,108	3,135	3,002	2,054	2,319	2,542		3,611	2,237	3,564	1,939	
14	65	Gouripur	Mymensingh	BWDB	2,367	2,405	3,312	2,875	2,410	2,076	1,802	3,431	2,540	2,581	2,934	2,078	3,202	1,996	3,241	2,182		2,556		2,189		
15	72	Muktagacha	Mymensingh	BWDB	2,326	2,573	2,682	3,110	2,948	2,580	2,242	2,999	2,446	2,347	3,058	1,670	3,650	1,817	2,693	1,444		2,197	2,310	1,867	1,531	
16	73	Mymensingh	Mymensingh	BWDB	2,383	2,023	3,102	2,654	2,071	2,810	2,384	3,373	2,451	3,002	4,094	2,265	3,053	2,074	2,836	1,697	2,547	2,542	4,166	2,288	2,095	2,742
17	75	Nandail	Mymensingh	BWDB	2,698	1,898	2,751	2,605	1,826	2,044	2,019	3,561	3,401	4,466	4,600	1,585	3,557	1,709	2,907	2,638		3,058	2,729	3,396		3,780
18	77	Phulpur	Mymensingh	BWDB					2,297	2,875	2,540	4,016	2,561	3,325	3,771	2,343	3,245	1,840	2,579	2,449		2,505	2,536	2,501	2,612	2,745
19	63	Durgapur	Netrokona	BWDB	3,491	3,196	4,067	3,962	2,720	3,154	3,740	4,943	4,226	4,099	4,347	3,302	4,467	2,970	3,717	2,996		2,041	3,073	2,615	3,338	4,419
20	68	Jaria-Jhanjail	Netrokona	BWDB	3,330	3,634	4,043	3,675	2,694	2,922	3,822	4,952	3,539	3,789	3,779	3,035	3,945	2,435	3,352	2,379		2,740	3,959		3,385	4,885
21	113	Khaliajuri	Netrokona	BWDB	3,038	2,271	3,572	3,303	2,670	3,744	3,254	4,939	3,045	5,551	4,332	2,419	4,205	2,178	4,760	3,535	5,048	4,658	4,308	5,339	4,312	5,365
22	115	Kendua	Netrokona	BWDB	3,248	2,562	3,614	3,480	2,662				3,068	4,980	**5,949**	3,166	3,562	2,113	3,730	2,463			2,662	2,649	2,166	2,841
23	121	Mohanganj	Netrokona	BWDB	3,130	3,103	3,304	2,335	2,662	2,803	2,964		4,074	5,244	4,676	3,311	4,807	3,106	4,388	4,068		4,241	2,031	1,435	1,902	3,528
24	123	Netrokona	Netrokona	BWDB	2,463	3,114	3,491		2,178	3,063	3,293	4,327	3,371	3,721	4,221	3,375	3,976	2,619	3,474	3,076		3,072	3,404	2,972	2,211	3,421
25	74	Nalitabari	Sherpur	BWDB	2,596	2,132		3,243	2,029	2,569	2,796	3,639	3,107	3,439	3,637	1,746	2,969	2,026	2,675	2,309			2,436	2,661	1,821	2,863
26	78	Sherpur Town	Sherpur	BWDB	2,197	2,185	2,340	2,332	1,718	2,407	2,682	2,833	2,419	2,762	2,612	1,858	2,712	1,224	2,840	1,846		2,527	1,926		1,477	
27	227	Nakuagaon	Sherpur	BWDB				3,735	2,334	2,521	3,260	3,145	3,354	3,563	5,425	3,089	4,282	2,953	3,997							
28	2	Atia (Tangail)	Tangail	BWDB	1,677	1,546	2,286	2,355	1,644	2,510	1,732	2,133	1,502	1,814	3,079	1,821	2,582	2,398	3,049	1,908		1,038	1,488	1,702		
29	13	Gopalpur	Tangail	BWDB	1,850	1,025	1,684	2,448	1,289	1,960	1,766		1,561	1,411	1,455	2,551	2,052	1,486	1,890	1,268		1,442	1,284	1,516	1,604	2,610
30	18	Kalihati	Tangail	BWDB	1,375	902	2,132	**803**	1,369	1,859	1,946	2,218	1,593	1,361	1,643	1,433	2,235	1,245	1,662	1,392	1,414	1,976	1,663	1,753	1,629	2,052
31	21	Mirzapur	Tangail	BWDB	1,604	1,216	1,877	4,027	1,319	1,977	1,421	2,227	1,416	1,007	1,035	1,779	2,446	1,349	1,804	1,715		1,712	1,844	1,694	1,671	
32	10609	Mymensingh	Agri University, Mymensingh	BMD	2,187	2,354	2,840	2,679	1,559	2,971	2,209	3,209	2,274	2,439	3,312	1,584	3,213	1,604	2,645	1,620	2,208	2,347	2,174	2,266	1,948	2,395
33	41909	Tangail	Near Mosque	BMD																						
Maximum					3,491	3,634	4,503	4,335	2,948	3,744	3,923	4,952	4,226	5,551	**5,949**	3,375	4,807	3,106	4,760	4,068	5,048	4,658	4,308	5,339	4,312	5,365
Minimum					1,375	902	1,684	**803**	1,289	1,533	1,421	2,133	1,416	1,007	1,035	1,197	2,052	1,224	1,662	1,268	1,414	1,038	1,284	1,435	1,477	2,052

Source: BWDB and BMD rainfall data (1981 - 2002)

Table 2.3.1 Average Monthly Water Level at BWDB non-tidal Station in the Study Area

