CHAPTER 1

INTRODUCTION

Main Report

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Peoples Republic of Bangladesh has a population of 123 million (as of June 1996) and a per capita GDP (Fiscal Year 1994/1995) of US$ 235.00. Of the 48 nations categorized as LLDC, Bangladesh is the most heavily populated. Even after gaining independence, the nation repeatedly suffers from floods, cyclones, etc.; 1/3 of the nation is inundated every year. Shortage in almost all sectors (e.g. development funds, infrastructure, human resources, natural resources, etc.) also leaves both urban and rural regions very underdeveloped.

The supply of safe drinking water is an issue of significant importance to Bangladesh. Since its independence, the majority of the population use surface water (rivers, ponds, etc.) leading to rampancy in water-borne diseases. The combined efforts of UNICEF, WHO, donor countries and the government resulted in the construction of wells. At present, 95% of the national population depend on groundwater for their drinking water supply, consequently leading to the decline in the mortality rate caused by contagious diseases. This condition, however, was reversed in 1990 by problems concerning contamination brought about by high levels of arsenic detected in groundwater resources.

Groundwater contamination by high arsenic levels was officially announced in 1993. In 1994, this was confirmed in the northwestern province of Nawabganji where arsenic poisoning was detected. In the province of Bengal, in the western region of the neighboring nation, India, groundwater contamination due to high arsenic levels has been a problem since the 1980s. Although the researchers of the Jadapur University in Calcutta were studying this problem, doctors of NIPSOM (National Institute of Preventive and Social Medicine) and DCH (Dhaka Community Hospital) have only started their research work. Studies carried out in the western region of Bengal also indicated the possible danger of arsenic contamination extending over a wide area in the Ganges delta where the topography and geology is similar to western Bengal. Consequently, medical institutions, NGO, international agencies and the Bangladeshi government started studies on the area as well.

These studies confirmed that, until 1996, arsenic contamination was not limited to the western region and also affected more than 2/3 of the national territory. By the end of 1999, groundwater resources in 59 of the 64 districts of Bangladesh - excluding mountain and hilly regions - were confirmed to be highly contaminated with arsenic. The current number of patients poisoned by arsenic is more than 7,000, while the population at risk is estimated at a minimum of 20 million and a maximum of 70 million.

To counter-act this state of emergency, the Bangladeshi government, fully acknowledging the significance of the problem to the development of the nation as whole, organized a national arsenic steering committee in 1996, appointing the Minister of Health & Family Welfare (MoHFW) as chairman and representative of relevant agencies as members. International agencies such as UNICEF, World Bank and WHO, international cooperation agencies and domestic and foreign NGOs also carried out studies on arsenic contamination in the nation. In 1998, the 15 years BAMWSP (Bangladesh Arsenic Mitigation Project) commenced.

Despite the fact that 7 years have elapsed since the problem has been officially confirmed, the government has still neither identified actual conditions, nor fully determined arsenic mechanism in groundwater resources, nor implemented any concrete countermeasures.

To determine suitable means of tackling this critical problem, JICA dispatched a project formulation team to Bangladesh for a month, from March to April 1998. The team held discussions with the DPHE, relevant government agencies, international agencies, and the NGO. It conducted field studies and proposed measures to solve the problem.

In December 1998, JICA dispatched to DPHE 3 experts to provide short-term technical assistance in the implementation of studies on actual conditions of arsenic contamination and the formulation of countermeasures. The groundwater development study for the adoption of countermeasures is planned for the 3 districts in the western region of Bangladesh. These districts were selected as candidate study sites due to very high arsenic levels in groundwater and difficulty in securing surface water as an alternative water source.

Given the above background, the Government of Bangladesh requested the technical assistance of the Government of Japan in 1999 for the implementation of the development study. In response, the Japanese government dispatched a preliminary study team to Bangladesh in December 1999; the team concluded the S/W thereafter.

The Study Team commenced the first phase of the study in May 2000 and submitted the Progress Report (P/R) in October 2000. The P/R was compiled based on the field work conducted from May to September 2000.

The study was continuously carried out in the second phase from October 2000 to March 2001 and the Study Team submitted the Interim Report (IT/R) in March 2001. In the third phase from April 2001 to March 2002, the study was carried out mainly focusing on formulation of the master plan and pre-feasibility study of the priority projects. In the fourth phase, the Draft Final Report Seminar and water quality reanalysis was conducted from September to November 2002. This Final Report was compiled based on all of the survey results conducted from the first to fourth phase.

1.2 Objectives of the Study

The objectives of the study are enumerated below.

(1) To formulate the master plan for development of groundwater resources in arsenic affected areas in western Bangladesh.

(2) To conduct pre-feasibility study on the project with higher priority.

(3) To transfer technology to counterpart personnel in the course of the study.

1.3 Study Area

The areas for the study are the three western districts of Chuadanga, Jhenaidha, and Jessore. It is a part of the Ganges Delta and located in the right side of the Ganges River (the Padma River in Bangladesh). It comprises an area of 5,686km^2 and lies between 22º 80'and 23º 80' of the north latitude, and between 88º 60' and 89º 50' of the east longitude (Location Map).

The District is administratively subdivided into Thana, Union and Mouza. The population of these three districts and eighteen Thana are shown in Table 1.1 The study area is made up of 197 Union and 2,620 Mouza and a total population of about 5,088,000.

1.4 Study Implementation

This study will be implemented in 3 phases as detailed below.

Phase I:	Study on present conditions & Database construction
Phase II:	Deep Well Drilling and Verification Experiments for Arsenic Removal Equipment & Master Plan (M/P) Preparation
Phase III:	Pre-feasibility Study for the Priority Projects Selected in the M/P

1.5 Study Team

For this study, the Department of Public Health Engineering (DPHE) which is under the Ministry of Local Government, Rural Development & Cooperatives (MLGRD&C), acts as the counterpart agency. The JICA Study Team experts and the counterpart personnel from the DPHE offices of Dhaka, District and Thana carried out the study jointly.

JICA Study Team

Dr. Akira Kamata	Team Leader
Dr. Naoaki Shibasaki	Co-Leader, Hydrogeology (1)
Mr. Tsuguo Ishikawa	Hydrogeology (2)
Mr. Kazuyuki Suenaga	Hydrogeology (3)
Mr. Toshiyuki Matsumoto	Co-Leader, Hydrogeology (4)
Mr. Munehiro Fukuda	Water Quality Analysis (1)
Mr. Takeshi Higo	Water Quality Analysis (2)
Mr. Masatoshi Tanaka	Drilling Supervision (1)
Mr. Kazuro Bando	Drilling Supervision (2)
Mr. Toshiharu Yoshitake	Water Supply Plan & Facility Design (1)
Mr. Satoshi Ishida	Water Supply Plan & Facility Design (2)
Mr. Takeshi Nakano	Facility Design & Cost Estimate
Mr. Satoshi Sugimoto	Economy & Finance
Ms. Kaoru Oka	Social & Environmental Consideration (1)
Mr. Isao Endo	Social & Environmental Consideration (2)
Dr. Lei Peifeng	Information System (GIS)
Mr. Akio Tajima	Web Site Construction
Mr. Masashi Shimoda	Survey and Mapping Supervision (1)
Mr. Kazuhiro Ishizuka	Survey and Mapping Supervision (2)
Mr. Masahiko Ikemoto	Coordination

Table 1.1 Administration Units, Population and Area of the Study Area

District	Thana	No. of Union	No. of Mouza	Population	Area (km2)
Jessore	Jhikargachha	11	163	280,738	2,578
	Sharsha	11	135	308,002	
	Keshabpur	9	140	238,306	
	Jessore Sadar	16	245	631,480	
	Chaugachha	11	141	216,407	
	Monirampur	17	245	388,104	
	Abhaynagar	8	89	243,572	
	Bagherpara	9	156	201,064	
	Subtotal	92	1314	2,507,673	
Jhenaidah	Sailkupa	15	169	349,124	1,950
	Harinakunda	8	78	192,900	
	Moheshpur	13	156	293,197	
	Kotchandpur	6	80	127,577	
	Kaliganj	12	185	260,796	
	Jhenaidah Sadar	18	265	396,553	
	Subtotal	72	933	1,620,147	
Cuadanga	Chuadanga Sadar	8	101	265,701	1,158
	Alamdanga	14	125	292,214	
	Jibannagar	4	70	148,892	
	Dhamurhuda	7	77	253,851	
	Subtotal	33	373	960,658	
TOTAL	18	197	2,620	5,088,478	5,686

Data source: Administration units: LGED (1994)
Population: DfID (1999)
Area: BBS (1997)

CHAPTER 2

NATURAL ENVIRONMENT OF THE STUDY AREA

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2.1 Climate

The study area, which covers Chuadanga, Jhenaidah and Jessore districts, is located in the western part of Bangladesh. The climate conditions in and around the study area are reviewed based on the existing available data.

2.1.1 Overview of Climatic Conditions

In Bangladesh, the climate data of the country are collected and managed by the climate division of the Bangladesh Meteorological Department (BMD). In addition, worldwide climatologic data including that of Bangladesh are presented in the Global Historical Climatology Network (GHCN version 2) in the National Climatic Data Center (NCDC), USA. There are 27 meteorological stations in Bangladesh that are recorded in the GHCN database as shown in Table 2.1.1. The location of the meteorological stations is shown in Figure 2.1.1. In the study area, there is one (1) station (WMO Station No. 41936) at Jessore airport.

1) Precipitation

Table 2.1.2 shows the average monthly precipitation in Bangladesh based on the GHCN database. At Jessore station, the monthly precipitation data available are from 1947 to 1995. The average annual precipitation at Jessore is 1,611.4mm, which is the second smallest value in Bangladesh.

Figure 2.1.2 shows the distribution of the average annual precipitation in Bangladesh. The average annual precipitation is more than 3,000mm in the northeastern and southeastern parts of Bangladesh. Although there is one meteorological station in the study area, it can be said that the study area is located in the area with the least precipitation in the country.

The monthly precipitation data at Jessore station from 1947 to 1995 retrieved from the GHCN database are tabulated in Table 2.1.3. The average monthly precipitation in June is 309.6mm, which is the yearly maximum, followed by July (= 305.4mm) and August (= 294.0mm). On the other hand, the month of December has a minimum average monthly precipitation of 6.9mm. From the table, it is understood that about 89% of the total rainfall occurs in the rainy season from May to October.

The distribution of the average monthly precipitation in Bangladesh is shown in Figure 2.1.3. It is common that the monthly precipitations of June, July and August are high in Bangladesh, however, the maximum monthly precipitation does not exceed 400mm at Jessore, Khulna, Rajshahi and Dhaka stations. The pattern of the average monthly rainfall at Jessore station is similar to that of Khulna, but it is different from Rajshahi where July has a clear peak of monthly precipitation.

2) Temperature

In the GHCN database, there are 20 stations having data on the monthly temperature in Bangladesh. The data on the monthly average temperature, the monthly average maximum temperature, and the monthly average minimum temperature are recorded as shown in Tables 2.1.4, 2.1.5, and 2.1.6, respectively.

Figure 2.1.4 shows the distribution of the average annual temperature in Bangladesh with the graphs of the average monthly mean, and the maximum and minimum temperatures at selected stations. The lowest average annual temperature is 24.8ºC at Sylhet and the highest average annual temperature is 26.6ºC at Khulna station. The study area is located in a relatively high-temperature zone in the country; the average annual temperature ranges from 26.0 to 26.4ºC. The monthly average temperature graph in Jessore is characterized by the clear peak of the monthly average maximum temperature in March, April and May; indicating hot and dry weather in the latter part of the dry season.

Tables 2.1.7, 2.1.8, and 2.1.9 show the monthly mean of the daily temperature, the monthly mean of the maximum daily temperature, and the monthly mean of the minimum daily temperature, respectively at the Jessore station from 1949 to 1989. The average monthly mean of the daily temperature is more than 30.0ºC in April and May, whereas the temperature is below 20.0ºC in January and December. The highest average monthly mean of the maximum daily temperature is 36.2ºC in April. The lowest average monthly mean of the minimum daily temperature is 11.2ºC in January.

3) Potential Evapotranspiration

Evaporation data are not included in the GHCN database so that the potential evapotranspiration (*PETP*) values are computed by the Thornthwaite method. The Thornthwaite method requires the monthly average temperature and daytime modifiers to compute the values of PETP.

The following equations are presented by Thornthwaite (1948) to compute *PETP* values:

$$PETP = 1.6\left(\frac{10T}{I}\right)^{a} \qquad (2.1.1)$$

$$I = \sum_{i=1}^{12}\left(\frac{T_i}{5}\right)^{1.514} \qquad (2.1.2)$$

$$a = \left(492390 + 17920I - 77.1I^{2} + 0.675I^{3}\right)\times 10^{-6} \qquad (2.1.3)$$

where T is the monthly average temperature (ºC).

The daytime modifiers are extrapolated based on the daytime modifier table presented by

Thornthwaite (1948) and the latitude value at the station.

Table 2.1.10 shows the result of PETP computations at Jessore station using the monthly average temperature values obtained from the GHCN database. According to the result, the highest PETP value is computed as 7.92mm/day in May and the lowest PETP value is 1.13mm/day in January. The average annual PETP value at Jessore station is 1,789.0mm, which is more than the average annual precipitation of 1,611.4mm.

Figure 2.1.5 shows the distribution of the average annual PETP with graphs of average monthly PETP and average monthly precipitation at selected stations. The average annual PETP values range from 1,450mm in the northeastern part to 1,850mm in southwestern Bangladesh. The average annual PETP value in the study area is estimated to be from 1,750 to 1,850mm. According to the data at Jessore station, the average monthly precipitation exceeds the average monthly PETP only in June to September.

4) Correlation of Annual Rainfall

Correlations of annual rainfall among the meteorological stations of Jessore, Faridpur, Dhaka, Khulna, Satkhira, and Calcutta were examined based on the GHCN database. The results are shown in Figures 2.1.6 to 2.1.8

It is understood from the results that the correlation coefficients of Jessore-Khulna and Jessore-Satkhira are 0.687565 and 0.595917, which are smaller than the coefficients of Jessore-Faridpur (= 0.81566) and Jessore-Dhaka (= 0.732155) even though Khulna and Satkhira stations are located in adjacent districts of Jessore. In addition, the correlation coefficient between Khulna and Satkhira is also poor (= 0.456597). It is, therefore, presumed that the occurrence of rainfall near the coastal area differs from place to place, which may be due to localized showers and thunderstorms in the rainy season.

The correlation coefficient of annual rainfall between Jessore and Calcutta is 0.61234, showing better correlation than that of Jessore-Khulna and Jessore-Satkhira.

5) Probability Analysis of Annual Rainfall

Probability analysis of annual rainfall at Jessore and Khulna stations was done by the Hazen plot method as shown in Figure 2.1.9. Return periods of flood years and drought years are also computed. From the results, the annual rainfall during a drought year of 100 years return period at Jessore is estimated as 890mm, whereas that at Khulna station is estimated as 1,000mm. On the other hand, the rainfall during a flood year of 100 years return period at Jessore and Khulna stations are estimated as 2,320 and 3,030mm, respectively.

Therefore, it can be said that the drought is severe in Jessore and the flooding is severe in Khulna.

6) Long-term Rainfall Analysis

Long-term rainfall analysis is important to understand the changes of the groundwater environment because rainfall is one of the important sources of groundwater recharge. In Bangladesh, rainfall data are available from 1947; that is insufficient for long-term rainfall analysis.

According to the GHCN database, the monthly rainfall has been recorded at Alipore station in Calcutta (WMO Station No.42807) since 1829. Figure 2.1.10 shows the result of a long-term rainfall analysis for Calcutta. The yearly rainfall from 1829 to 1990, the 5 years running average, and its polynomial fit are presented in the graph.

The 5 years running average values are plotted between 1,400 mm/year and 2,000 mm/year. Increasing trends of the polynomial fit are seen in periods from 1829 to 1860, 1895 to 1925, and 1955 to 1990. It is noted that the increasing trend of the polynomial fit after 1980 is very steep. Although the correlation coefficient of annual rainfall between Jessore and Calcutta is 0.61234 as mentioned before, it is estimated that the long-term rainfall pattern of the study area is similar to that of Calcutta. This suggests that the groundwater recharge from the rainfall has increased in the study area, particularly after 1980.

2.1.2 Rainfall and Evaporation in the Study Area

There are 8 meteorological stations in the study area based on the information from BMD and BWDB. The list of the meteorological stations is shown Table 2.1.11. Daily rainfall data have been recorded at 1 station in Chuadanga district, 3 stations in Jhenaidah district, and 4 stations in Jessore district as shown in Figure 2.1.11. Evaporation data are only recorded at Jessore station.

Table 2.1.12 shows the monthly availability of daily meteorological data in the study area. Although the study team collected the data for the period from 1988 to 1999, there are some missing and/or erroneous data. Therefore, it is difficult to evaluate the conditions of rainfall and evaporation throughout the period over the study area.

1) Rainfall

From the daily-basis rainfall data, the average annual rainfall was computed at each station. There are only 4 years from 1991 to 1994 in which all the data were recorded. Figure 2.1.12 shows the distribution of the average annual rainfall in the study area. The blue contour lines indicate the average annual rainfall computed from the data for the said period. The red contour lines show the distribution based on the data from 1988 to 1999 with some missing data. The figure shows that the central part of the study area has more than 1,800 mm/year of annual rainfall. On the other hand, Chuadanga and Jessore have less than 1,600 mm/year of annual rainfall.