Serial	Station		Location		Monthly Average Water Level (m PWD)												
No.	Code	Name	River Name	District	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
1	47	Bahadurabad	Brahmaputra-Jamuna	Jamalpur													
2	48	Jagannathganj	Brahmaputra-Jamuna	Jamalpur	9.02	8.70	8.85	9.91	11.36	13.26	14.58	14.45	14.23	12.96	10.79	9.62	11.48
3	134	Jukerchar	Jhenai	Jamalpur	8.27	8.15	7.97	7.89	8.43	9.94	11.58	11.62	11.52	10.25	8.68	8.41	9.39
4	**223**	**Goal Kanda**	**Old Brahmaputra**	**Jamalpur**	**18.38**	**18.25**	**18.13**	**18.18**	**18.79**	**19.94**	**21.07**	**20.81**	**20.59**	**19.69**	**18.76**	**18.51**	**19.26**
5	**224**	**Offtake of …**	**Old Brahmaputra**	**Jamalpur**													
6	**225**	**Jamalpur**	**Old Brahmaputra**	**Jamalpur**	**11.77**	**11.60**	**11.51**	**11.64**	**12.40**	**14.05**	**15.64**	**15.31**	**15.07**	**13.78**	**12.29**	**11.92**	**13.08**
7	**226**	**Oftake of …**	**Old Brahmaputra**	**Jamalpur**													
8	134A	Baushi Bridge	Jhenai	Jamalpur	10.61	10.42	10.29	10.32	11.30	13.16	14.75	14.52	14.27	12.97	11.24	10.82	12.06
9	134B	Offtake of Jhenai	Jhenai	Jamalpur	12.63	12.48	12.29	12.24	13.09	14.65	16.19	15.93	15.77	14.41	12.91	12.67	13.77
10	46.7L	Kholabarichar	Brahmaputra-Jamuna	Jamalpur	15.61	15.44	15.41	15.76	16.84	18.55	19.87	19.61	19.40	18.13	16.39	15.88	17.24
11	46.9L	Bahadurabad (Transit)	Brahmaputra-Jamuna	Jamalpur	13.64	13.38	13.59	14.59	15.99	17.71	18.90	18.67	18.47	17.24	15.24	14.20	15.97
12	47.3L	Jognaichar	Brahmaputra-Jamuna	Jamalpur													
13	311.4	Chamraghat	Mogra	Kishorganj	-	-	-	-	-	-	-	-	-	-	-	-	-
14	8	Basuri	Banar	Mymensingh	7.82	7.73	7.63	7.62	8.42	9.45	10.11	9.68	9.77	9.14	9.03	7.90	8.61
15	35.5	Sarchapur (Mymensingh)	Bhogai-Kangsa	Mymensingh	8.02	7.67	7.33	7.64	9.25	11.00	12.11	11.77	11.49	10.42	8.72	8.32	9.48
16	**227**	**Offtake of Sutia**	**Old Brahmaputra**	**Mymensingh**	**7.43**	**7.26**	**7.13**	**7.21**	**8.13**	**10.00**	**11.96**	**11.57**	**11.37**	**9.96**	**8.12**	**7.62**	**8.98**
17	**228**	**Mymensingh**	**Old Brahmaputra**	**Mymensingh**													
18	**228.5**	**Mymensingh**	**Old Brahmaputra**	**Mymensingh**	**6.87**	**6.68**	**6.53**	**6.61**	**7.43**	**9.22**	**10.95**	**10.72**	**10.43**	**9.09**	**7.45**	**7.04**	**8.25**
19	314	Ghosegaon	Nitai	Mymensingh	13.21	13.84	14.00	13.91	13.54	14.57	14.50	14.29	14.18	13.58	13.13	13.00	13.77
20	36	Jaria-Jhanjail	Bhogai-Kangsa	Netrokona	4.76	4.37	4.26	4.76	6.59	8.58	9.79	9.43	9.08	7.85	5.91	5.23	6.72
21	36.1	Mohangonj	Bhogai-Kangsa	Netrokona	4.29	3.67	3.15	3.72	5.23	6.43	7.13	7.06	6.82	6.12	4.82	4.40	5.24
22	262	Bijoypur	Sameswari	Netrokona	13.36	13.28	13.24	13.39	13.83	14.60	15.09	14.78	14.65	14.19	13.67	13.47	13.96
23	263	Durgapur	Sameswari	Netrokona	10.30	10.25	10.21	10.35	10.74	11.54	11.95	11.65	11.56	11.11	10.60	10.42	10.89
24	263.1	Kalmakanda	Sameswari	Netrokona	2.85	2.17	2.25	3.64	5.22	6.39	7.21	7.12	6.83	6.21	4.97	3.85	4.89
25	310	Netrokona	Mogra	Netrokona	4.10	3.66	3.46	3.71	5.23	7.09	8.28	8.23	7.93	7.01	4.99	4.20	5.66
26	311	Atpara	Mogra	Netrokona	4.34	3.84	3.66	4.38	5.92	7.32	8.21	8.20	7.95	7.30	5.77	4.97	5.99
27	344	Ghog Bazar	Saiduli Baruni	Netrokona	2.55	2.10	2.20	2.92	4.31	6.13	7.12	7.23	7.12	6.07	4.68	3.22	4.64
28	34	Nakuagaon	Bhogai-Kangsa	Sherpur	20.31	21.13	20.22	20.31	20.68	21.32	21.82	21.54	21.45	20.96	20.49	20.36	20.88
29	35	Nalitabari	Bhogai-Kangsa	Sherpur	14.43	14.41	14.33	14.40	14.80	15.38	15.91	15.61	15.51	15.03	14.58	14.45	14.90
30	53	Bath Kuchi	Chellakhali	Sherpur	23.81	23.78	23.75	23.82	23.98	24.19	24.42	24.31	24.32	24.10	23.92	23.87	24.02
31	12	Madhupur	Bangshi	Tangail	7.50	7.64	7.48	7.22	7.81	9.04	10.58	10.70	10.66	9.76	8.06	7.65	8.67
32	13	Kawaljani	Bangshi	Tangail	6.48	6.09	5.83	5.87	6.74	8.27	9.73	9.95	9.96	9.33	7.50	6.72	7.71
33	14	Mirzapur	Bangshi	Tangail	2.53	2.04	1.81	1.99	3.22	5.10	7.38	7.98	7.92	6.67	3.93	2.92	4.46
34	50	Porabari	Brahmaputra-Jamuna	Tangail	6.22	5.83	5.97	6.98	8.19	9.59	11.08	11.13	11.03	9.78	8.16	7.01	8.41
35	186	Jugini	Louhajang	Tangail													
36	342	Nolsafa	Futikjani	Tangail	7.38	7.01	6.54	6.55	7.28	8.60	10.50	10.89	10.88	9.52	7.83	7.54	8.38
37	343.5	Bhuiynapur	Futikjani	Tangail	-	-	-	-	-	-	-	-	-	-	-	-	-
38	68A	Elashin	Dhaleswari	Tangail	5.72	5.73	5.63	5.73	6.13	7.97	9.57	9.87	9.75	8.14	6.40	5.88	7.21

Source : BWDB daily average water level data (1981 - 2002)

A 2 - 34

Table 2.4.1 Outline of National Water Policy (NWPo) (1/2)

Issues	Description
River Basin Management	The government will work with co-riparian countries to establish a system for exchange of information and data on relevant aspects of hydrology, morphology, water pollution, ecology, changing watershed characteristics, cyclone, drought, flood warning, etc., and to help each other understand the current and emerging problems in the management of the shared water sources.
Planning and Management of Water Resources	• WARPO will prepare, and periodically update, a NWMP addressing the overall resource management issues in each region and the whole of Bangladesh. • Sector agencies of the government and local bodies will prepare and implement sub-regional and local water-management plans in conformance with the NWMP and approved government project appraisal guidelines. The Executive Committee of the National Water Resources Council (ECNWRC) will resolve any interagency conflict in this regard. • BWDB will implement all major surface water development projects and other FCDI projects with command area above 1,000 hectares. The Local Government will implement FCDI projects having a command area of 1,000 hectares or less after identification and appraisal through an interagency Project Appraisal Committee. Any interagency dispute will be resolved by means prescribed by the government
Water Rights and Allocation	• In general, the priority for allocating water during critical periods in the water shortage zones will be in the following order: domestic and municipal uses, non-consumptive uses (e.g. navigation, fisheries and wild-life), sustenance of the river regime, and other consumptive and non-consumptive uses such as irrigation, industry, environment, salinity management, and recreation. The above order of priority could however be changed on specific socio-economic criteria of an area by local bodies through local consensus. • The government may empower the local government or any local body it deems fit, to exercise its right to allocate water in scarcity zones during periods of severe drought, and it will monitor the water regime and enforcement of the regulations through specifically designed mechanisms.
Public and Private Involvement	• The management of public water schemes, barring municipal schemes, with command area up to 5,000 ha will be gradually made over to local and community organizations and their O&M will be financed through local resources. • Public water schemes, barring municipal schemes, with command area of over 5,000 ha will be gradually placed under private management, through leasing, concession, or management contract under open competitive bidding procedures, or jointly managed by the project implementing agency along with local government and community organizations. • Ownership of FCD and FCDI projects with command area of 1,000 ha or less will gradually be transferred to the local governments, beginning with the ones that are being satisfactorily managed and operated by the beneficiary/ community organizations.
Public Water Investment	• Planning and feasibility studies of all projects will follow the Guidelines for Project Assessment (GPA), the Guidelines for People's Participation (GPP), the Guidelines for Environmental Impact Assessment (EIA), and all other instructions that may be issued from time to time by the government. • Interests of low-income water users, and that of women, are adequately protected in water resource management.
Water Supply and Sanitation	• Preserve natural depressions and water bodies in major urban areas for recharge of underground aquifers and rainwater management. • Mandate local governments to create awareness among the people in checking water pollution and wastage.
Water and Agriculture	• Improve efficiency of resource utilization through conjunctive use of all forms of surface water and groundwater for irrigation and urban water supply. • Strengthen crop diversification programs for efficient water utilization.