Tables 2.1.13 to 2.1.20 show the monthly rainfall at the meteorological stations. The average monthly rainfalls were then computed and the graphs are presented in Figure 2.1.13. The monthly rainfall is clearly high in the rainy season from May to October. At Chaugacha and Kaliganj, rainfall in July is greater than that of other stations.

2) Evaporation

Actual daily pan-evaporation has been measured at Jessore station. The data for the period from April 1988 to March 1995 were collected. Tables 2.1.21 and 2.1.22 summarizes the monthly evaporation. The month of April has the highest average evaporation of 113.1mm/month. The lowest evaporation is 48.6mm/month recorded in January. The monthly average values of daily evaporation in January and April are 1.6 and 3.8mm, respectively.

Figures 2.1.14 and 2.1.15 show the daily rainfall and daily evaporation at Jessore from 1990 to 1994. It is seen that the daily evaporation is influenced by the occurrence of daily rainfall. The daily evaporation in the hot and dry period from April to May rises up to 5mm/day.

The daily rainfall and evaporation data can be used for computing groundwater recharge by the tank model, which employs the water balance equation for ground surface to groundwater table.

Table 2.1.1 List of Meteorological Stations in Bangladesh

Serial No.	Country No.	WMO Station No.	Modifier No.	Station Name	Latitude (deg-N)	Longitude (deg-E)	Elevation (m)
1	203	41859	0	RANGPUR	25.7	89.2	33
2	203	41863	0	DINAJPUR	25.6	88.7	36
3	203	41863	1	DINAJPUR	25.7	88.7	37
4	203	41883	0	BOGRA	24.9	89.4	20
5	203	41886	1	MYMENSINGH	24.7	90.4	19
6	203	41891	0	SYLHET	24.9	91.9	35
7	203	41895	1	RAJSHAHI	24.4	88.7	20
8	203	41898	2	SIRAJGANJ	24.5	89.7	15
9	203	41907	2	ISHURDI	24.1	89.1	14
10	203	41907	3	PABNA	24.0	89.3	15
11	203	41915	0	SRIMANGAL	24.3	91.7	23
12	203	41923	0	DHAKA	23.8	90.4	7
13	203	41923	2	DACCA	23.8	90.4	9
14	203	41923	3	NARAYANGANJ	23.6	90.5	10
15	203	41929	0	FARIDPUR	23.6	89.8	8
16	203	41933	0	COMILLA	23.4	91.2	9
17	203	41933	2	BRAHMANBARIA	24.0	91.1	10
18	203	41936	0	JESSORE	23.2	89.2	12
19	203	41941	0	CHANDPUR	23.3	90.7	6
20	203	41946	0	SATKHIRA	22.7	89.1	4
21	203	41947	0	KHULNA	22.8	89.5	3
22	203	41950	0	BARISAL	22.8	90.4	3
23	203	41951	0	BHOLA	22.7	90.6	4
24	203	41953	0	MAIJIDICOURT	22.9	91.1	5
25	203	41966	1	RANGAMATI	22.6	92.2	63
26	203	41977	0	CHITTAGONG AMABAGAN	22.4	91.8	14
27	203	41992	0	COX'S BAZAR	21.4	92.0	4

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.2 Average Monthly Precipitation in Bangladesh

Serial No.	Station Name	Latitude (deg-N)	Longitude (deg-E)	Average Precipitation (mm)													Data Available Year	
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YAER	From	To
1	RANGPUR	25.7	89.2	7.1	9.2	24.7	71.9	271.1	430.9	501.4	343.5	293.0	141.5	7.5	6.1	2107.9	1954	1991
2	DINAJPUR	25.6	88.7	12.4	2.7	11.6	57.7	182.0	278.3	557.7	393.0	241.8	141.0	4.9	11.3	1894.4	1947	1988
3	DINAJPUR	25.7	88.7	14.4	8.1	14.8	47.6	162.0	364.3	355.1	305.3	248.7	138.3	6.5	0.3	1665.3	1947	1963
4	BOGRA	24.9	89.4	10.2	11.4	22.6	62.8	202.1	327.1	386.8	314.1	267.3	149.5	13.9	5.6	1773.4	1947	1995
5	MYMENSINGH	24.7	90.4	10.8	18.1	42.3	104.6	263.5	487.4	405.8	375.8	320.0	199.8	16.7	1.5	2246.2	1947	1977
6	SYLHET	24.9	91.9	10.8	26.4	105.4	348.0	556.8	812.4	800.1	621.3	512.7	241.7	24.9	7.8	4068.3	1947	1995
7	RAJSHAHI	24.4	88.7	15.6	9.8	29.2	29.2	111.4	244.3	361.0	253.7	212.0	114.2	14.4	1.4	1396.3	1947	1976
8	SIRAJGANJ	24.5	89.7	14.0	20.0	34.2	78.6	227.6	322.2	356.5	318.0	245.8	154.7	26.0	1.6	1799.1	1947	1976
9	ISHURDI	24.1	89.1	12.1	14.1	19.7	86.9	189.2	324.6	323.7	321.9	224.1	149.8	16.0	0.9	1683.1	1947	1977
10	PABNA	24.0	89.3	20.1	21.4	37.9	56.2	155.6	297.9	249.7	295.6	245.4	229.4	15.6	3.1	1627.8	1947	1962
11	SRIMANGAL	24.3	91.7	8.4	26.5	84.6	227.4	390.6	502.1	353.5	316.2	270.1	176.0	38.5	6.7	2400.5	1947	1989
12	DHAKA	23.8	90.4	6.8	20.0	54.4	131.4	281.7	376.9	386.8	311.6	274.8	164.1	31.8	8.5	2048.8	1953	1995
13	DACCA	23.8	90.4	8.0	20.8	58.4	115.8	267.2	357.7	399.0	317.2	256.3	163.8	30.1	5.8	2000.0	1947	1977
14	NARAYANGANJ	23.6	90.5	9.1	18.7	56.2	178.7	240.2	379.8	376.3	336.6	248.5	162.0	34.5	2.2	2042.8	1947	1977
15	FARIDPUR	23.6	89.8	5.3	17.2	40.3	126.5	229.2	358.3	356.8	298.0	257.2	162.2	28.5	7.2	1886.5	1948	1991
16	COMILLA	23.4	91.2	6.8	22.4	43.0	149.4	269.9	462.0	472.6	411.1	278.0	183.2	45.8	5.0	2349.2	1947	1991
17	BRAHMANBARIA	24.0	91.1	11.3	21.3	73.1	144.4	248.1	427.4	323.4	224.8	249.4	144.6	50.4	2.1	1920.4	1947	1963
18	JESSORE	23.2	89.2	10.4	18.6	38.2	79.0	156.8	309.6	305.4	294.0	227.4	138.3	26.7	6.9	1611.4	1947	1995
19	CHANDPUR	23.3	90.7	5.8	9.6	45.8	165.5	260.5	385.2	447.0	360.2	257.6	120.5	34.4	8.2	2100.4	1948	1991
20	SATKHIRA	22.7	89.1	7.6	22.7	30.0	71.2	145.5	294.7	353.4	324.9	266.2	142.8	24.9	8.1	1691.9	1948	1989
21	KHULNA	22.8	89.5	7.6	16.0	39.3	84.8	178.3	344.8	350.9	288.7	219.2	138.4	24.8	3.8	1696.7	1948	1990
22	BARISAL	22.8	90.4	7.7	17.8	37.9	97.1	208.8	417.4	428.0	368.4	304.8	189.2	39.9	11.1	2127.9	1949	1990
23	BHOLA	22.7	90.6	1.7	25.3	37.0	139.7	271.7	505.1	480.6	417.3	304.6	158.1	51.0	4.3	2396.3	1952	1989
24	MAIJIDICOURT	22.9	91.1	12.4	15.3	46.9	113.6	308.4	595.4	735.6	648.7	375.7	228.4	51.9	7.2	3139.4	1952	1992
25	RANGAMATI	22.6	92.2	6.1	18.8	32.9	105.9	216.2	617.0	644.4	450.6	278.9	187.5	62.8	14.9	2636.0	1947	1977
26	CHITTAGONG AMABAGAN	22.4	91.8	5.6	15.4	51.4	126.6	245.6	565.3	746.5	538.6	284.9	218.5	55.6	8.3	2862.2	1947	1990
27	COX'S BAZAR	21.4	92.0	7.6	11.4	17.9	92.4	280.0	821.2	983.6	736.4	363.8	250.3	68.8	15.5	3648.9	1948	1995

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.3 Monthly Precipitation Data at Jessore (WMO Station No. = 41936)

Country No.	WMO Station No.	Modifier No.	Station Name	Year	Precipitation (mm) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
203	41936	0	JESSORE	1947	-	-	-	-	-	-	-	366.0	281.0	89.0	0.0	14.0	-
203	41936	0	JESSORE	1948	5.0	63.0	72.0	113.0	6.0	325.0	286.0	371.0	124.0	224.0	50.0	0.0	1639.0
203	41936	0	JESSORE	1949	13.0	2.0	30.0	320.0	234.0	248.0	362.0	314.0	167.0	224.0	0.0	0.0	1914.0
203	41936	0	JESSORE	1950	0.0	14.0	40.0	41.0	86.0	558.0	280.0	327.0	149.0	61.0	124.0	0.0	1680.0
203	41936	0	JESSORE	1951	0.0	0.0	34.0	18.0	170.0	123.0	278.0	244.0	150.0	225.0	27.0	0.0	1269.0
203	41936	0	JESSORE	1952	0.0	0.0	37.0	122.0	94.0	278.0	306.0	205.0	210.0	117.0	10.0	0.0	1379.0
203	41936	0	JESSORE	1953	7.0	8.0	114.0	10.0	180.0	355.0	346.0	474.0	376.0	12.0	20.0	0.0	1902.0
203	41936	0	JESSORE	1954	21.0	3.0	0.0	34.0	197.0	674.0	196.0	407.0	166.0	109.0	0.0	0.0	1807.0
203	41936	0	JESSORE	1955	0.0	6.0	11.0	62.0	126.0	184.0	311.0	207.0	80.0	91.0	63.0	0.0	1141.0
203	41936	0	JESSORE	1956	13.0	19.0	57.0	33.0	230.0	367.0	316.0	354.0	309.0	30.0	20.0	0.0	1748.0
203	41936	0	JESSORE	1957	27.0	38.0	0.0	30.0	15.0	332.0	377.0	144.0	83.0	60.0	0.0	0.0	1106.0
203	41936	0	JESSORE	1958	10.0	23.0	0.0	72.0	161.0	74.0	271.0	166.0	108.0	51.0	2.0	0.0	938.0
203	41936	0	JESSORE	1959	19.0	10.0	31.0	81.0	314.0	204.0	209.0	477.0	267.0	509.0	0.0	0.0	2121.0
203	41936	0	JESSORE	1960	0.0	0.0	22.0	0.0	137.0	97.0	537.0	144.0	212.0	104.0	5.0	0.0	1258.0
203	41936	0	JESSORE	1961	20.0	50.0	20.0	10.0	150.0	360.0	200.0	390.0	130.0	50.0	1.0	0.0	1381.0
203	41936	0	JESSORE	1962	-	30.0	3.0	120.0	110.0	230.0	-	320.0	270.0	220.0	0.0	0.0	-
203	41936	0	JESSORE	1963	0.0	0.0	34.0	81.0	28.0	-	-	165.0	270.0	170.0	-	1.0	-
203	41936	0	JESSORE	1964	1.0	2.0	5.0	186.0	62.0	209.0	518.0	178.0	127.0	442.0	49.0	1.0	1780.0
203	41936	0	JESSORE	1965	0.0	22.0	41.0	25.0	142.0	579.0	273.0	-	-	-	-	-	-
203	41936	0	JESSORE	1966	-	0.0	0.0	34.0	230.0	278.0	158.0	223.0	124.0	192.0	12.0	12.0	1263.0
203	41936	0	JESSORE	1967	13.0	0.0	24.0	-	-	147.0	197.0	239.0	279.0	71.0	0.0	0.0	-
203	41936	0	JESSORE	1968	0.0	1.0	20.0	15.0	87.0	454.0	338.0	236.0	164.0	78.0	54.0	0.0	1447.0
203	41936	0	JESSORE	1969	0.0	10.0	99.0	75.0	58.0	228.0	297.0	365.0	426.0	79.0	21.0	0.0	1658.0
203	41936	0	JESSORE	1970	30.0	0.0	29.0	24.0	136.0	304.0	516.0	258.0	611.0	347.0	10.0	0.0	2265.0
203	41936	0	JESSORE	1971	16.0	-	-	-	-	-	309.0	410.0	239.0	11.0	-	-	-
203	41936	0	JESSORE	1981	8.0	108.0	45.0	292.0	234.0	124.0	377.0	292.0	251.0	0.0	0.0	148.0	1879.0
203	41936	0	JESSORE	1982	0.0	4.0	52.0	224.0	51.0	319.0	171.0	195.0	232.0	5.0	21.0	1.0	1275.0
203	41936	0	JESSORE	1983	20.0	118.0	71.0	61.0	361.0	142.0	192.0	465.0	255.0	152.0	0.0	14.0	1851.0
203	41936	0	JESSORE	1984	51.0	1.0	0.0	18.0	305.0	822.0	247.0	365.0	168.0	54.0	0.0	0.0	2031.0
203	41936	0	JESSORE	1985	46.0	4.0	50.0	2.0	171.0	318.0	251.0	300.0	237.0	189.0	0.0	0.0	1568.0
203	41936	0	JESSORE	1986	9.0	0.0	1.0	73.0	174.0	319.0	362.0	180.0	606.0	228.0	159.0	6.0	2117.0
203	41936	0	JESSORE	1987	1.0	0.0	58.0	165.0	52.0	327.0	389.0	768.0	196.0	136.0	5.0	10.0	2107.0
203	41936	0	JESSORE	1988	0.0	27.0	93.0	148.0	297.0	543.0	257.0	307.0	117.0	87.0	99.0	1.0	1976.0
203	41936	0	JESSORE	1989	0.0	2.0	1.0	39.0	273.0	164.0	255.0	88.0	161.0	192.0	0.0	10.0	1185.0
203	41936	0	JESSORE	1990	0.0	42.0	173.0	25.0	162.0	343.0	392.0	53.0	186.0	94.0	126.0	10.0	1606.0
203	41936	0	JESSORE	1991	24.0	24.0	33.0	54.0	-	-	-	-	-	-	-	-	-
203	41936	0	JESSORE	1992	-	-	-	-	-	303.0	-	-	-	-	3.0	-	-
203	41936	0	JESSORE	1993	0.0	-	-	-	142.0	-	-	-	-	-	-	-	-
203	41936	0	JESSORE	1995	-	-	-	-	-	196.0	-	-	-	-	-	-	-
203	41936	0	JESSORE	Average	10.4	18.6	38.2	79.0	156.8	309.6	305.4	294.0	227.4	138.3	26.7	6.9	1611.4

Note: Monthly average and annual average values are computed from available data. Therefore, the sum of monthly average values is not equal to the annual average value.