Table 2.4.1 Outline of National Water Policy (NWPo) (2/2)

Issues	Description
Water and Industry	Standards of effluent disposal into common watercourses will be set by WARPO in consultation with DOE
Water and Fisheries and Wildlife	• Water bodies like baors, haors, beels, roadside borrow pits, etc. will, as far as possible, be reserved for fish production and development. Perennial links of these water bodies with the rivers will also be properly maintained. • Water development plans will not interrupt fish movement and will make adequate provisions in control structures for allowing fish migration and breeding.
Water and Navigation	• Water development projects should cause minimal disruption to navigation and, where necessary, adequate mitigation measures should be taken. • Minimum stream-flows in designated rivers and streams will be maintained for navigation after diversion of water for drinking and municipal purposes.
Water for Hydropower and Recreation	Recreational activities at or around water bodies will be allowed provided it is not damaging to the environment.
Water for the Environment	• Give full consideration to environmental protection, restoration and enhancement measures consistent with the National Environmental Management Action Plan (NEMAP) and the NWMP. • Adhere to a formal environmental impact assessment (EIA) process, as set out in EIA guidelines and manuals for water sector projects, in each water resources development project or rehabilitation program of size and scope specified by the Government from time to time. • Protect against degradation and resuscitate natural water-bodies such as lakes, ponds, beels, khals, tanks, etc. affected by man-made interventions or other causes.
Water for Preservation of Haors, Baors, and Beels	• Haors that naturally dry up during the winter will be developed for dry season agriculture. • Take up integrated projects in those water bodies for increasing fish production.
Economic and Financial Management	• Water charges realized from beneficiaries for O&M in a project would be retained locally for the provision of services within that project. • Effective beneficiary participation and commitment to pay for O&M will be realized at the project identification and planning stages by respective public agencies.
Research and Information Management	Develop a central database and management information system (MIS) consolidating information from various data collection and research agencies on the existing hydrological systems, supply and use of national water resources, water quality, and the eco-system.
Stakeholder Participation	• The "Guidelines for People's Participation (GPP) in Water Development Projects" be adhered to as part of project planning by all institutions and agencies involved in public sector management of water resources. • Guidelines for formation of water user groups (WUG) and similar community organizations will be formulated. • Generally 25 percent of the earthwork of any public water project will be offered to specific target groups or beneficiaries. • New projects proposed by a community or local institution will be considered for implementation on a priority basis only when the beneficiaries have mobilized a certain percentage of the total cost as their contribution to the project.

Table 2.4.2 Programs in the NC and NE Areas under LGL, LGED and LGIs

Cluster / Su-Sector	Program			Region	Location	Responsible Agency		Program Phase Phase	Starting Year	Duration (years)
	Code	ID	Title			Leading	Supporting			
Institutional Development	ID	001	Local Government Needs Assessment for Water Management	All	Nationwide	LGD	None	Short Term	2002	2
		002	Independent Regulatory Body for Water Supply and Sanitation Service Sector	All	Nationwide	LGD	MoFinance, New agencies	Short Term, Medium Term	2003	7
		005	Local Government Capacity Building for Water Management	All	Nationwide	LGIs	None	Short Term, Medium Term, Long Term	2003	25
Enabling Environment	EE	002	Field Testing of Participatory Management Models	All	Nationwide	BWDB	LGED, LGIs, CBOs	Short Term, Medium Term	2003	5
Main Rivers	MR	006	Regional River Management and Improvement	All	Nationwide, in regional phases	BWDB	LGIs	Short Term, Medium Term, Long Term	2002	25
		008	North East and South East Regional Surface Water Distribution Networks	NE, SE	NE & SE Regions	BWDB	LGED	Medium Term, Long Term	2016	5
		009	North Central and North West Regional Surface Water Distribution Networks	NW, NC	NW & NC Regions	BWDB	LGED	Long Term	2021	12
Towns and Rural Areas	TR	004	Rural Water Supply and Distribution Systems	All	Rural Areas Nationwide	DPHE	LGIs, DPHE, CBOs	Short Term, Medium Term, Long Term	2001	25
		005	Large and Small Town Sanitation and Sewerage Systems	All	Nationwide	Paurash avas	LGIs, LGED, DPHE, CBOs	Short Term, Medium Term, Long Term	2002	25
		006	Rural Sanitation	All	Rural Areas Nationwide	DPHE	CBOs, Private sector, LGIs	Short Term, Medium Term, Long Term		
		008	Large and Small Town Stormwater Drainage	All	Nationwide	Paurash avas	LGIs	Short Term, Medium Term, Long Term	2003	25
Disaster Management	DM	003	Flood Proofing in the Charlands and Haor Basin	NW, NE, RE	NW, NE, & RE Regions	NGOs	LGED	Short Term, Medium Term, Long Term	2003	10
	DM	004	National, Regional and Key Feeder Roads - Flood Proofing	NW, NC, NE, SE, SC,SW	Regions NW, NC, NE, SE, SC, SW	RHD	LGED	Short Term, Medium Term, Long Term	2001	25
Agriculture and Water Management	AW	002	Improved Performance of Existing Public Surface Water Irrigation Schemes	All	Nationwide	BWDB	BMDA, CBOs, LGIs, NGOs, Private Sector	Short Term, Medium Term, Long Term	2004	20
		003	New Public Surface Water Irrigation Schemes	All	Nationwide	BWDB	LGED	Medium Term, Long Term	2005	15
		005	Improved Water Management at Local Government Level	All	Nationwide	LGED	None	Short Term, Medium Term, Long Term	2001	24
		006	Improved Water Management at Community Level	All	Nationwide	LGED	LGIs, DAE	Short Term, Medium Term, Long Term	2001	24
		007	Rationalisation of Existing FCD Infrastructure	All	Nationwide	BWDB	LGED	Medium Term, Long Term	2007	20
Environment and Aquatic Resources	EA	006	Unspecified Regional Programmes	All	Nationwide	WARPO	DoE, DoFish, DoForest, BWDB, LGED, RHD	Medium Term, Long Term	2005	15
		008	Environmentally Critical Areas and Integrated Wetland Management	All	Nationwide	DoE	WARPO, LGIs	Short Term, Medium Term, Long Term	2003	23