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.4 Monthly Average Temperature in Bangladesh

Serial No.	Station Name	WMO Station No.	Modifier No.	Monthly Average Temperature (℃)												Data Available Year	
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	From	To
1	DINAJPUR	41863	2	17.5	19.9	24.5	27.6	28.1	28.7	28.8	28.9	28.6	26.9	22.5	18.8	1949	1988
2	BOGRA	41883	0	18.4	20.8	25.4	29.0	28.8	29.0	28.8	28.9	28.7	27.2	23.5	19.7	1954	1987
3	MYMENSINGH	41886	2	18.4	20.9	25.0	27.8	27.8	28.3	28.6	28.7	28.5	27.2	23.7	19.9	1950	1988
4	SYLHET	41891	0	18.7	20.6	24.3	26.1	26.7	27.5	27.9	28.1	27.8	26.4	23.3	20.0	1956	1988
5	SIRAJGANJ	41898	10	18.4	20.7	25.0	28.6	28.9	28.4	28.5	28.5	28.7	27.3	23.4	19.9	1951	1968
6	PABNA	41907	10	18.5	21.0	26.0	29.5	29.9	29.3	29.0	29.0	29.1	27.5	23.4	19.6	1933	1968
7	DHAKA	41923	0	18.8	21.6	26.2	28.7	28.9	28.8	28.6	28.8	28.7	27.4	23.7	19.9	1953	1990
8	NARAYANJAN	41923	10	20.0	22.3	26.7	28.7	29.1	29.0	28.8	28.8	29.2	28.1	24.5	21.0	1931	1968
9	FARIDPUR	41929	0	18.1	20.8	25.7	28.4	28.8	28.6	28.3	28.6	28.6	27.3	23.3	19.2	1949	1988
10	COMILLA	41933	0	19.1	21.4	25.7	27.9	28.6	28.3	28.1	28.2	28.4	27.3	24.0	20.1	1949	1987
11	BRAHMANBARIA	41933	11	19.1	21.3	25.7	28.2	28.3	28.2	28.4	28.5	28.8	27.5	24.0	20.3	1931	1968
12	JESSORE	41936	0	18.7	21.5	26.5	30.0	30.2	29.4	28.8	28.9	28.9	27.6	23.4	19.4	1949	1989
13	SATKHIRA	41946	0	19.2	22.2	26.9	29.7	30.3	29.6	28.8	28.9	28.9	27.9	24.0	20.0	1949	1987
14	KHULNA	41947	10	20.0	22.7	27.2	29.5	30.0	29.4	28.8	28.9	29.1	28.1	24.6	20.8	1949	1989
15	BARISAL	41950	0	19.2	21.8	26.3	28.8	29.2	28.7	28.2	28.4	28.6	27.7	23.9	20.1	1949	1988
16	MAIJIDICOURT	41953	10	19.3	21.7	25.5	27.8	28.6	28.0	27.7	27.7	28.1	27.4	23.9	20.4	1951	1989
17	RANGAMATI	41966	0	20.6	22.8	26.7	28.6	28.9	28.1	27.9	28.1	28.6	27.8	25.0	21.7	1957	1987
18	CHITTAGONG (A	41977	1	19.9	22.0	25.7	27.6	28.3	27.9	27.5	27.5	27.9	27.3	24.0	20.7	1931	1964
19	CHITTAGONG (B	41978	0	20.0	22.1	25.5	27.7	28.6	28.2	27.9	27.9	28.2	27.5	24.5	20.9	1949	1989
20	COX'S BAZAR	41992	0	20.6	22.3	25.4	27.7	28.6	27.6	27.3	27.2	27.7	27.5	24.9	21.6	1949	1988

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.5 Monthly Average Maximum Temperature in Bangladesh

Serial No.	Station Name	WMO Station No.	Modifier No.	Monthly Average Maximum Temperature (°C)												Data Available Year	
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	From	To
1	DINAJPUR	41863	2	24.6	27.5	32.0	33.7	32.4	32.2	31.7	31.8	31.9	31.2	28.9	25.8	1949	1988
2	BOGRA	41883	0	25.0	28.0	32.7	35.2	33.4	32.2	31.4	31.5	31.6	31.1	29.1	26.1	1954	1987
3	MYMENSINGH	41886	2	25.0	27.8	31.7	33.2	32.0	31.3	31.3	31.4	31.3	30.7	28.9	26.1	1950	1988
4	SYLHET	41891	0	25.0	27.2	30.7	31.1	30.7	30.5	30.7	31.1	31.0	30.5	28.8	26.1	1956	1988
5	SIRAJGANJ	41898	10	25.1	28.2	32.8	35.8	33.8	31.7	31.0	30.8	31.5	30.9	28.9	26.3	1951	1968
6	PABNA	41907	10	25.6	28.3	33.7	36.3	35.2	33.0	31.9	31.8	32.3	31.6	29.3	26.4	1933	1968
7	DHAKA	41923	0	25.5	28.3	32.4	33.8	32.9	31.6	31.1	31.3	31.5	31.0	29.0	26.1	1953	1990
8	NARAYANJAN	41923	10	26.4	28.6	33.0	34.0	33.2	32.1	31.4	31.5	32.1	31.9	29.9	27.2	1931	1968
9	FARIDPUR	41929	0	24.3	27.6	32.4	33.9	33.2	31.7	31.0	31.0	31.3	30.8	28.1	24.9	1949	1988
10	COMILLA	41933	0	25.7	28.1	31.6	32.6	32.5	31.2	30.7	31.0	31.5	31.1	29.2	26.4	1949	1987
11	BRAHMANBARIA	41933	11	25.7	28.1	32.2	33.8	32.8	31.5	31.3	31.3	31.8	31.0	28.8	26.3	1931	1968
12	JESSORE	41936	0	25.9	29.0	33.6	36.2	35.3	32.8	31.8	31.8	32.3	31.8	29.4	26.5	1949	1989
13	SATKHIRA	41946	0	26.0	28.9	33.3	35.0	34.9	33.1	31.7	31.8	32.0	31.9	29.6	26.6	1949	1987
14	KHULNA	41947	10	26.2	29.2	33.5	34.7	34.4	32.5	31.4	31.5	32.1	31.8	29.6	26.7	1949	1989
15	BARISAL	41950	0	25.7	28.3	32.3	33.5	33.2	31.5	30.7	30.8	31.4	31.3	29.0	26.3	1949	1988
16	MAIJIDICOURT	41953	10	25.4	28.1	31.2	32.2	32.3	30.6	30.0	30.2	30.8	30.6	28.6	26.1	1951	1989
17	RANGAMATI	41966	0	26.3	29.2	32.8	33.6	33.1	31.2	30.6	31.0	31.8	31.4	29.2	26.6	1957	1987
18	CHITTAGONG (A	41977	1	26.8	28.6	31.3	31.8	31.8	30.5	29.9	30.1	30.9	31.1	29.4	27.0	1931	1964
19	CHITTAGONG (B	41978	0	25.9	28.0	30.7	31.8	32.3	31.1	30.7	30.8	31.3	31.1	29.2	26.5	1949	1989
20	COX'S BAZAR	41992	0	26.5	28.2	30.5	31.7	32.1	30.2	29.6	29.6	30.4	30.9	29.3	27.0	1949	1988

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.6 Monthly Average Minimum Temperature in Bangladesh

Serial No.	Station Name	WMO Station No.	Modifier No.	Monthly Average Minimum Temperature (℃)												Data Available Year	
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	From	To
1	DINAJPUR	41863	2	10.4	12.3	16.8	21.2	23.6	25.3	25.9	25.9	25.3	22.4	16.1	11.8	1949	1988
2	BOGRA	41883	0	11.8	13.5	18.1	22.8	24.1	25.7	26.1	26.2	25.7	23.1	17.8	13.2	1954	1987
3	MYMENSINGH	41886	2	11.8	13.8	18.2	22.2	23.7	25.3	25.8	25.9	25.6	23.6	18.3	13.8	1950	1988
4	SYLHET	41891	0	12.4	14.0	18.0	21.1	22.6	24.5	25.1	25.1	24.6	22.4	17.8	13.8	1956	1988
5	SIRAJGANJ	41898	10	11.7	13.4	17.9	21.9	24.2	25.3	26.0	26.2	25.9	23.5	17.7	13.6	1951	1968
6	PABNA	41907	10	11.5	13.8	18.4	22.8	24.6	25.6	26.0	26.2	26.1	23.3	17.4	12.8	1933	1968
7	DHAKA	41923	0	12.1	14.8	19.8	23.5	24.7	25.9	26.2	26.2	25.9	23.6	18.3	13.6	1953	1990
8	NARAYANJAN	41923	10	13.3	15.8	20.4	23.6	24.9	25.8	26.2	26.2	26.2	24.3	19.2	14.8	1931	1968
9	FARIDPUR	41929	0	11.9	13.9	18.9	22.9	24.3	25.5	25.7	26.2	25.9	23.8	18.5	13.4	1949	1988
10	COMILLA	41933	0	12.3	14.8	19.7	23.1	24.5	25.2	25.3	25.4	25.3	23.5	18.7	13.6	1949	1987
11	BRAHMANBARIA	41933	11	12.3	14.6	19.3	22.3	23.9	25.2	25.7	25.6	25.7	24.0	19.0	14.3	1931	1968
12	JESSORE	41936	0	11.2	13.9	19.4	23.7	25.1	25.8	25.9	25.8	25.5	23.3	17.3	12.2	1949	1989
13	SATKHIRA	41946	0	12.4	15.5	20.5	24.3	25.6	26.1	26.0	26.0	25.8	23.8	18.2	13.4	1949	1987
14	KHULNA	41947	10	13.5	16.1	20.9	24.3	25.6	26.3	26.1	26.2	26.1	24.4	19.5	14.6	1949	1989
15	BARISAL	41950	0	12.6	15.3	20.4	24.0	25.1	25.9	25.8	25.9	25.7	24.1	18.8	13.9	1949	1988
16	MAIJIDICOURT	41953	10	12.9	15.2	19.8	23.5	24.9	25.3	25.2	25.3	25.3	24.2	19.2	14.6	1951	1989
17	RANGAMATI	41966	0	15.2	17.0	20.6	23.5	24.7	25.2	25.2	25.2	25.3	24.3	20.8	17.1	1957	1987
18	CHITTAGONG (A	41977	1	13.0	15.4	20.1	23.4	24.7	25.2	24.9	24.9	24.9	23.5	18.6	14.4	1931	1964
19	CHITTAGONG (B	41978	0	14.0	16.0	20.2	23.5	24.9	25.2	25.1	25.0	25.0	23.9	19.8	15.3	1949	1989
20	COX'S BAZAR	41992	0	14.7	16.4	20.3	23.7	25.0	25.0	24.9	24.9	24.8	24.0	20.5	16.3	1949	1988

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.7 Monthly Average Temperature at Jessore (WMO Station No. = 41936)

Country No.	WMO Station No.	Modifier No.	Station Name	Year	Monthly Mean of the Daily Temperature (℃) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
203	41936	0	JESSORE	1949	-	-	26.0	27.7	28.2	28.8	28.7	28.8	29.3	28.3	21.8	17.3
203	41936	0	JESSORE	1950	18.6	20.8	25.6	29.9	30.4	28.8	28.9	28.3	28.8	26.8	21.7	18.8
203	41936	0	JESSORE	1951	17.4	20.3	25.0	30.2	30.2	29.9	29.1	29.7	29.0	28.7	23.6	19.9
203	41936	0	JESSORE	1952	19.1	22.3	25.3	28.7	29.6	29.4	28.3	28.9	29.2	27.9	23.6	18.9
203	41936	0	JESSORE	1953	17.9	22.1	28.7	31.1	30.4	29.0	28.9	29.1	28.7	27.5	22.7	20.7
203	41936	0	JESSORE	1954	17.5	23.3	26.5	32.0	30.9	28.4	29.0	29.0	29.0	26.6	21.6	19.5
203	41936	0	JESSORE	1955	18.5	20.5	28.1	29.5	30.9	29.1	28.5	28.7	28.8	27.4	23.3	18.4
203	41936	0	JESSORE	1956	19.0	19.8	26.7	30.3	29.8	28.0	28.5	28.9	28.3	27.5	23.0	19.9
203	41936	0	JESSORE	1957	19.5	20.4	25.0	30.4	32.9	30.8	28.8	29.4	29.2	27.8	22.9	20.2
203	41936	0	JESSORE	1958	20.3	22.4	27.3	30.9	31.3	30.8	29.2	28.8	29.0	28.3	24.7	21.2
203	41936	0	JESSORE	1959	19.3	20.1	26.0	30.4	30.7	29.3	28.8	28.6	28.1	26.8	22.6	19.4
203	41936	0	JESSORE	1960	18.6	22.9	25.5	32.0	31.1	30.2	28.3	29.3	28.8	27.5	22.7	19.5
203	41936	0	JESSORE	1961	19.4	20.1	28.2	31.3	30.4	29.6	29.1	29.3	28.9	27.8	22.5	17.4
203	41936	0	JESSORE	1962	17.4	22.1	26.7	30.0	30.0	29.3	29.6	28.8	29.1	26.7	22.9	19.2
203	41936	0	JESSORE	1963	18.0	23.2	26.3	29.1	28.9	29.1	29.2	29.4	29.3	27.8	23.5	20.3
203	41936	0	JESSORE	1964	19.1	22.8	28.3	29.5	30.3	30.3	28.3	29.1	29.1	27.8	24.0	20.3
203	41936	0	JESSORE	1965	19.6	21.6	25.3	29.2	30.9	29.4	28.8	28.0	29.2	27.3	24.3	19.6
203	41936	0	JESSORE	1966	18.6	23.3	26.7	30.6	30.8	29.0	29.1	28.8	28.3	26.2	23.7	18.3
203	41936	0	JESSORE	1967	18.1	21.5	25.2	27.9	30.6	29.5	28.9	28.4	28.7	27.0	21.8	20.1
203	41936	0	JESSORE	1968	17.9	20.5	26.0	28.9	30.7	28.1	28.6	29.0	29.6	26.9	23.0	18.5
203	41936	0	JESSORE	1969	17.6	21.7	27.5	30.3	30.2	29.6	28.8	28.4	28.6	27.3	23.4	19.0
203	41936	0	JESSORE	1970	18.1	21.5	26.1	29.9	30.5	29.3	28.8	28.7	28.4	27.2	23.2	18.3
203	41936	0	JESSORE	1971	18.7	20.9	-	-	-	26.9	28.3	27.5	29.1	-	-	-
203	41936	0	JESSORE	1972	-	18.3	26.8	30.2	32.1	31.1	29.1	27.9	28.8	27.6	23.0	19.4
203	41936	0	JESSORE	1973	19.4	23.5	25.3	30.8	28.8	29.1	28.7	28.6	28.3	27.1	22.9	18.5
203	41936	0	JESSORE	1974	17.8	20.1	26.3	29.5	29.4	29.3	28.0	28.6	28.5	28.2	24.7	18.1
203	41936	0	JESSORE	1975	17.9	21.1	26.8	31.0	30.6	29.4	27.9	28.6	28.6	28.2	22.6	17.9
203	41936	0	JESSORE	1976	18.5	21.8	27.3	29.9	28.8	29.2	28.8	28.2	28.9	27.8	24.8	18.7
203	41936	0	JESSORE	1977	17.9	21.6	28.4	28.8	28.2	28.3	28.8	29.1	29.2	27.2	24.2	18.8
203	41936	0	JESSORE	1979	19.5	20.1	26.1	29.7	32.3	30.4	29.4	29.2	29.3	28.1	26.3	20.0
203	41936	0	JESSORE	1980	18.8	21.7	26.5	31.2	29.7	29.3	29.4	29.3	29.6	27.2	23.6	20.6
203	41936	0	JESSORE	1981	18.7	21.3	25.3	26.8	28.7	30.0	28.9	29.4	28.8	28.0	23.5	18.8
203	41936	0	JESSORE	1982	19.8	21.7	24.8	29.0	30.7	29.4	30.1	28.5	29.4	27.7	22.9	19.1
203	41936	0	JESSORE	1983	18.7	21.0	26.6	29.6	29.3	30.6	29.8	29.1	29.3	27.8	24.5	19.0
203	41936	0	JESSORE	1984	18.2	20.4	27.2	30.1	30.3	28.5	28.7	28.7	28.8	28.2	23.2	19.8
203	41936	0	JESSORE	1985	19.8	21.7	28.6	31.5	29.5	29.4	28.2	29.1	28.7	27.9	23.8	20.8
203	41936	0	JESSORE	1986	20.6	22.3	27.5	29.6	29.5	29.8	28.2	29.3	28.1	26.8	24.3	20.4
203	41936	0	JESSORE	1987	19.1	23.1	26.6	29.5	29.8	30.4	28.9	30.1	29.5	28.7	25.2	20.3
203	41936	0	JESSORE	1988	19.3	22.8	26.3	30.4	29.8	28.7	29.4	29.1	29.7	28.7	23.9	21.8
203	41936	0	JESSORE	1989	17.1	21.4	26.1	31.3	30.7	29.2	29.2	29.3	29.0	27.9	-	19.2
203	41936	0	JESSORE	Average	18.7	21.5	26.5	30.0	30.2	29.4	28.9	28.9	28.9	27.6	23.4	19.4

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.8 Monthly Average Maximum Temperature at Jessore (WMO Station No. = 41936)