Source: National Water Management Plan, WARPO, December 200

Table 2.4.3 Policy Matrix of Water Resources Development & Management

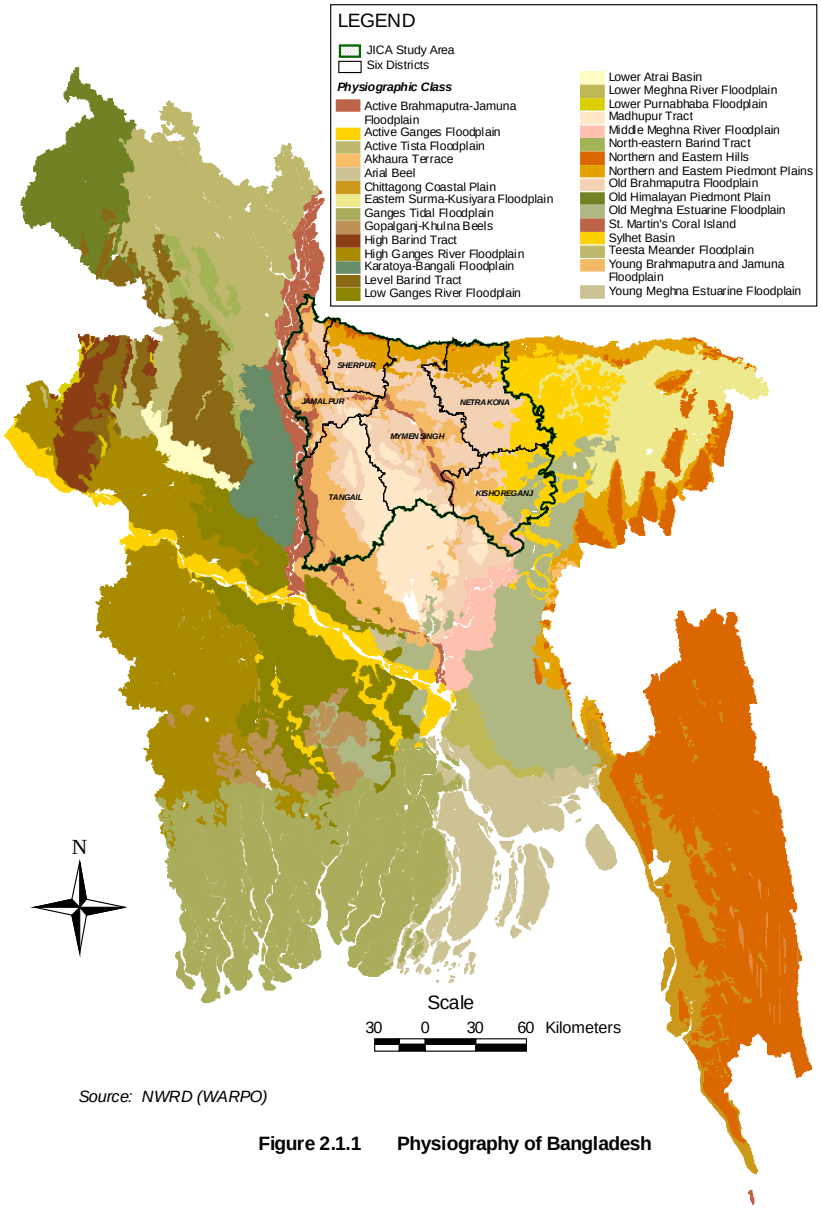
Strategic Goal	Key targets	PRSP Policy agenda (FY2005-FY2007)	Responsibilities
1. Expand utilization of Surface Water.	• Creation of additional irrigation facilities • Supply of safe water for domestic use.	• Abstraction from main rivers: • Undertake studies to determine utilization of the flow of the main rivers, • Identify suitable locations for dual purpose pump houses (to be used both for irrigation and flood reduction). • Include irrigation components in large flood control projects.	MOWR (JRC, BWDB, WARPO) MOA (DAE, BADC), MOFA, **MOLGRD & Co. (LGED, DPHE.)**
2. Rationalize utilization of ground water.	Ensuring: - Supply of safe water for domestic use - Regulate Industrial & agricultural use - Ensure conjunctive use of water.	• Monitor quality & quantity of groundwater regularly. • Promote private investment under regulatory framework. • Undertake of New FCDI Projects Start construction of Ganges Barrage and Bromoputra Barrage.	**MOLGED & Co (DPHE, LGED)**, MOEF, MOWR (IWM, WARPO) MOA, IWMU, (Integrated Water Management Unit of DAE), BADC.
3. Protect flood, improve drainage and reduce vulnerability.	• Protection of lives and properties. • Rehabilitation of 123 polders for protection of 1.28 million ha land from tidal flood and salinity intrusion.	• Fixed-agency-wise responsibilities • Gradually handover O & M of the existing projects to the beneficiaries. • Replicated Mechanism developed under Command Area Development (CAD) Projects.	MOEF (PWD), M/O. Commerce (R & H). MOWR (BWDB), MOFDM
4. Enhance access of the poor to water and common properties resources.	• Creation of Income Generating Activities (IGA) for the poor through water resources management program. • Protection of 0.28 million hectares from	• Promote community participation in multipurpose use of water & other facilities like irrigation canal, fish pass, regulators, irrigation inlets, cross dams, embankment slope, etc.	**Local Government Division (LGED)**, MOWR (BWDB, WARPO), MOEF, MOFL, MOA (DAE)
5. Augment surface water utilization (retention) in rivers, creeks and khals.	• Re-excavation of rivers, canals, derelict ponds and rainwater harvest.	• Undertake desiltation and re excavation of small rivers and canals using human labour • Initiate construction of Ganges Barrage, augmentation of flow in the Gorai river, • Replicate Tidal River Management (TRM) Programme in the (South West region) coastal zone. • Divert surface water through small barrage and large Water Control Structure (WCS). • Take up performance evaluation of the rubber dams projects.	MOWR (BWDB, WARPO), MOA, MOH, DPHE, **LGD (LGED)**.
6. Protect wetland/ Sundarban, saline water intrusion and promote accretion of land from the sea.	• Environmental protection, habitation for the poor people on the raised platforms and in the char areas.	• Undertake coordinated efforts to make the accreted land habitable and suitable for crop production. • Implement Integrated Coastal Zone Management Plan (ICZMP).	MOWR (BWDB, WARPO), MOL, MOA (DAE.).
7. Make Institutional Development of water sector agencies.	• Development of knowledge and capability for design of future water resources management plans & monitoring.	• Strengthen capacity of Disaster Management Bureau (DMB) and other organizations, i.e. BWDB, SPARSO, IWM, CEGIS, and WARPO.	**LGD**, DMB, BWDB, MOWR (BWDB, WORPO, IWM, CEGIS), BWDB.
8. Control Erosion of major rivers and protect large and small towns	• Save property worth Tk. 50000/- million • Generate employment for 470 million person day annually for construction works.	• Protect vulnerable areas from erosion, specially saving places of economic importance and densely populated areas. • Protect wet lands.	MOWR. (BWDB. WARPO, IWM)