Country No.	WMO Station No.	Modifier No.	Station Name	Year	Monthly Mean of the Maximum Daily Temperature (°C)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
203	41936	0	JESSORE	1949	25.5	27.4	33.2	32.7	32.2	32.3	31.7	31.6	32.9	32.9	28.5	25.5
203	41936	0	JESSORE	1950	26.9	28.7	33.3	37.1	36.3	32.4	32.1	31.3	32.8	30.7	27.4	26.0
203	41936	0	JESSORE	1951	25.3	28.3	32.2	37.6	37.0	34.0	33.1	33.5	33.7	33.4	29.7	27.4
203	41936	0	JESSORE	1952	27.3	30.7	32.4	35.1	34.6	33.3	31.2	32.1	32.8	32.8	29.6	27.1
203	41936	0	JESSORE	1953	25.4	29.8	34.8	38.0	35.5	32.6	31.7	32.1	32.0	32.0	28.8	28.2
203	41936	0	JESSORE	1954	25.3	31.5	34.5	38.7	35.7	31.5	31.8	31.8	32.1	31.0	28.6	26.6
203	41936	0	JESSORE	1955	26.3	29.4	35.7	36.2	36.3	32.6	31.5	31.8	32.0	31.1	28.8	25.8
203	41936	0	JESSORE	1956	27.0	28.0	33.5	37.1	33.9	30.8	31.3	31.7	31.2	31.5	28.6	27.4
203	41936	0	JESSORE	1957	25.7	27.5	32.4	37.8	38.8	35.4	31.6	32.5	32.6	32.7	30.4	28.0
203	41936	0	JESSORE	1958	28.0	29.3	35.6	37.1	36.3	34.9	32.4	31.6	32.6	32.3	30.5	28.6
203	41936	0	JESSORE	1959	26.7	27.5	33.7	36.6	35.7	32.6	31.4	31.3	30.8	29.8	28.5	26.3
203	41936	0	JESSORE	1960	26.2	31.1	32.5	39.5	35.9	33.6	30.9	32.0	31.7	31.6	28.9	27.0
203	41936	0	JESSORE	1961	26.4	26.8	34.2	37.9	35.4	32.7	32.1	32.2	32.0	31.9	28.7	24.9
203	41936	0	JESSORE	1962	25.4	29.6	35.1	36.1	34.9	32.8	32.7	32.1	32.4	30.8	29.6	26.6
203	41936	0	JESSORE	1963	26.1	31.7	34.3	35.6	33.8	32.4	32.0	32.3	32.6	31.9	29.0	26.9
203	41936	0	JESSORE	1964	26.0	29.9	35.4	35.1	35.2	33.9	31.1	32.0	32.2	31.0	29.4	26.8
203	41936	0	JESSORE	1965	26.4	28.7	32.7	34.6	35.4	32.6	31.5	30.3	32.4	31.3	31.0	26.2
203	41936	0	JESSORE	1966	25.3	31.1	34.0	36.9	35.7	32.1	32.6	31.9	31.9	30.5	29.3	25.6
203	41936	0	JESSORE	1967	25.2	30.0	31.8	34.7	35.6	33.3	31.9	31.0	31.6	31.4	28.8	27.0
203	41936	0	JESSORE	1968	25.2	28.2	32.8	34.7	35.7	31.0	31.1	31.9	33.1	30.9	28.2	25.1
203	41936	0	JESSORE	1969	25.5	29.8	34.4	36.5	35.4	33.2	31.7	31.4	31.7	31.3	29.4	26.0
203	41936	0	JESSORE	1970	24.9	28.7	31.8	35.3	35.3	32.5	31.7	31.3	31.0	30.7	29.2	25.8
203	41936	0	JESSORE	1971	25.5	28.2	-	-	-	29.8	31.0	29.9	32.4	-	-	-
203	41936	0	JESSORE	1972	-	26.3	34.1	36.9	38.0	-	32.4	30.8	32.7	32.4	29.8	27.5
203	41936	0	JESSORE	1973	27.7	31.4	32.7	36.7	33.6	33.0	31.5	31.5	30.9	30.6	27.5	24.2
203	41936	0	JESSORE	1974	25.1	28.7	32.7	34.8	34.5	33.1	30.7	31.5	31.8	32.0	30.0	25.4
203	41936	0	JESSORE	1975	25.2	28.8	34.5	37.6	36.1	33.1	30.7	31.8	31.7	31.7	27.8	25.5
203	41936	0	JESSORE	1976	26.6	29.0	34.5	36.7	33.8	33.0	31.9	31.4	32.5	32.7	31.1	26.7
203	41936	0	JESSORE	1977	25.7	29.4	35.4	34.1	32.9	31.5	31.7	32.2	32.7	31.6	29.4	25.8
203	41936	0	JESSORE	1979	26.7	26.7	33.6	35.8	38.4	34.6	32.6	32.2	32.7	32.3	31.7	26.0
203	41936	0	JESSORE	1980	25.9	28.7	32.8	37.1	35.4	32.4	32.0	32.5	32.9	31.6	29.8	26.6
203	41936	0	JESSORE	1981	25.1	27.7	31.4	31.8	33.1	33.5	31.9	32.5	32.4	33.2	30.6	24.9
203	41936	0	JESSORE	1982	27.1	28.2	31.1	35.0	36.3	33.3	33.3	31.3	33.5	33.2	28.8	26.6
203	41936	0	JESSORE	1983	25.7	27.7	32.8	36.2	34.5	34.9	33.2	32.2	32.7	31.8	30.8	26.0
203	41936	0	JESSORE	1984	24.8	27.4	35.0	36.8	35.2	31.5	31.6	31.8	32.4	32.5	30.2	27.1
203	41936	0	JESSORE	1985	25.9	28.9	35.3	37.6	34.6	32.8	31.3	32.3	32.0	32.4	30.0	28.0
203	41936	0	JESSORE	1986	25.8	29.4	35.2	35.6	34.9	33.2	32.0	33.0	31.5	31.0	29.2	26.3
203	41936	0	JESSORE	1987	25.7	30.0	33.1	35.1	34.3	33.5	31.5	32.1	32.7	33.7	29.4	26.9
203	41936	0	JESSORE	1988	26.7	30.1	32.7	36.4	33.7	31.6	32.3	31.9	33.4	32.3	30.1	28.8
203	41936	0	JESSORE	1989	24.6	28.7	33.8	37.8	35.5	32.5	32.2	32.4	32.3	31.8	30.2	26.3
203	41936	0	JESSORE	Average	25.9	29.0	33.6	36.2	35.3	32.8	31.8	31.8	32.3	31.8	29.4	26.5

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.9 Monthly Average Minimum Temperature at Jessore (WMO Station No. = 41936)

Country No.	WMO Station No.	Modifier No.	Station Name	Year	Monthly Mean of the Minimum Daily Temperature (℃) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
203	41936	0	JESSORE	1949	–	–	18.7	22.7	24.1	25.2	25.7	25.9	25.7	23.6	15.1	9.1
203	41936	0	JESSORE	1950	10.3	12.9	17.8	22.6	24.4	25.2	25.7	25.2	24.8	22.8	15.9	11.5
203	41936	0	JESSORE	1951	9.4	12.2	17.8	22.7	23.4	25.8	25.1	25.8	24.3	23.9	17.4	12.4
203	41936	0	JESSORE	1952	10.8	13.8	18.2	22.3	24.5	25.5	25.3	25.6	25.6	23.0	17.6	10.7
203	41936	0	JESSORE	1953	10.4	14.4	22.5	24.2	25.2	25.3	26.0	26.1	25.4	23.0	16.6	13.2
203	41936	0	JESSORE	1954	9.7	15.0	18.5	25.3	26.0	25.3	26.2	26.1	25.9	22.2	14.6	12.4
203	41936	0	JESSORE	1955	10.7	11.5	20.4	22.7	25.4	25.6	25.5	25.6	25.5	23.6	17.7	11.0
203	41936	0	JESSORE	1956	11.0	11.5	19.8	23.5	25.7	25.2	25.7	26.1	25.4	23.5	17.3	12.3
203	41936	0	JESSORE	1957	13.3	13.3	17.5	22.9	26.9	26.1	26.0	26.3	25.7	22.9	15.3	12.4
203	41936	0	JESSORE	1958	12.6	15.4	18.9	24.7	26.2	26.6	26.0	26.0	25.4	24.2	18.8	13.8
203	41936	0	JESSORE	1959	11.8	12.6	18.3	24.2	25.7	26.0	26.1	25.8	25.4	23.8	16.6	12.5
203	41936	0	JESSORE	1960	11.0	14.6	18.5	24.4	26.3	26.7	25.7	26.6	25.9	23.4	16.4	12.0
203	41936	0	JESSORE	1961	12.4	13.4	22.2	24.6	25.3	26.4	26.0	26.3	25.8	23.7	16.2	9.9
203	41936	0	JESSORE	1962	9.4	14.5	18.2	23.8	25.0	25.8	26.5	25.5	25.7	22.6	16.2	11.8
203	41936	0	JESSORE	1963	9.8	14.6	18.3	22.6	24.0	25.7	26.4	26.5	25.9	23.7	17.9	13.6
203	41936	0	JESSORE	1964	12.1	15.7	21.2	23.8	25.4	26.6	25.4	26.2	26.0	24.6	18.5	13.7
203	41936	0	JESSORE	1965	12.7	14.4	17.9	23.8	26.3	26.2	26.1	25.7	25.9	23.3	17.6	13.0
203	41936	0	JESSORE	1966	11.9	15.4	19.3	24.2	25.9	25.8	25.6	25.6	24.6	21.8	18.1	11.0
203	41936	0	JESSORE	1967	11.0	13.0	18.5	21.0	25.6	25.7	25.9	25.8	25.7	22.6	14.7	13.2
203	41936	0	JESSORE	1968	10.5	12.8	19.1	23.1	25.6	25.2	26.1	26.0	26.1	22.9	17.7	11.8
203	41936	0	JESSORE	1969	9.6	13.6	20.5	24.1	24.9	26.0	25.9	25.4	25.4	23.2	17.3	12.0
203	41936	0	JESSORE	1970	11.2	14.3	20.3	24.4	25.7	26.0	25.9	26.1	25.7	23.7	17.1	10.8
203	41936	0	JESSORE	1971	11.9	13.6	–	–	–	–	25.6	25.0	25.7	–	–	–
203	41936	0	JESSORE	1972	–	10.3	19.5	23.5	26.1	26.3	25.8	25.0	24.8	22.8	16.2	11.3
203	41936	0	JESSORE	1973	11.1	15.5	17.9	24.8	23.9	25.2	25.9	25.6	25.6	23.6	18.3	12.7
203	41936	0	JESSORE	1974	10.5	11.5	19.8	24.2	24.3	25.4	25.2	25.7	25.2	24.4	19.3	10.8
203	41936	0	JESSORE	1975	10.5	13.4	19.0	24.3	25.1	25.7	25.1	25.4	25.4	24.6	17.3	10.2
203	41936	0	JESSORE	1976	10.4	14.6	20.1	23.1	23.7	25.4	25.6	24.9	25.3	22.8	18.5	10.6
203	41936	0	JESSORE	1977	10.0	13.8	21.4	23.4	23.5	25.1	25.9	26.0	25.7	22.8	19.0	11.8
203	41936	0	JESSORE	1979	12.2	13.5	18.5	23.5	26.1	26.2	26.2	26.1	25.9	23.8	20.9	14.0
203	41936	0	JESSORE	1980	11.7	14.7	20.1	25.2	23.9	26.1	26.8	26.1	26.2	22.7	17.3	14.5
203	41936	0	JESSORE	1981	12.2	14.9	19.1	21.8	24.3	26.4	25.8	26.2	25.2	22.8	16.3	12.6
203	41936	0	JESSORE	1982	12.4	15.1	18.4	22.9	25.1	25.4	26.8	25.6	25.3	22.2	16.9	11.5
203	41936	0	JESSORE	1983	11.7	14.3	20.4	23.0	24.0	26.3	26.3	25.9	25.8	23.7	18.2	11.9
203	41936	0	JESSORE	1984	11.6	13.4	19.3	23.4	25.4	25.4	25.8	25.6	25.2	23.8	16.2	12.5
203	41936	0	JESSORE	1985	13.6	14.5	21.8	25.3	24.4	25.9	25.1	25.9	25.4	23.3	17.5	13.6
203	41936	0	JESSORE	1986	–	15.2	19.8	23.5	24.0	26.4	–	25.6	24.7	22.6	19.4	14.4
203	41936	0	JESSORE	1987	12.5	16.1	20.1	23.9	25.2	27.2	26.2	–	26.2	23.6	–	13.7
203	41936	0	JESSORE	1988	11.9	15.4	19.8	24.3	25.8	25.8	26.4	26.3	26.0	25.0	17.7	14.8
203	41936	0	JESSORE	1989	9.6	14.0	18.4	24.8	25.8	25.9	26.1	26.2	25.6	24.0	–	12.0
203	41936	0	JESSORE	Average	11.2	13.9	19.4	23.7	25.1	25.8	25.9	25.8	25.5	23.3	17.3	12.2

Data source: The Global Historical Climatology Network (GHCN version 2) in National Climatic Data Center (NCDC), USA [http://www.ncdc.noaa.gov/pub/data/ghcn/v2/ghcnftp.html]

Table 2.1.10 Computation of Potential Evapotranspiration at Jessore by Thornthwaite Method

Place: Jessore
Lati.: 23.2° N

Month	Monthly Average Temperature, T (℃)	$(T/5)$^1.514	I	a	Daytime Modifier	Monthly Potential Evapotranspiration, Et		No. of Days	Daily Amount
						(cm/month)	(mm/month)		(mm/day)
Jan	18.7	7.3	147.9	3.640	0.935	3.49	34.91	31	1.13
Feb	21.5	9.1	147.9	3.640	0.889	5.54	55.39	28	1.98
Mar	26.5	12.5	147.9	3.640	1.031	13.82	138.25	31	4.46
Apr	30.0	15.0	147.9	3.640	1.057	22.10	221.05	30	7.37
May	30.2	15.2	147.9	3.640	1.141	24.56	245.62	31	7.92
Jun	29.4	14.6	147.9	3.640	1.129	21.94	219.39	30	7.31
Jul	28.9	14.2	147.9	3.640	1.158	21.09	210.89	31	6.80
Aug	28.9	14.2	147.9	3.640	1.114	20.36	203.56	31	6.57
Sep	28.9	14.3	147.9	3.640	1.022	18.79	187.93	30	6.26
Oct	27.6	13.3	147.9	3.640	0.993	15.39	153.87	31	4.96
Nov	23.4	10.4	147.9	3.640	0.922	7.86	78.57	30	2.62
Dec	19.4	7.8	147.9	3.640	0.925	3.96	39.59	31	1.28

(Temperature Data Source: GHCN version 2)

$$Et = 1.6\left(\frac{10T}{I}\right)^{a} \qquad I = \sum_{i=1}^{12}\left(\frac{T_i}{5}\right)^{1.514} \qquad a = \left(492390 + 17920I - 77.1I^2 + 0.675I^3\right)\times 10^{-6}$$

(Equations: Thornthwaite, 1948)

Table 2.1.11 Meteorological Stations in the Study Area

Station	Long. (deg-E)	Lati. (deg-N)	Available Data Type	
			Daily Rainfall	Daily Evaporation
Benapol	88.90180	23.04626	○	
Chaugacha	89.02736	23.25992	○	
Chuadanga	88.85142	23.63984	○	
Jessore	89.21321	23.16719	○	○
Jhenaidah	89.17895	23.54511	○	
Kaliganj	89.14468	23.39999	○	
Keshabpur	89.22833	22.90618	○	
Sailkupa	89.21825	23.67512	○	

[Data Source: BMD & BWDB]

Table 2.1.12 Monthly Availability of Daily Meteorological Data in the Study Area

Station		Benapol	Chaugacha	Chuadanga	Jessore		Jhenaidah	Kaliganj	Keshabpur	Sailkupa
Data Type		Rain	Rain	Rain	Rain	Evaporation	Rain	Rain	Rain	Rain
Year	1988	9	9	0	0	8	9	9	9	12
	1989	12	12	0	0	0	12	12	11	12
	1990	12	12	8	12	12	12	12	12	12
	1991	12	12	12	12	12	12	12	12	12
	1992	12	12	12	12	12	12	12	12	12
	1993	12	12	12	12	12	12	12	12	12
	1994	12	12	12	12	11	12	12	12	12
	1995	3	3	12	12	3	3	3	3	4
	1996	3	3	12	12	0	0	3	3	4
	1997	9	3	12	12	0	7	9	7	12
	1998	9	10	12	12	0	12	12	10	12
	1999	11	0	12	12	0	8	9	9	9

(Unit: Number of Available Months)

Table 2.1.13 Monthly Rainfall at Benapol

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	–	0.0	0.0	0.0	66.1	0.0	9.5	10.5	16.8	0.0	0.0	0.0	9.4
FEB	–	0.0	208.0	50.8	0.0	48.0	25.3	79.3	23.0	0.0	0.0	0.0	39.5
MAR	–	12.7	92.7	63.5	0.0	111.4	0.0	0.0	0.0	12.7	330.0	0.0	56.6
APR	103.4	25.4	9.4	64.7	0.0	51.3	83.2	–	–	0.0	–	17.0	39.4
MAY	177.0	288.6	330.9	26.6	192.7	226.6	66.8	–	–	–	265.5	217.5	199.1
JUN	564.8	222.4	294.3	387.6	176.0	296.9	343.9	–	–	–	600.5	261.0	349.7
JUL	309.7	217.8	616.7	215.2	325.8	584.9	362.9	–	–	–	345.0	357.0	370.6
AUG	190.5	133.7	452.1	249.1	257.8	252.4	175.0	–	–	682.5	999.0	248.0	364.0
SEP	257.9	234.2	418.3	151.1	318.8	148.2	52.3	–	–	111.0	120.5	518.5	233.1
OCT	101.7	121.0	180.9	34.2	106.7	93.0	97.0	–	–	0.0	–	478.5	134.8
NOV	116.1	0.0	91.2	0.0	26.0	0.0	0.0	–	–	0.0	–	0.0	25.9
DEC	0.0	7.6	0.0	53.4	0.0	0.0	0.0	–	–	0.0	0.0	–	6.8
											Total of Monthly Average Rainfall =		1828.8

[Data Source: BMD & BWDB]

Table 2.1.14 Monthly Rainfall at Chaugacha

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	–	0.0	0.0	25.5	19.1	0.0	0.6	8.0	4.0	0.0	60.0	–	11.7
FEB	–	0.0	106.6	19.1	179.0	12.5	1.8	10.0	10.5	0.0	45.0	–	38.5
MAR	–	14.0	231.1	58.4	0.0	134.0	0.0	37.0	0.0	0.0	142.0	–	61.7
APR	156.9	50.9	43.2	67.9	0.0	99.0	48.0	–	–	–	87.0	–	69.1
MAY	285.0	472.5	193.1	40.6	128.2	184.0	243.0	–	–	–	223.0	–	221.2
JUN	946.7	266.9	243.9	436.9	241.5	293.0	376.0	–	–	–	53.0	–	357.2
JUL	319.8	330.3	528.4	398.9	440.0	672.0	214.0	–	–	–	434.0	–	417.2
AUG	402.5	138.9	292.3	235.1	173.0	326.0	394.0	–	–	–	309.0	–	283.9
SEP	185.5	297.2	264.5	254.2	225.0	593.5	102.0	–	–	–	300.0	–	277.7
OCT	231.2	382.3	86.5	279.5	76.0	63.5	90.0	–	–	–	75.0	–	160.5
NOV	120.7	0.0	135.9	1.3	2.5	0.0	0.0	–	–	–	–	–	37.2
DEC	0.0	14.0	19.1	129.6	0.0	0.0	0.0	–	–	–	–	–	23.2
											Total of Monthly Average Rainfall =		1959.1

[Data Source: BMD & BWDB]

Table 2.1.15 Monthly Rainfall at Chuadanga

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	–	–	–	16.0	15.0	0.0	50.0	15.0	13.0	4.0	42.0	0.0	17.2
FEB	–	–	–	21.0	47.0	26.0	34.0	36.0	36.0	36.0	13.0	0.0	27.7
MAR	–	–	–	18.0	0.0	55.0	8.0	2.0	3.0	79.0	67.0	0.0	25.8
APR	–	–	–	42.0	5.0	114.0	65.0	1.0	60.0	39.0	44.0	17.0	43.0
MAY	–	–	94.0	144.0	150.0	99.0	120.0	78.0	128.0	177.0	162.0	158.0	131.0
JUN	–	–	211.0	260.0	157.0	410.0	272.0	303.0	281.0	184.0	89.0	297.0	246.4
JUL	–	–	431.0	221.0	402.0	253.0	266.0	246.0	217.0	350.0	440.0	463.0	328.9
AUG	–	–	139.0	206.0	303.0	223.0	256.0	300.0	263.0	304.0	277.0	296.0	256.7
SEP	–	–	366.0	502.0	131.0	471.0	98.0	456.0	213.0	201.0	175.0	416.0	302.9
OCT	–	–	155.0	141.0	76.0	61.0	125.0	0.0	204.0	27.0	131.0	136.0	105.6
NOV	–	–	55.0	0.0	10.0	6.0	3.0	75.0	0.0	6.0	68.0	5.0	22.8
DEC	–	–	0.0	106.0	0.0	0.0	0.0	7.0	0.0	20.0	0.0	0.0	13.3
Total of Monthly Average Rainfall =													1521.3

[Data Source: BMD & BWDB]

Table 2.1.16 Monthly Rainfall at Jessore

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	–	–	0.0	24.0	27.0	0.0	10.0	17.0	39.0	9.0	44.0	0.0	17.0
FEB	–	–	54.0	10.0	77.0	33.0	31.0	25.0	20.0	39.0	26.0	0.0	31.5
MAR	–	–	173.0	31.0	0.0	115.0	1.0	18.0	22.0	51.0	141.0	0.0	55.2
APR	–	–	25.0	54.0	1.0	147.0	51.0	5.0	90.0	64.0	130.0	22.0	58.9
MAY	–	–	162.0	186.0	223.0	132.0	175.0	88.0	146.0	116.0	216.0	141.0	158.5
JUN	–	–	335.0	407.0	303.0	437.0	365.0	196.0	350.0	231.0	163.0	244.0	303.1
JUL	–	–	369.0	220.0	307.0	327.0	225.0	279.0	271.0	406.0	181.0	356.0	294.1
AUG	–	–	137.0	543.0	152.0	213.0	253.0	288.0	380.0	227.0	209.0	251.0	265.3
SEP	–	–	196.0	216.0	204.0	336.0	83.0	270.0	195.0	361.0	174.0	301.0	233.6
OCT	–	–	99.0	285.0	36.0	58.0	64.0	95.0	257.0	15.0	88.0	151.0	114.8
NOV	–	–	126.0	0.0	3.0	4.0	2.0	113.0	5.0	14.0	118.0	1.0	38.6
DEC	–	–	10.0	76.0	0.0	0.0	0.0	3.0	0.0	20.0	0.0	0.0	10.9
Total of Monthly Average Rainfall =													1581.5

[Data Source: BMD & BWDB]

Table 2.1.17 Monthly Rainfall at Jhenaidah

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	-	0.0	0.0	0.0	2.5	0.0	26.0	12.0	-	-	87.0	0.0	14.2
FEB	-	50.8	125.7	126.5	0.0	78.0	42.3	9.0	-	-	10.0	0.0	49.1
MAR	-	6.4	226.2	226.2	0.0	38.0	49.1	5.1	-	-	76.5	0.0	69.7
APR	116.1	0.0	0.0	1.3	0.0	152.0	83.2	-	-	77.0	86.0	-	57.3
MAY	333.3	506.3	506.9	198.1	105.5	225.5	210.0	-	-	-	53.0	235.0	263.7
JUN	646.9	190.8	190.6	295.9	233.2	370.3	267.2	-	-	-	73.9	310.0	286.5
JUL	243.4	437.0	427.0	467.2	41.8	279.0	110.5	-	-	176.0	648.5	660.0	349.0
AUG	267.7	7.6	7.6	226.0	230.0	190.0	287.5	-	-	279.2	280.1	271.0	204.7
SEP	261.6	228.6	230.6	398.8	312.0	287.0	138.0	-	-	214.5	239.2	340.0	265.0
OCT	160.0	207.3	227.3	225.9	45.0	31.6	93.5	-	-	51.0	103.0	-	127.2
NOV	97.8	0.0	0.0	0.0	0.0	0.0	21.3	-	-	0.0	140.0	-	28.8
DEC	0.0	27.9	28.0	81.3	0.0	0.0	0.0	-	-	0.0	0.0	-	15.2
										Total of Monthly Average Rainfall =			1730.5

[Data Source: BMD & BWDB]

Table 2.1.18 Monthly Rainfall at Kaliganj

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	-	0.0	0.0	1.0	24.1	0.0	14.0	0.7	0.0	100.1	0.0	0.0	12.7
FEB	-	58.5	70.4	26.6	82.7	37.9	18.0	25.0	21.3	-	0.0	0.0	34.0
MAR	-	38.1	237.2	30.0	0.0	22.0	14.0	33.2	0.0	147.0	0.0	0.0	47.4
APR	99.1	16.5	98.0	43.0	17.8	151.5	94.5	-	-	113.7	153.9	-	87.6
MAY	248.5	606.9	281.2	204.6	72.3	270.0	315.6	-	-	-	261.3	241.7	278.0
JUN	563.5	335.3	192.9	395.6	117.8	566.0	193.8	-	-	352.5	53.0	175.0	294.5
JUL	303.8	787.9	486.4	356.3	486.6	377.0	239.5	-	-	310.7	632.1	632.0	461.2
AUG	400.9	186.5	243.0	224.4	145.2	337.0	245.7	-	-	334.7	442.0	447.0	300.6
SEP	228.9	204.3	173.7	358.6	151.5	312.0	139.5	-	-	243.6	297.8	222.0	233.2
OCT	91.9	193.0	77.8	234.8	10.9	108.0	127.2	-	-	-	112.4	232.0	132.0
NOV	151.2	0.0	79.0	0.0	0.0	0.0	0.0	-	-	0.0	129.0	-	39.9
DEC	0.0	27.7	0.0	88.9	0.0	0.0	0.0	-	-	4.0	0.0	-	13.4
										Total of Monthly Average Rainfall =			1934.6

[Data Source: BMD & BWDB]

Table 2.1.19 Monthly Rainfall at Keshabpur

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	–	0.0	0.0	48.2	5.1	15.0	14.0	0.0	0.0	0.0	–	0.0	8.2
FEB	–	0.0	132.1	40.6	177.8	10.0	14.0	83.0	22.9	18.0	32.0	0.0	48.2
MAR	–	–	283.2	64.7	0.0	180.0	0.0	4.0	38.1	0.0	136.0	–	78.4
APR	119.5	50.1	24.1	62.2	0.0	91.0	57.0	–	–	110.0	24.0	12.0	55.0
MAY	220.9	410.7	233.9	73.8	182.4	194.0	91.0	–	–	–	52.0	164.0	180.3
JUN	429.5	163.9	307.2	376.9	366.0	310.0	470.0	–	–	–	54.0	146.0	291.5
JUL	367.6	230.3	362.9	231.9	297.9	249.0	273.0	–	–	–	271.0	397.0	297.8
AUG	401.6	160.0	242.7	287.8	246.0	436.0	276.0	–	–	–	194.0	247.0	276.8
SEP	137.2	299.2	174.8	314.6	188.0	427.0	153.0	–	–	178.0	301.0	301.0	247.4
OCT	69.9	167.9	96.5	132.2	131.0	163.0	40.0	–	–	–	43.0	118.0	106.8
NOV	171.5	0.0	93.9	0.0	0.0	10.0	0.0	–	–	10.0	27.0	–	34.7
DEC	0.0	0.0	12.7	30.5	0.0	0.0	0.0	–	–	9.0	–	–	6.5
												Total of Monthly Average Rainfall =	1631.8

[Data Source: BMD & BWDB]

Table 2.1.20 Monthly Rainfall at Sailkupa

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	0.0	0.0	0.0	0.0	0.0	50.4	0.0	0.0	0.0	0.0	38.0	0.0	7.4
FEB	14.2	83.8	29.7	68.6	47.0	4.5	11.1	0.0	18.0	16.0	30.0	0.0	26.9
MAR	0.0	106.4	17.0	0.0	106.5	0.0	0.0	54.5	0.0	0.0	35.0	0.0	26.6
APR	77.2	0.0	61.0	32.2	0.0	157.8	8.5	–	–	20.0	145.0	–	55.7
MAY	291.5	363.7	216.9	265.2	63.9	215.3	186.4	–	–	53.5	240.9	232.0	212.9
JUN	495.9	206.9	84.9	265.0	238.0	538.7	116.8	–	–	214.5	166.2	364.0	269.1
JUL	272.0	429.7	426.7	363.3	281.8	331.2	102.2	–	–	328.5	535.3	458.5	352.9
AUG	283.3	172.7	250.6	238.5	275.7	317.2	104.5	–	–	253.0	401.0	366.0	266.3
SEP	251.0	112.6	308.7	572.2	535.2	264.6	68.7	–	–	310.0	189.0	198.0	281.0
OCT	127.0	174.8	147.3	252.5	80.8	81.4	38.5	–	–	7.0	43.0	–	105.8
NOV	53.8	0.0	55.2	0.0	0.0	0.0	13.5	–	–	14.0	132.0	–	29.8
DEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
												Total of Monthly Average Rainfall =	1634.5

[Data Source: BMD & BWDB]

Table 2.1.21 Monthly Evaporation at Jessore

(Unit: mm/month)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	-	51.1	52.2	56.8	46.2	46.4	47.3	39.9	-	-	-	-	48.6
FEB	-	69.9	66.6	74.8	56.5	55.8	54.7	46.0	-	-	-	-	60.6
MAR	-	111.6	75.5	91.5	98.6	91.0	-	89.3	-	-	-	-	92.9
APR	122.9	136.5	102.1	106.0	134.2	92.8	96.9	-	-	-	-	-	113.1
MAY	102.0	108.0	103.0	102.0	104.0	96.0	102.9	-	-	-	-	-	102.6
JUN	74.2	74.7	85.2	79.4	99.1	79.1	39.2	-	-	-	-	-	75.8
JUL	-	83.5	60.2	68.9	69.6	69.1	31.0	-	-	-	-	-	63.7
AUG	63.2	72.5	75.1	68.6	75.6	69.1	25.9	-	-	-	-	-	64.3
SEP	74.3	62.5	62.2	67.1	66.6	62.5	54.8	-	-	-	-	-	64.3
OCT	79.5	71.1	73.7	61.3	74.9	66.6	70.5	-	-	-	-	-	71.1
NOV	78.8	67.2	71.7	56.4	65.8	51.5	50.4	-	-	-	-	-	63.1
DEC	44.0	54.4	68.8	54.0	42.1	49.2	47.5	-	-	-	-	-	51.4
Total of Monthly Average Evaporation =													871.5

[Data Source: BMD & BWDB]

Table 2.1.22 Monthly Average of Daily Evaporation at Jessore

(Unit: mm/day)

	Year												Average
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
JAN	-	1.6	1.7	1.8	1.5	1.5	1.5	1.3	-	-	-	-	1.6
FEB	-	2.5	2.4	2.7	2.0	2.0	2.0	1.6	-	-	-	-	2.2
MAR	-	3.6	2.4	3.0	3.2	2.9	-	2.9	-	-	-	-	3.0
APR	4.1	4.6	3.4	3.5	4.5	3.1	3.2	-	-	-	-	-	3.8
MAY	3.3	3.5	3.3	3.3	3.4	3.1	3.3	-	-	-	-	-	3.3
JUN	2.5	2.5	2.8	2.6	3.3	2.6	1.3	-	-	-	-	-	2.5
JUL	-	2.7	1.9	2.2	2.2	2.2	1.0	-	-	-	-	-	2.1
AUG	2.0	2.3	2.4	2.2	2.4	2.2	0.8	-	-	-	-	-	2.1
SEP	2.5	2.1	2.1	2.2	2.2	2.1	1.8	-	-	-	-	-	2.1
OCT	2.6	2.3	2.4	2.0	2.4	2.1	2.3	-	-	-	-	-	2.3
NOV	2.6	2.2	2.4	1.9	2.2	1.7	1.7	-	-	-	-	-	2.1
DEC	1.4	1.8	2.2	1.7	1.4	1.6	1.5	-	-	-	-	-	1.7

[Data Source: BMD & BWDB]

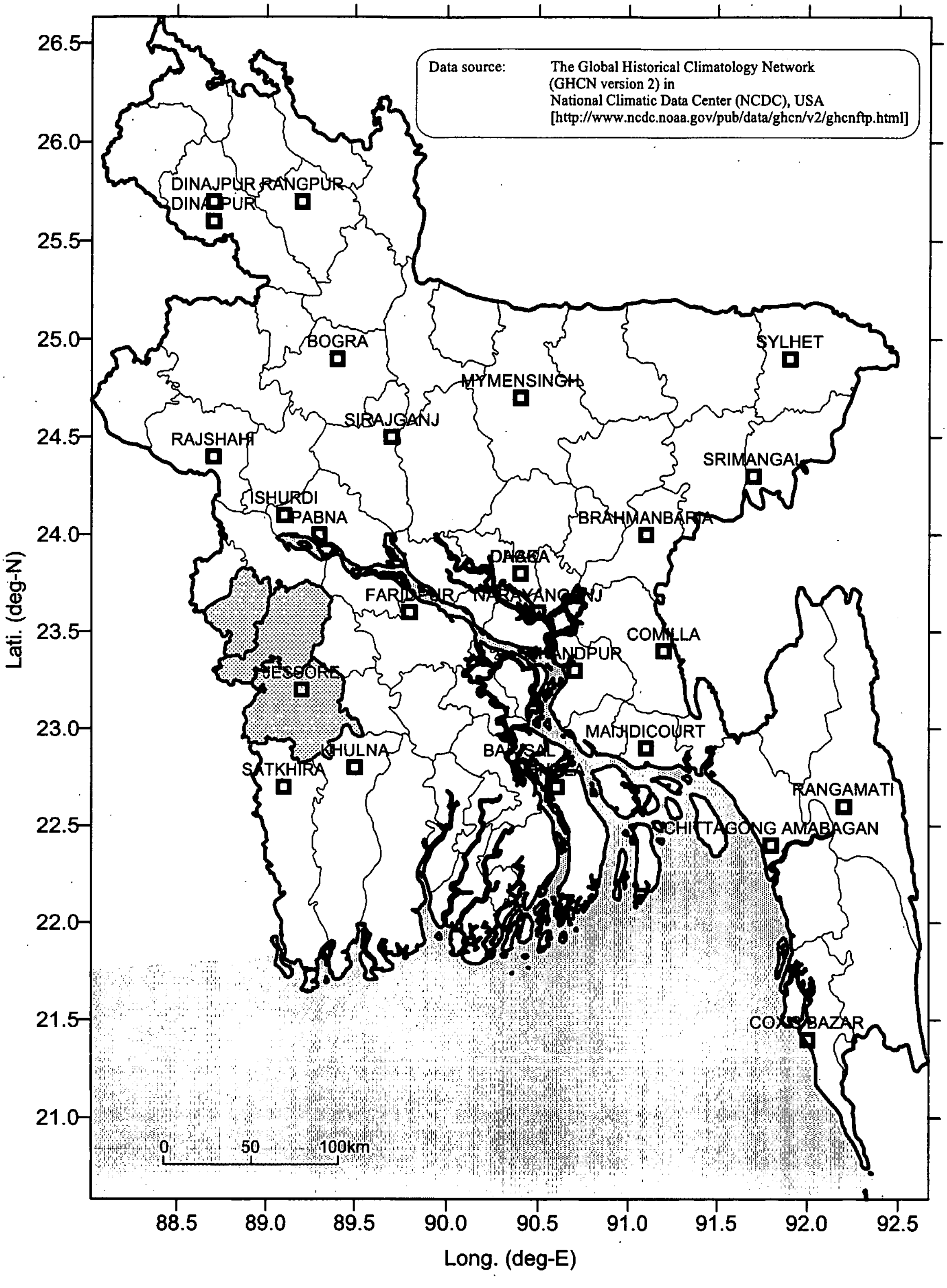
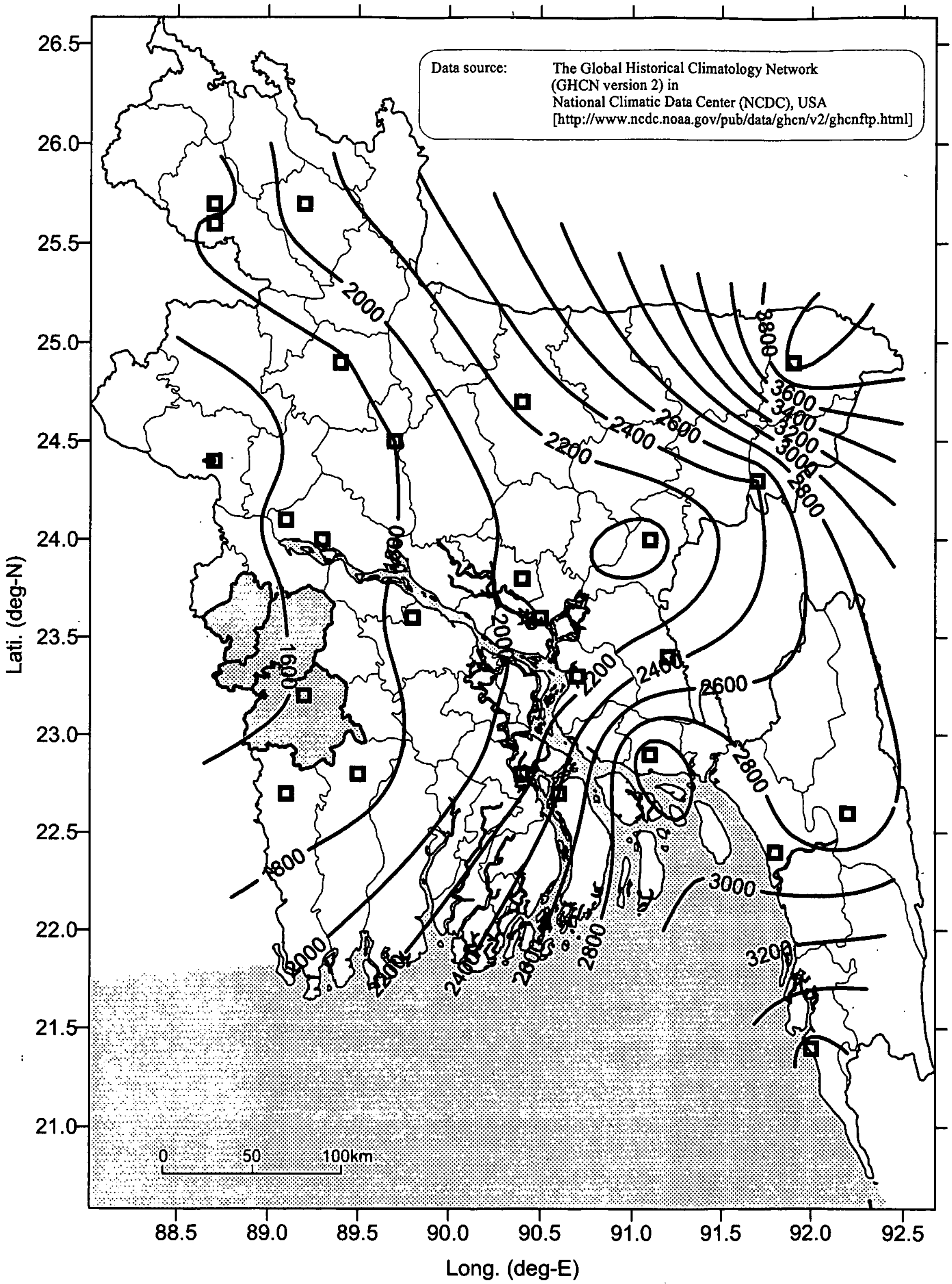