Table 2.4.4 Rubber Dam Projects and their Impacts

Sl.	Name of Rubber Dam Project	District and Upazila	F.Y.	Planned Irrigable Area (ha)	Rubber dam				Winter Crop Area (Ha) and Production (Ton/year)				Change (+/-)		Increased Employ-ment Generation	Remarks
									Pre-Project		Post-Project					
					L(m)	H(m)	A(m2)	Cost in Tk (1,000)	Cropped Area (Ha)	Crop Production (Ton/year)	Cropped Area (Ha)	Crop Production (Ton/year)	Increased Cropped Area (Ha)	Increased Crop Production (Ton/year)		
	A	B	C	D	E	F	G	H	I	J	K	L	M=K-I	N=L-J	O	P
1.	Idgaon Rubber Dam Project	Cox's Bazar, Idgaon	1994-95	2,000	52	3.0	156.0	18,000	729	4,170.00	2,000	14,000.00	(+) 1,271	(+) 9,830.00	14,000	Pilot Project
2.	Bakkhali Rubber Dam Project	Cox's Bazar, Sadar	1994-95	6,000	84	3.5	294.0	36,000	950	8,181.00	3,000	20,000.00	(+) 2,050	(+) 11,819.00	15,000	Pilot Project
3.	Bhogai Nadi Rubber Dam Project	Sherpur, Nalitabari	1997-98	1,700	100	3.3	330.0	56,200	1,800	9,985.00	2,800	16,000.00	(+) 1,000	(+) 6,015.00	15,000	Pilot Project
	Sub-Total-I								3,479	22,336.00	7,800	50,000.00	(+) 4,321	(+) 27,664.00	44,000	
4.	Atrai Kakra Nadi Rubber Dam Project	Dinajpur, Chirirbandar	1999-2000	1,365	130	4.0	520.0	84,000	815	5,595.97	1,365	10,629.14	(+) 550	(+) 5,033.17	13,000	Only HYV boro production considered (5.5 Ton/year).
5.	Tankabati Khal Rubber Dam Project	Chittagong, Lohagara	2000-01	987	50	3.5	175.0	29,500	616	7,676.00	987	12,204.00	(+) 371	(+) 4,528.00	10,000	
6.	Kawraith-Sutia Nadi Rubber Dam Project	Gazipur, Sripur	2001-02	1,232	25	3.0	75.0	24,500	776	4,290.65	1,232	6,891.80	(+) 456	(+) 2,601.15	12,000	
7.	Sonai Nadi Rubber Dam Project	Hobigonj, Madhabpur	2001-02	1,082	45	3.5	157.5	31,900	481	3,359.00	1,082	7,570.00	(+) 601	(+) 4,211.00	13,000	Potato and Vegetables not included in the consideration.
8.	Nandakuja-Atrai Nadi Rubber Dam Project	Natore, Gurudaspur	2002-03	1,840	45	3.5	157.5	40,300	1,000	8,281.00	1,840	11,400.00	(+) 840	(+) 3,119.00	13,000	
9.	Bramahputra Nadi Rubber Dam Project	Narayangonj, Sonargaon	2002-03	1,558	54	3.5	189.0	54,400	1,000	8,426.00	1,558	14,872.00	(+) 558	(+) 6,446.00	13,000	
10.	Khasiamara Khal Rubber Dam Project	Sunamgonj, Doara Bazar	2003-04		45	3.5	157.5	33,400	650	4,110.00	Evaluation not yet done				11,000	Completed in FY.2004-2005
11.	Netai Nadi Rubber Dam Project	Mymensingh, Dhobaura	2003-04		60	3.5	210.0	50,300	630	4,095.00	Evaluation not yet done				12,000	
	Sub-Total-II								5,968	45,833.62	8,064	63,566.94	(+) 3,376	(+) 25,938.32	97,000	
12.	Sonaichari Khal Rubber Dam Project	Cox's Bazar, Ramu	2003-04		30	3.0	90.0	16,230	822	4,021.60	Evaluation not yet done				12,000	Constructed under SSWRD-2
13.	Shomesweri Rubber Dam Project	Sherpur, Jhenaigati	2003-04	940	35	2.5	87.5	14,000	972	4,365.00	Evaluation not yet done				10,000	Constructed under SAIP*
	Sub-Total-III								1,794	8,386.60	-	-	-	-	22,000	
	Total of Sub-Total I, II & III					3.3 Ave. of above			11,241	76,556.22	15,864	113,566.94	(+) 7,697 **(68%)**	(+) 53,602.32 **(70%)**	163,000	

Note : *SAIP: Smallholder Agricultural Improvement Project

Source : 10/8/2004 Provided by Md. Ismail Hossain



Source: NWRD (WARPO)

Figure 2.1.1 Physiography of Bangladesh

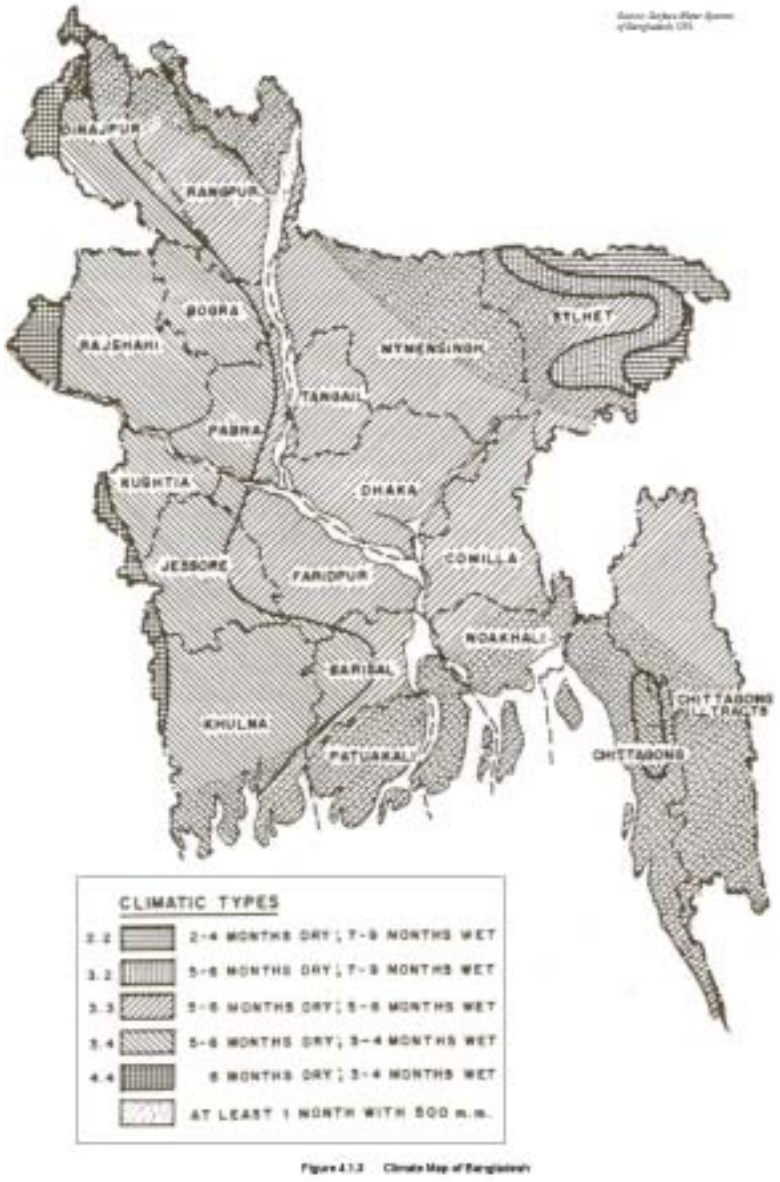
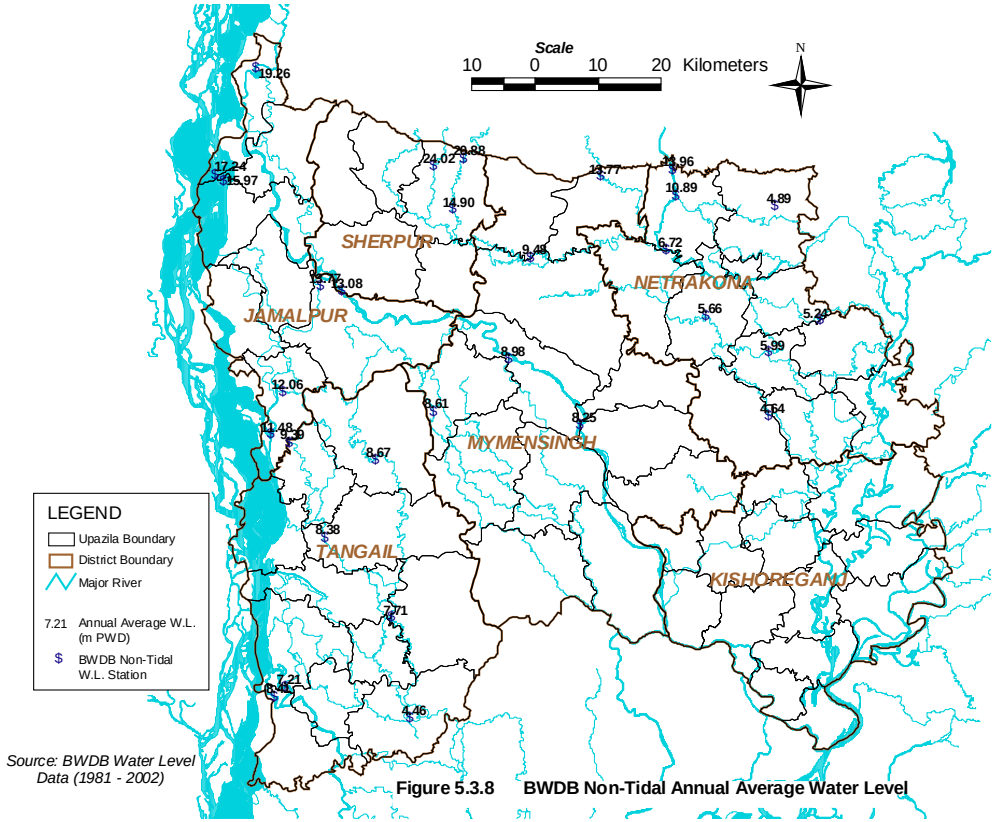