Figure 2.1.1	Location of Meteorological Stations in Bangladesh

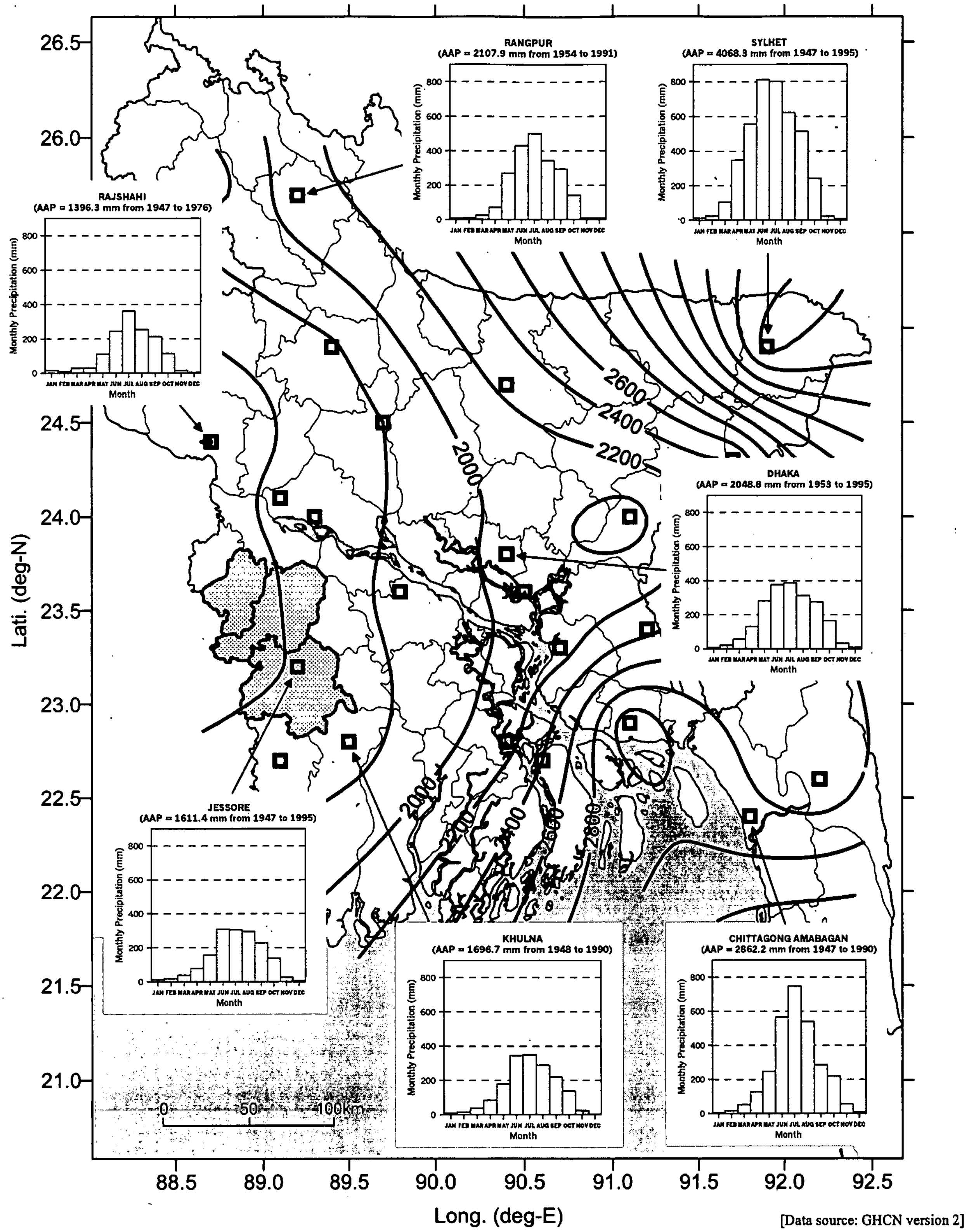
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



——— **2000**
Equal Line of
Average Annual
Precipitation (mm)

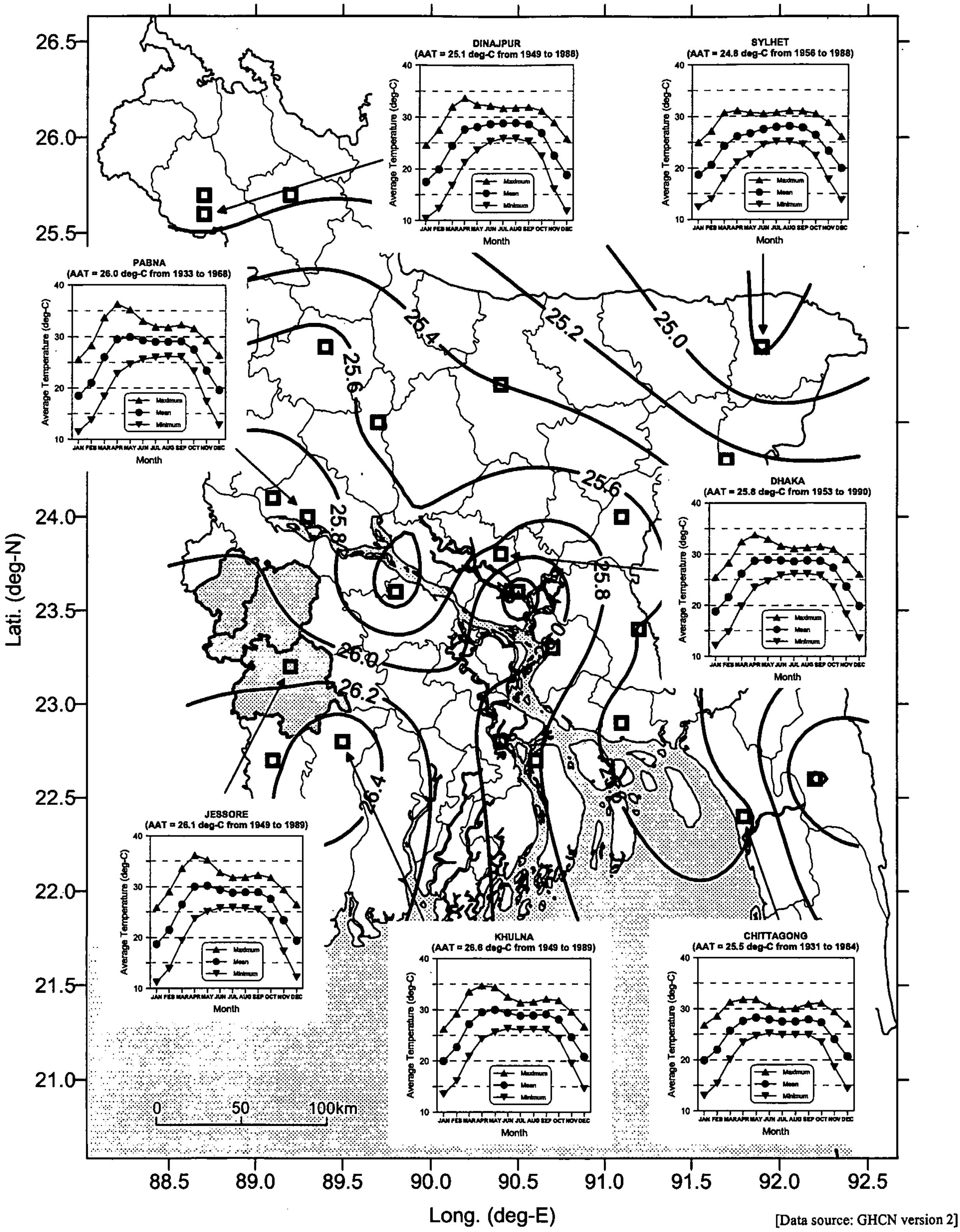
Figure 2.1.2	**Distribution of Average Annual Precipitation in Bangladesh**
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[Data source: GHCN version 2]

——— **2000**
Equal Line of Average Annual Precipitation (mm)

Figure 2.1.3	**Average Monthly Precipitation in Bangladesh**
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



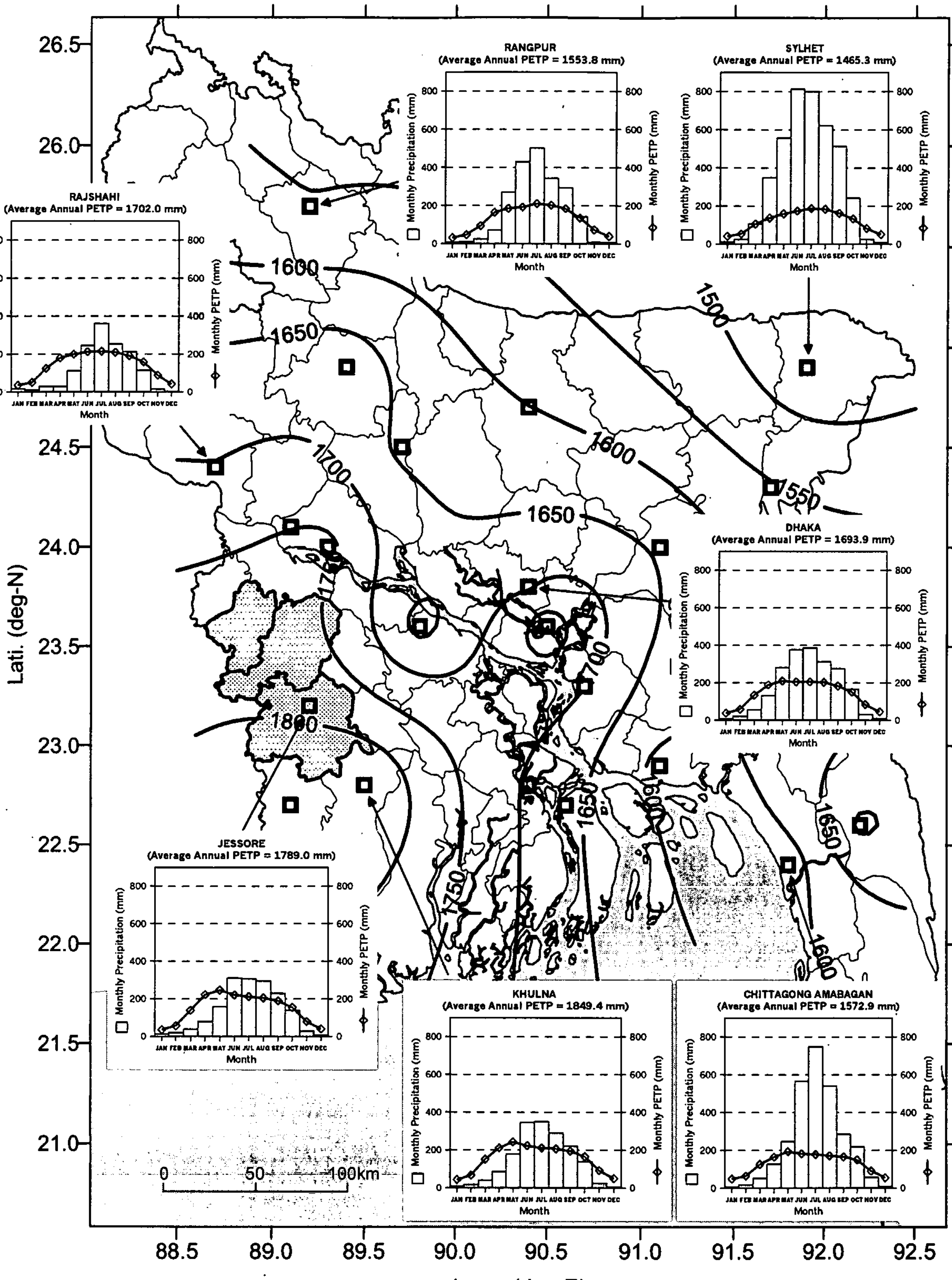
[Data source: GHCN version 2]