Fig. 2.1.1 Physiography of Bangladesh

Fig. 2.2.1 Climate Map of Bangladesh



Source: BWDB Water Level Data (1981 - 2002)

Figure 5.3.8 BWDB Non-Tidal Annual Average Water Level

Fig. 2.3.1 BWDB Gauging Station S and their Annual Water Level

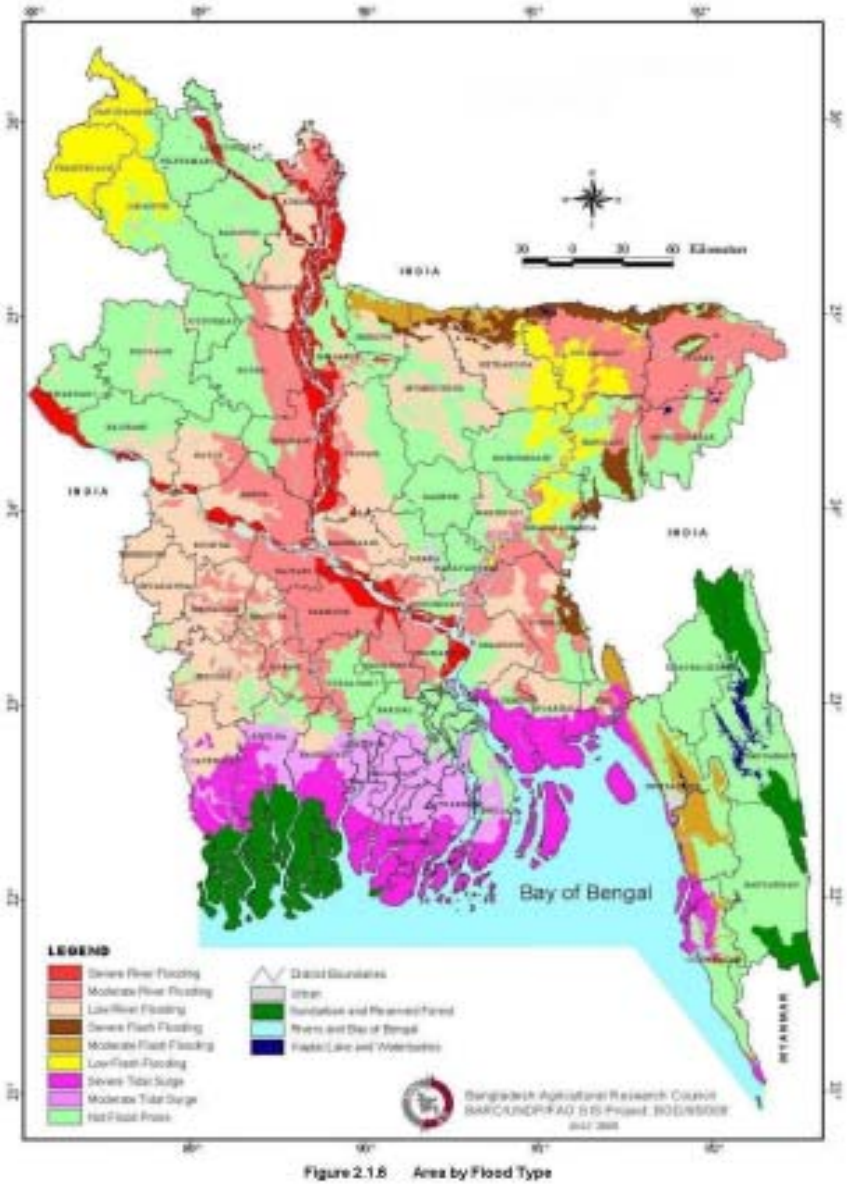


Figure 2.1.6 Area by Flood Type

Fig.2.3.2 Area by Flood Type

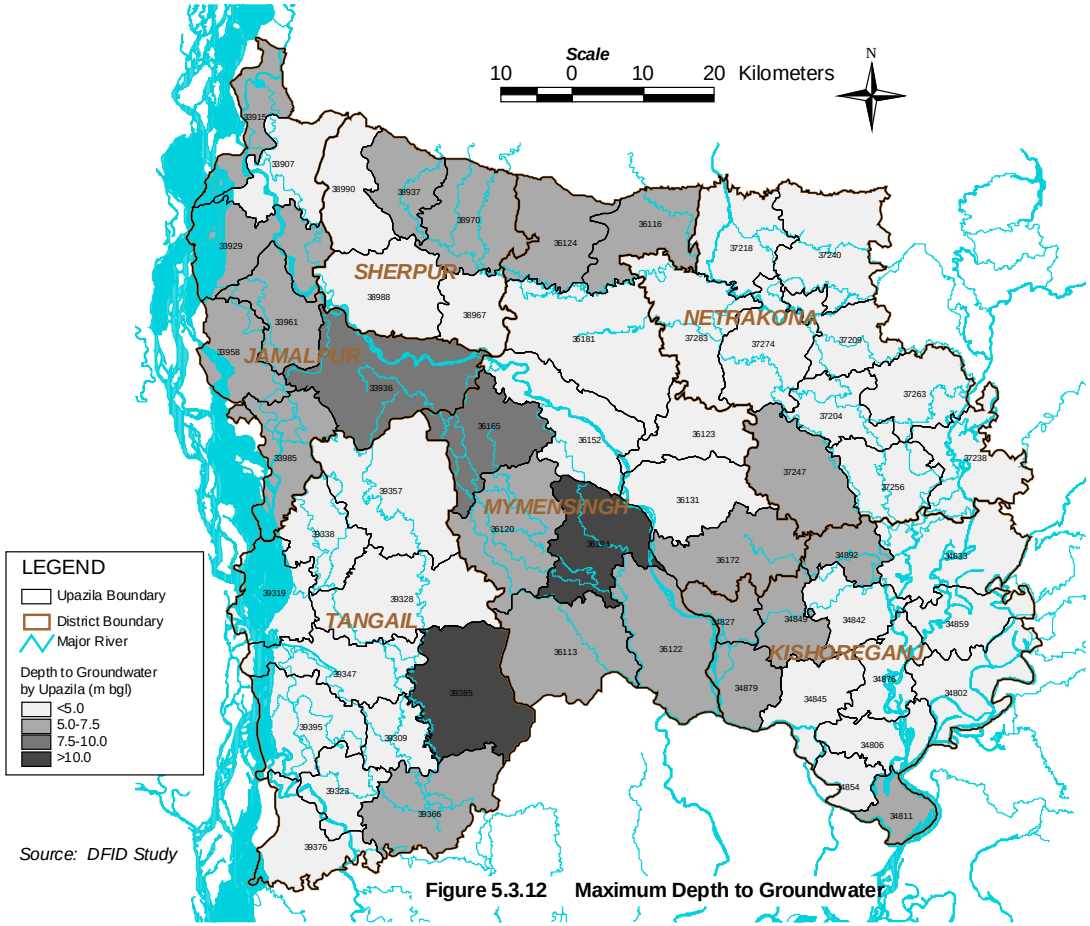


Figure 5.3.12 Maximum Depth to Groundwater

Fig. 2.3.5 Maximum Depth of Ground Water

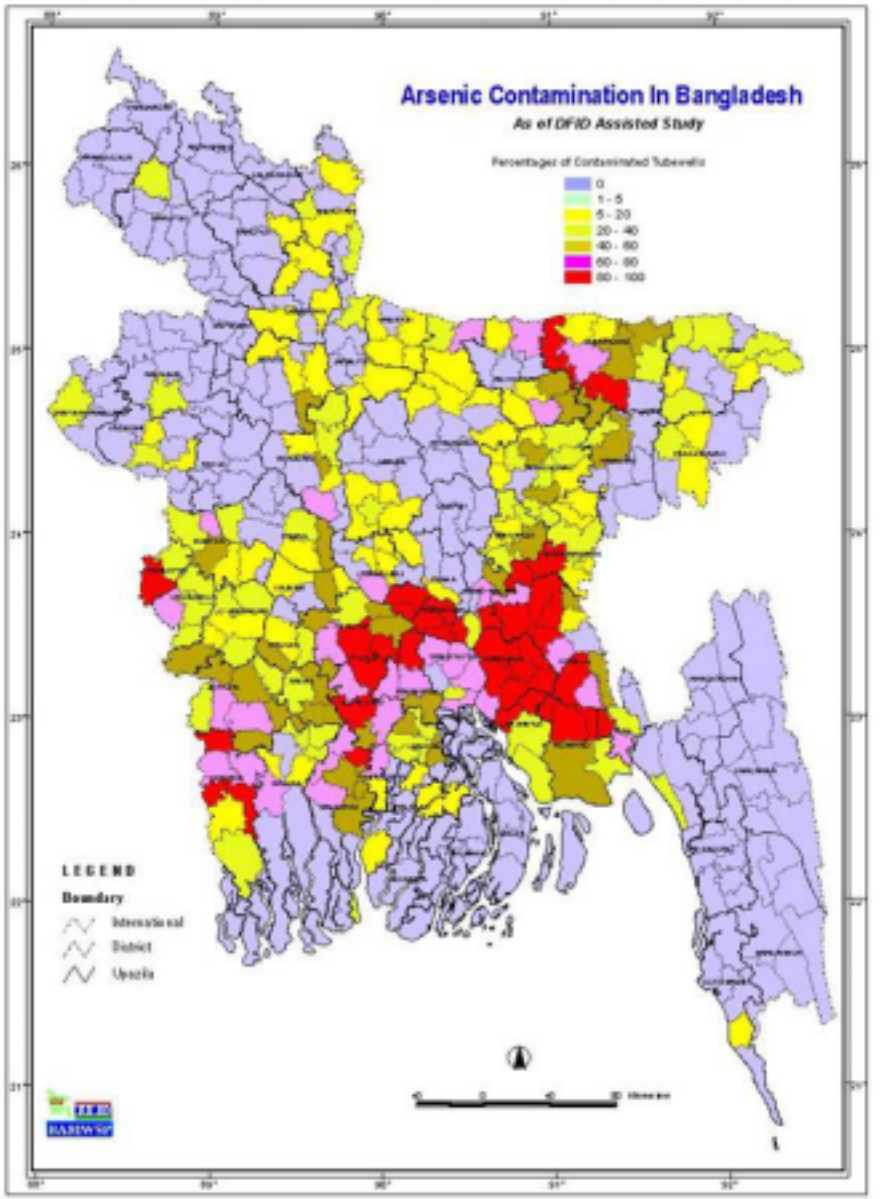


Fig. 2.3.6 Arsenic Contamination in Bangladesh

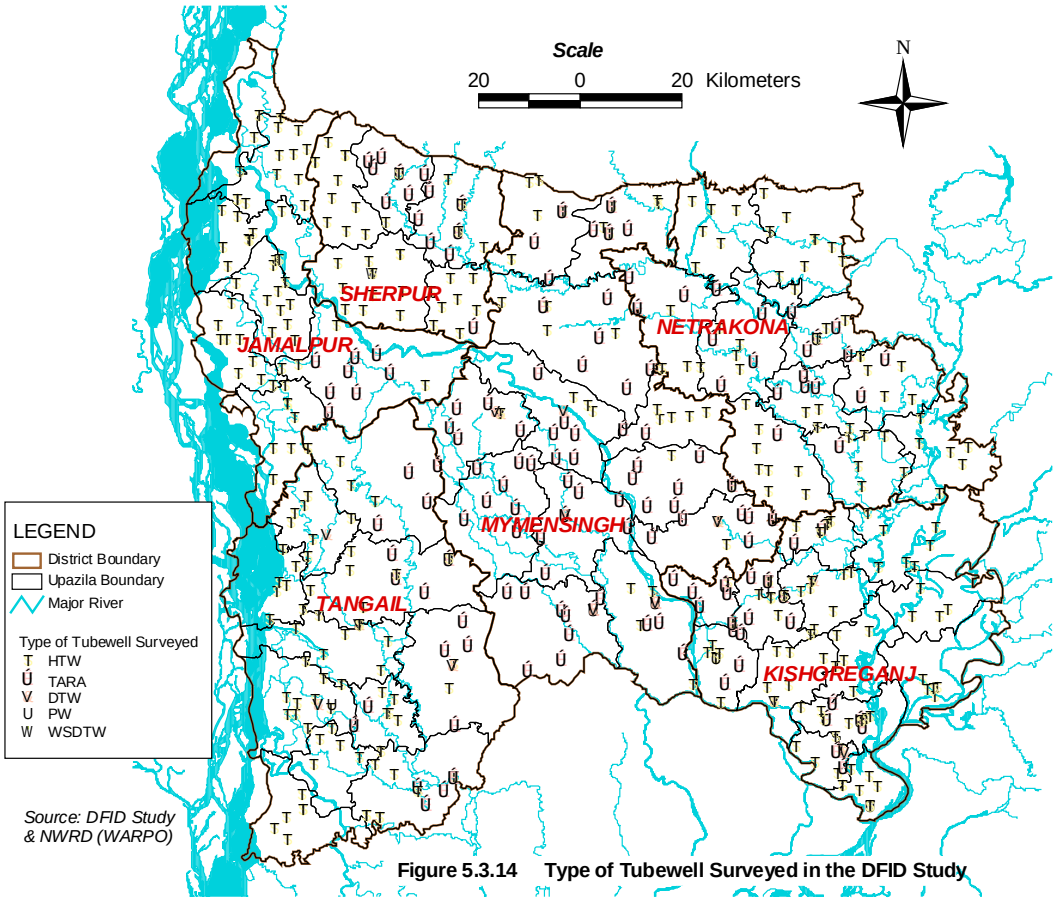


Figure 5.3.14 Type of Tubewell Surveyed in the DFID Study