26.2 Equal Line of Average Annual Temperature (deg-C)

Figure 2.1.4	Average Monthly Temperature in Bangladesh

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

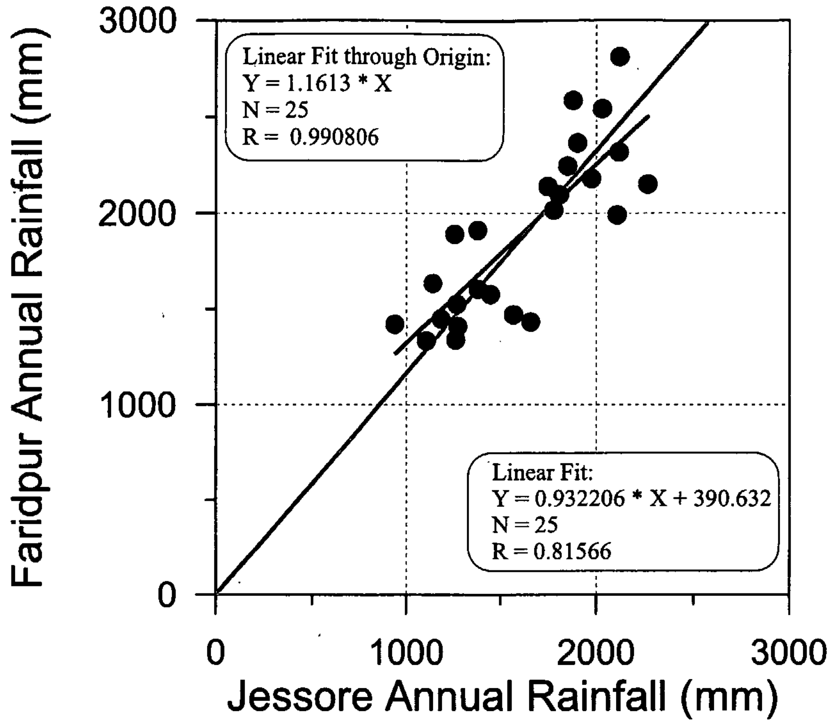


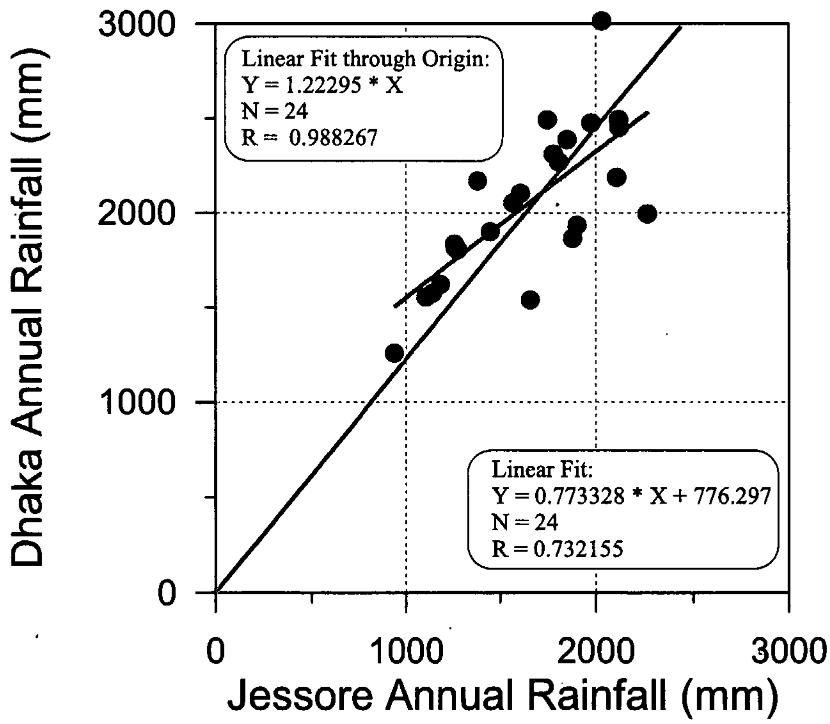
(PETP: Potential Evapotranspiration)

[Data source: GHCN version 2]
[PETP values were computed by Thornthwaite Method]

1750 Equal Line of Average Annual PETP (mm)

Figure 2.1.5	**Average Monthly Potential Evapotranspiration in Bangladesh**
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	





[Data source: GHCN version 2]

Figure 2.1.6	**Correlation of Annual Rainfall (1) [Jessore-Faridpur, Jessore-Dhaka]**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

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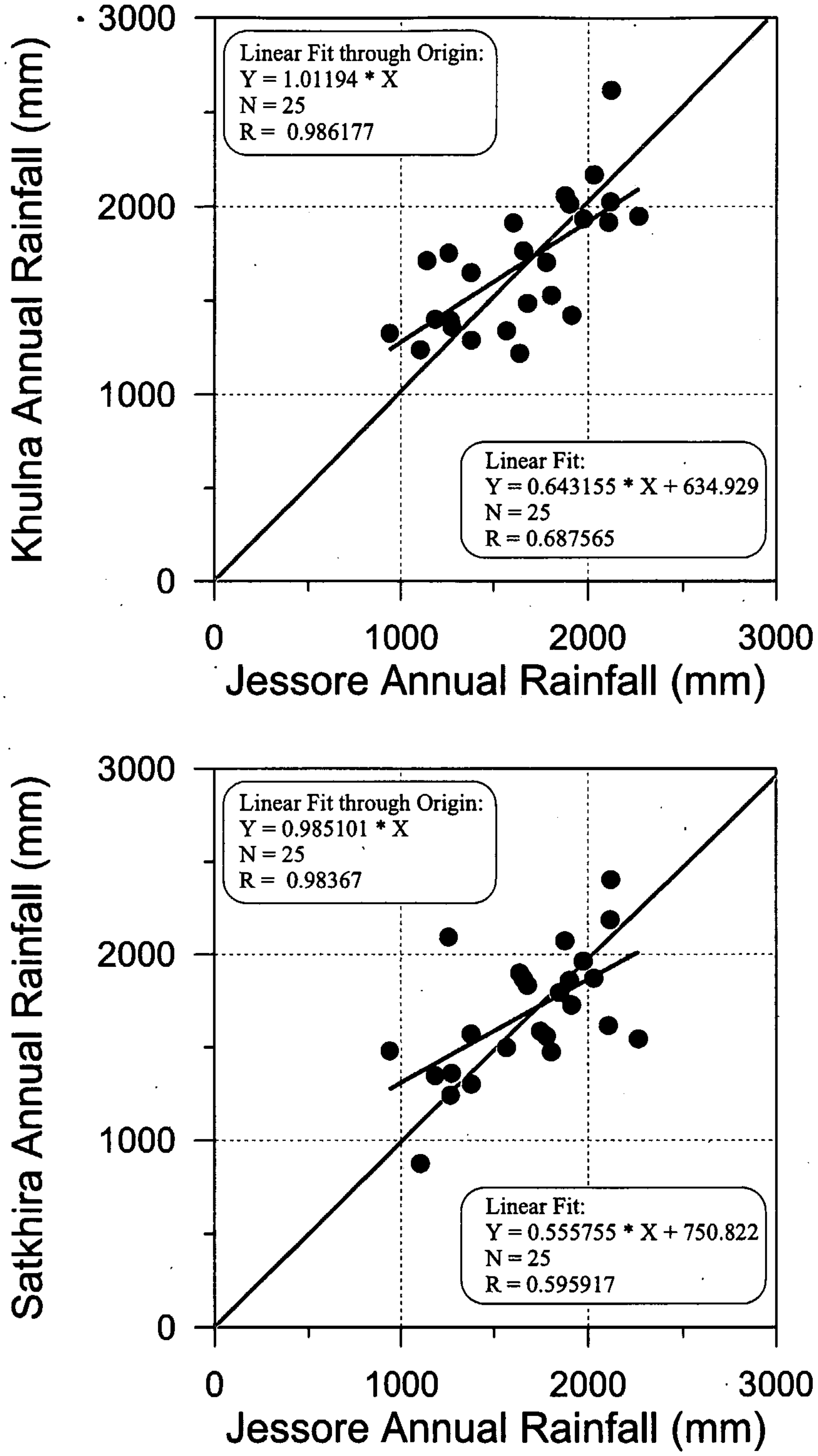

[Data source: GHCN version 2]

Figure 2.1.7	Correlation of Annual Rainfall (2) [Jessore-Khulna, Jessore-Satkhira]
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
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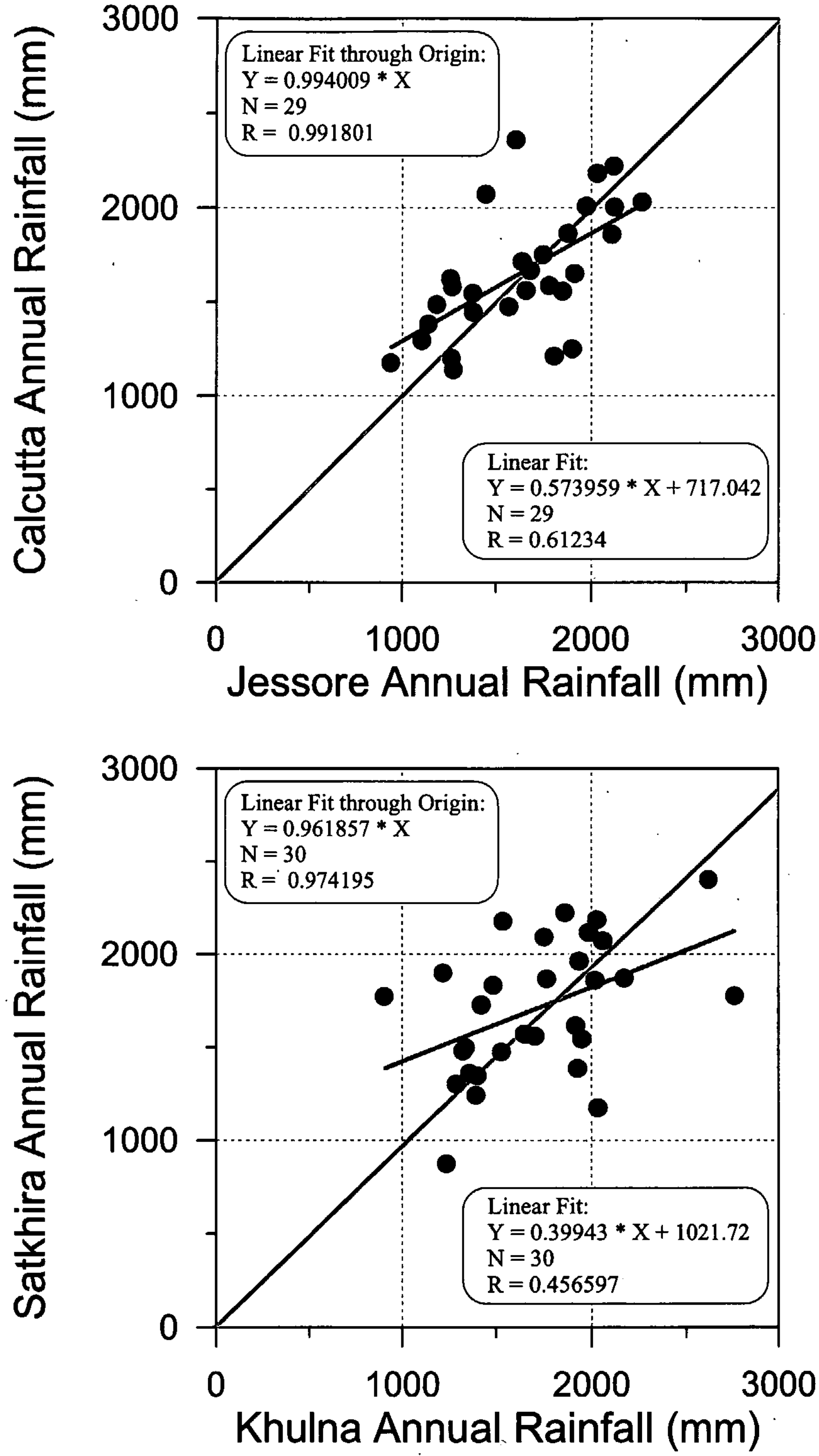
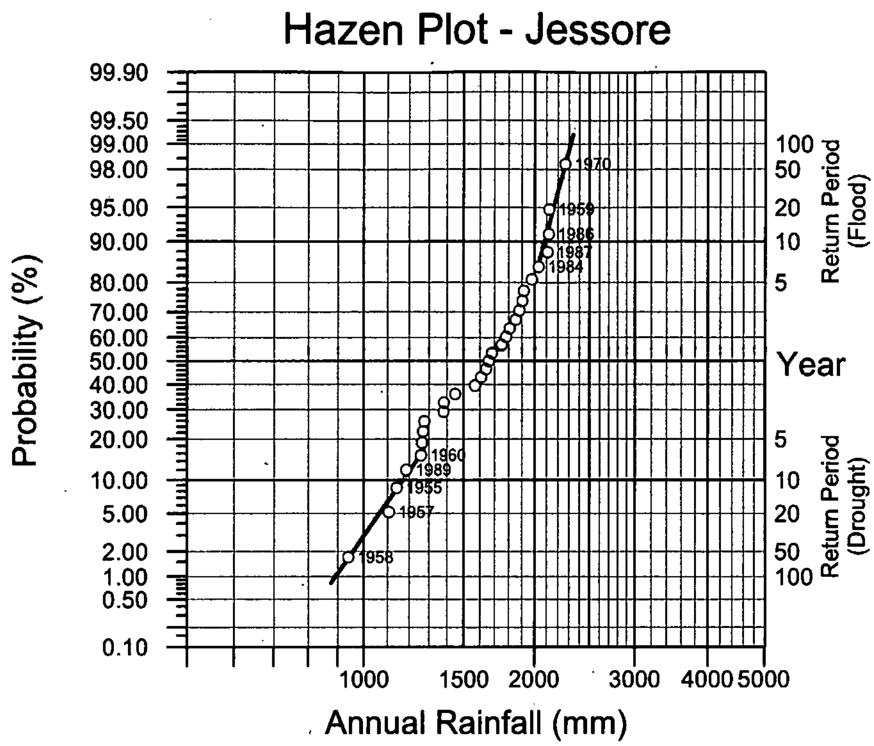
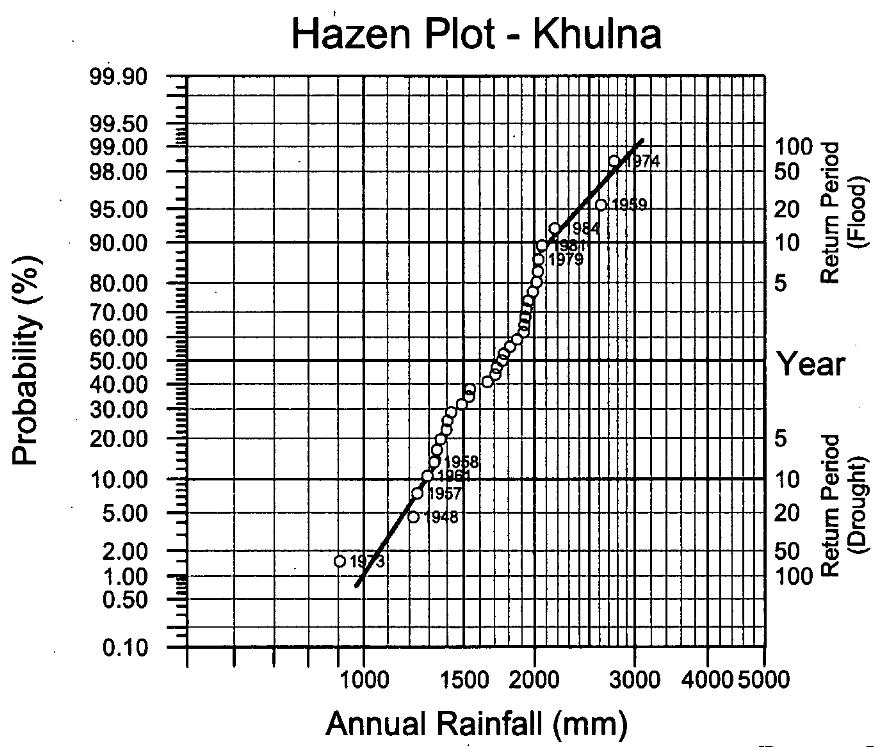


[Data source: GHCN version 2]

Figure 2.1.8	Correlation of Annual Rainfall (3) [Jessore-Calcutta, Khulna-Satkhira]
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	





[Data source: GHCN version 2]

Figure 2.1.9	Probability Analysis of Annual Rainfall [Jessore, Khulna]