Fig. 2.3.7 Arsenic Contamination in the Study Area

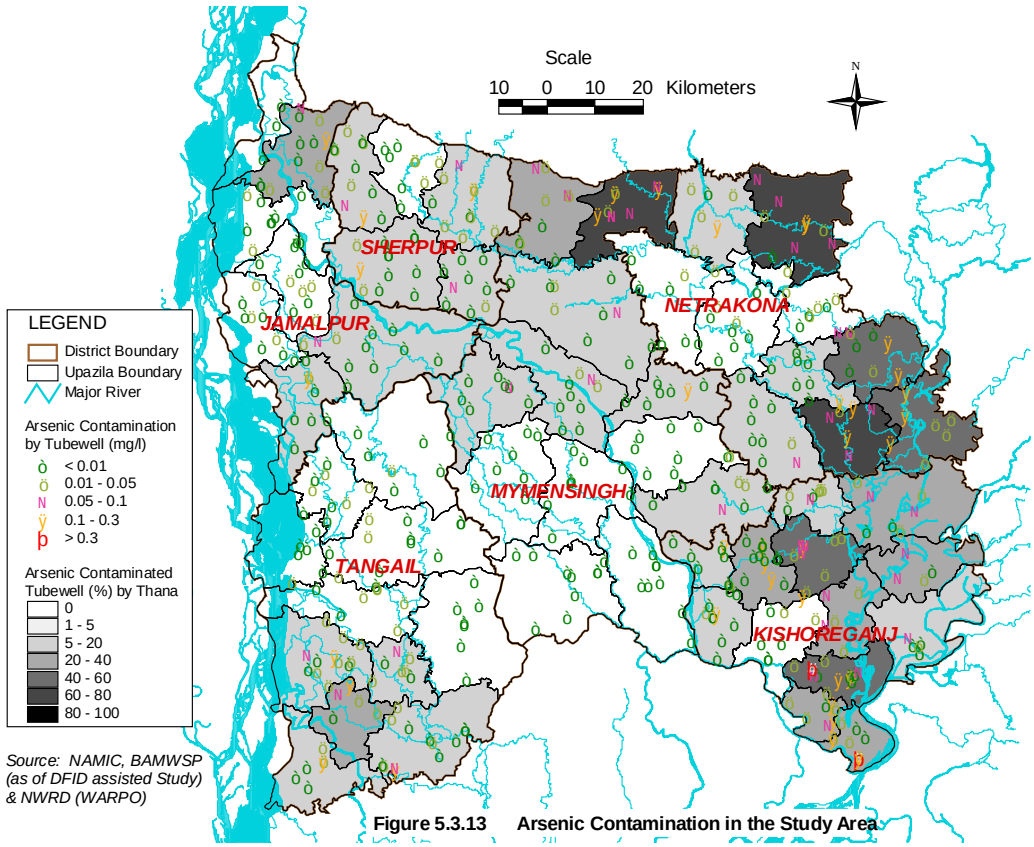


Figure 5.3.13 Arsenic Contamination in the Study Area

Fig. 2.3.8 Type of Tubewell Surveyed in the DFID Study

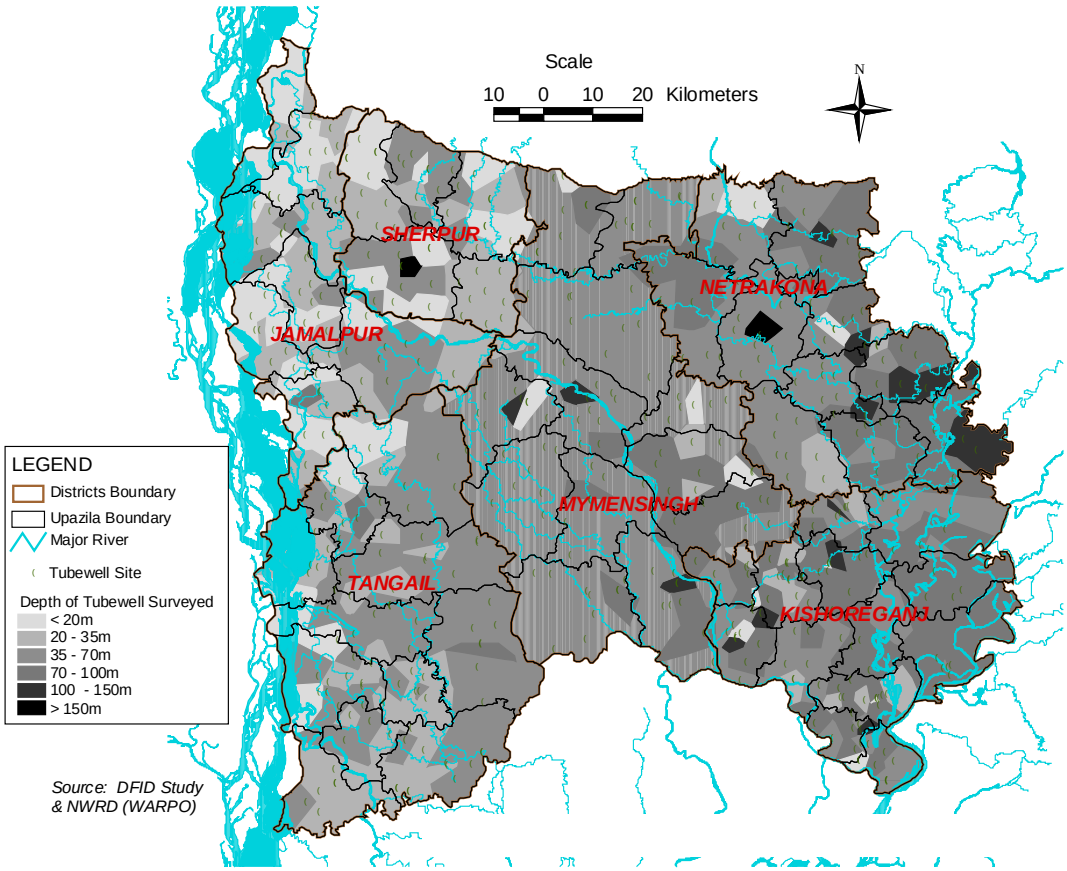


Fig. 2.3.9 Depth of Tubewell Surveyed in the DFID Study