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

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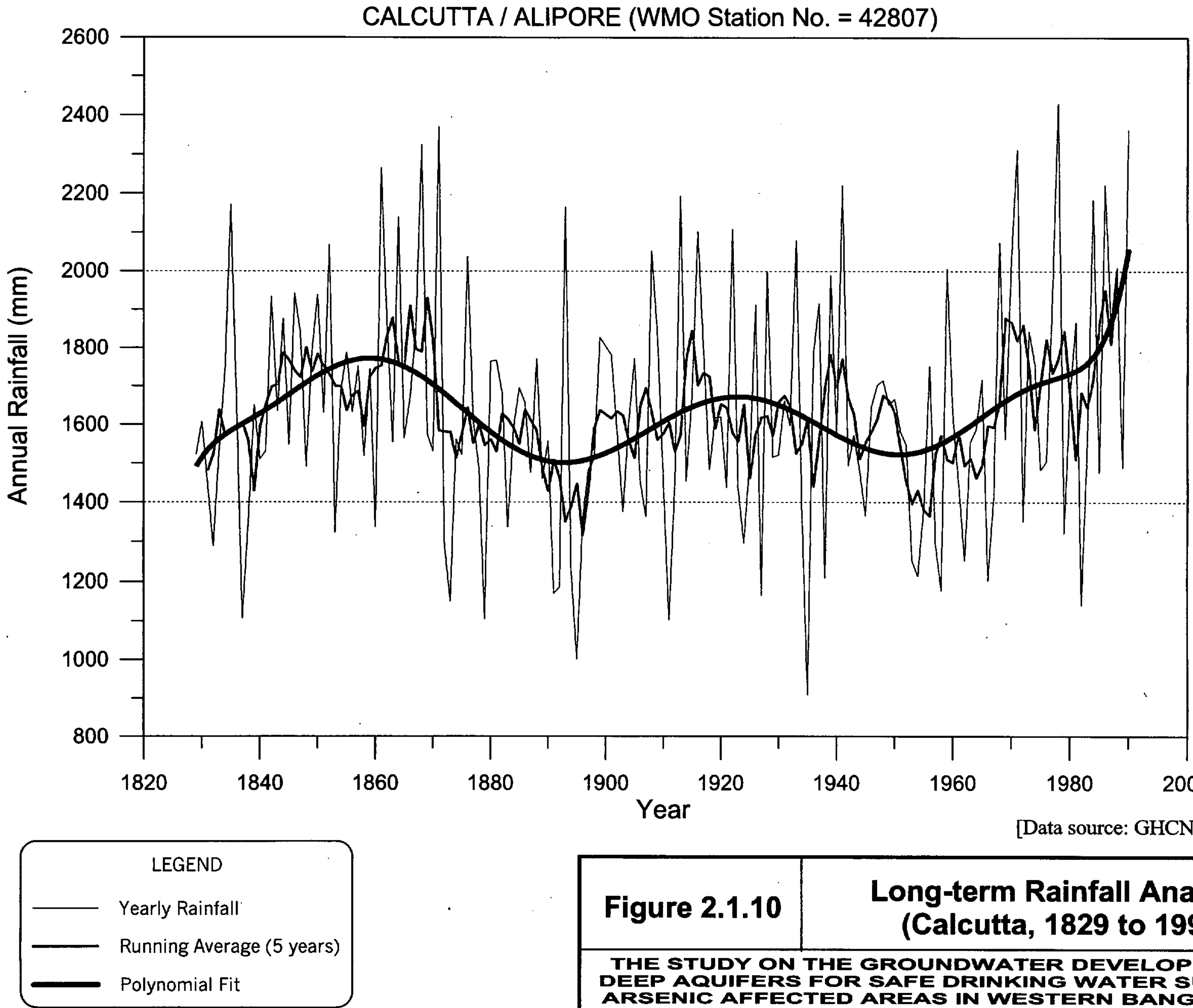
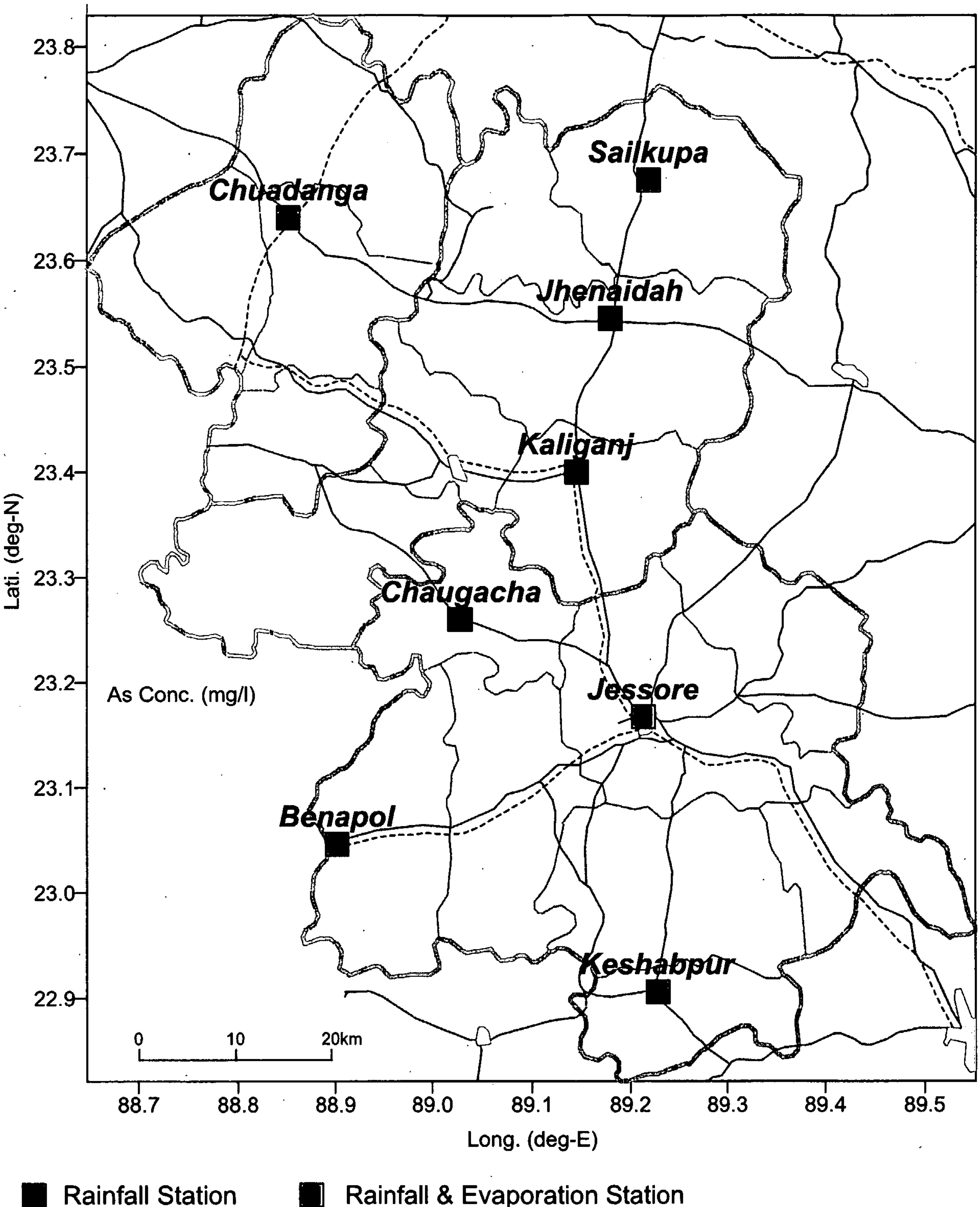


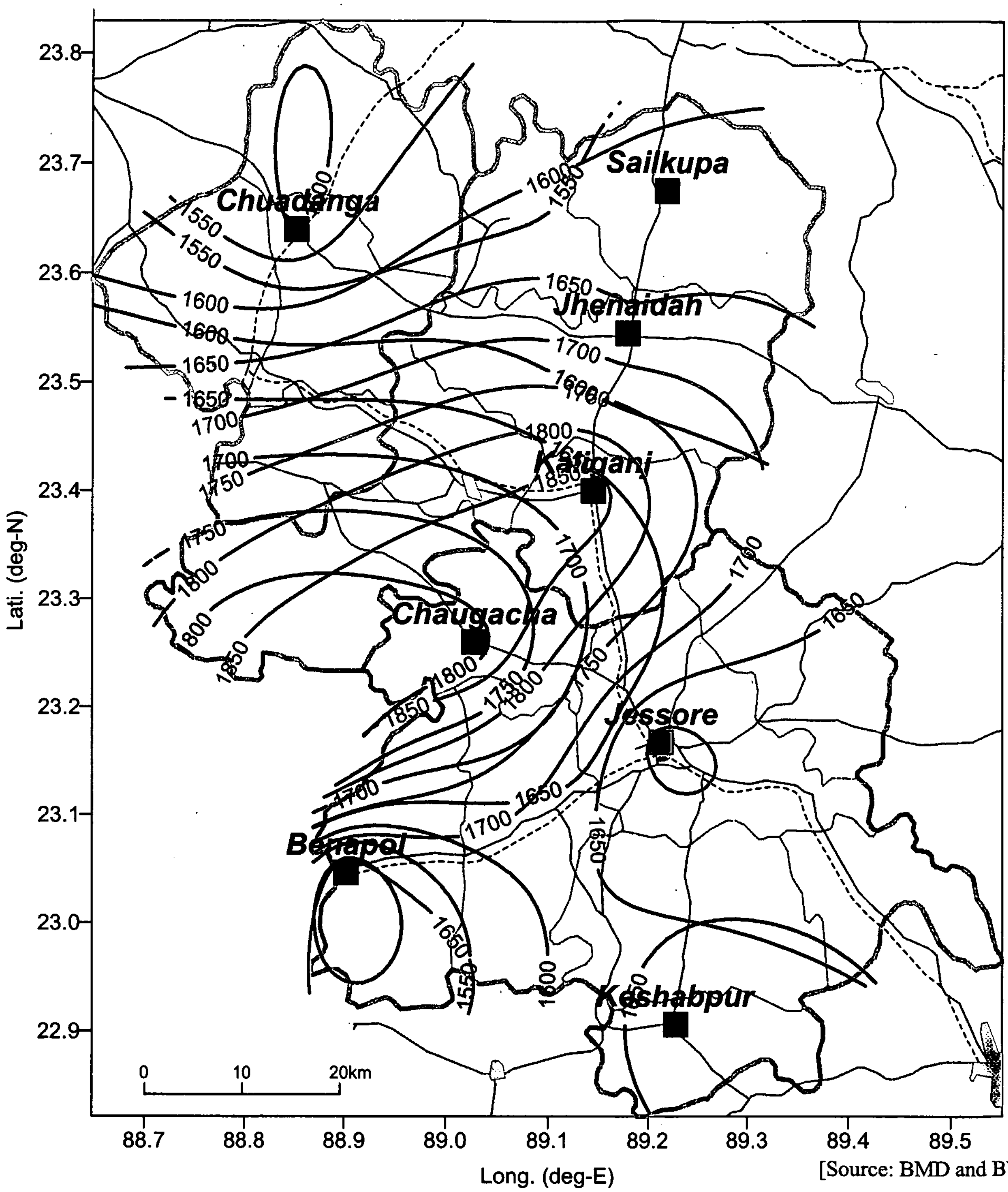
[Data source: GHCN version 2]

Figure 2.1.10	Long-term Rainfall Analysis (Calcutta, 1829 to 1990)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[Source: BMD and BWDB]

Figure 2.1.11	Rainfall and Evaporation Stations in the Study Area
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



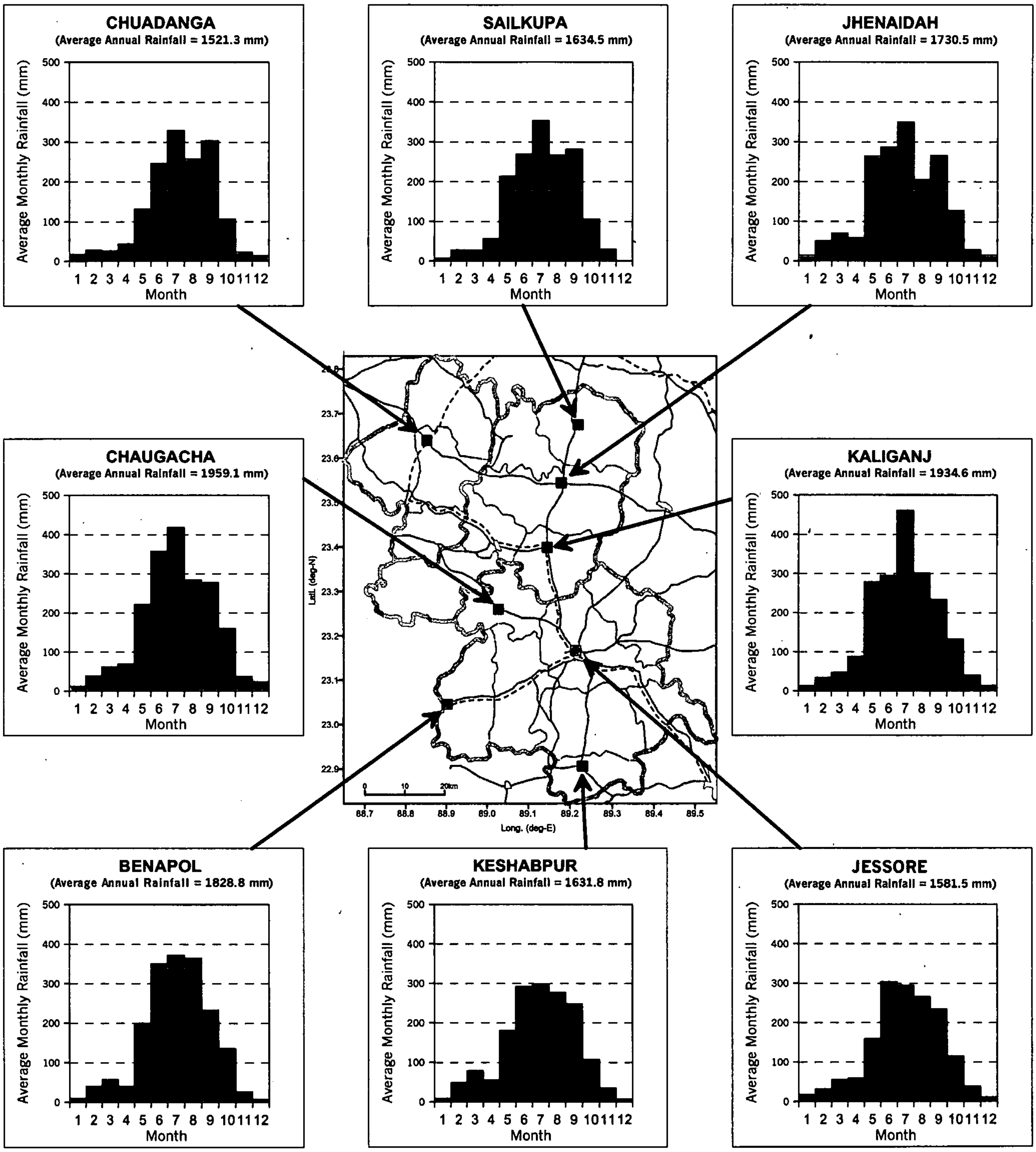
[Source: BMD and BWDB]

Legend	
———	Average Annual Rainfall (mm) from 1991 to 1994
———	Average Annual Rainfall (mm) from 1988 to 1999 with missing data
■	Rainfall Station
■	Rainfall & Evaporation Station

Figure 2.1.12	**Average Annual Rainfall in the Study Area**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

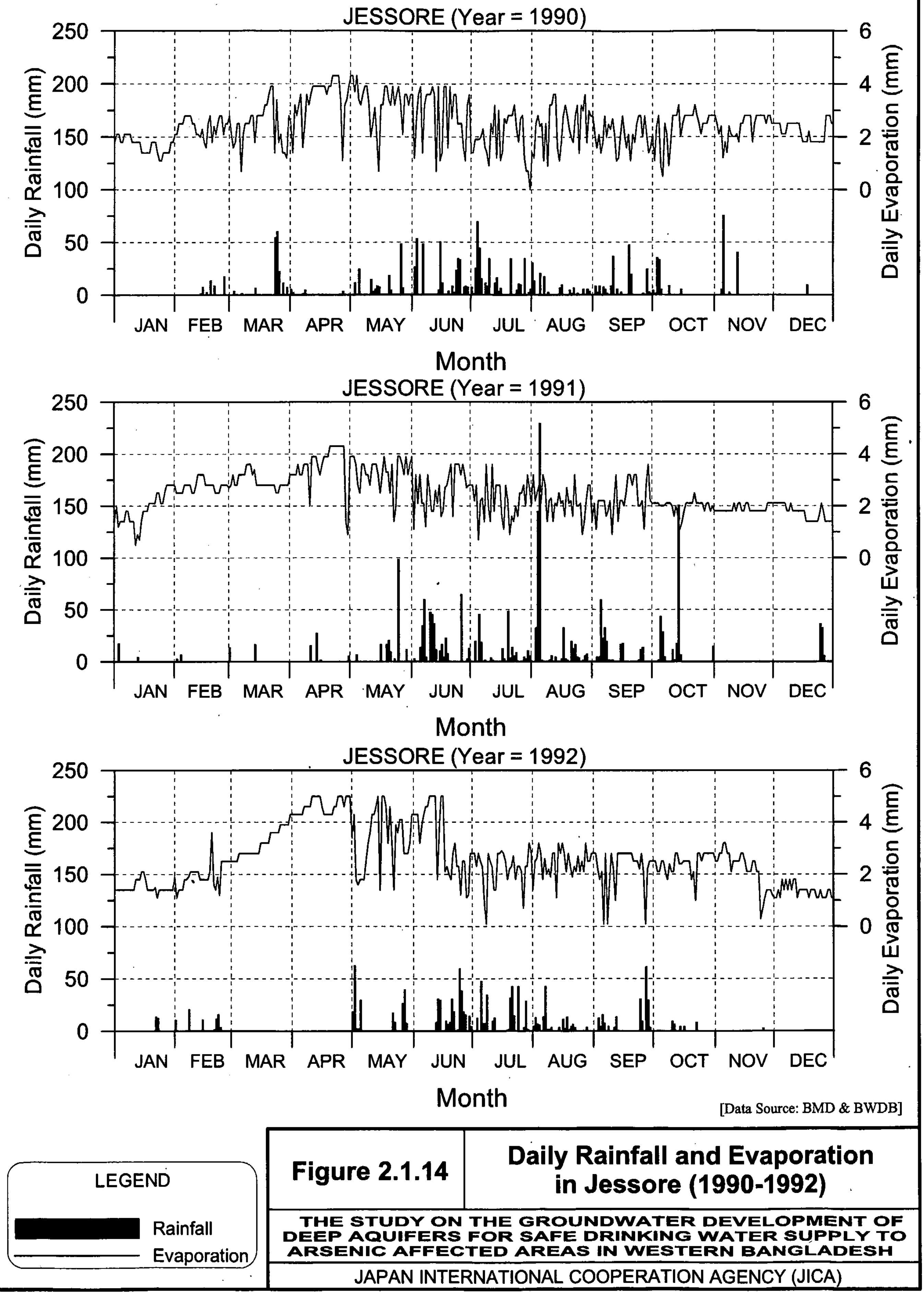


[Source: BMD and BWDB]

■ Rainfall Station

■ Rainfall & Evaporation Station

Figure 2.1.13	Average Monthly Rainfall in the Study Area
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

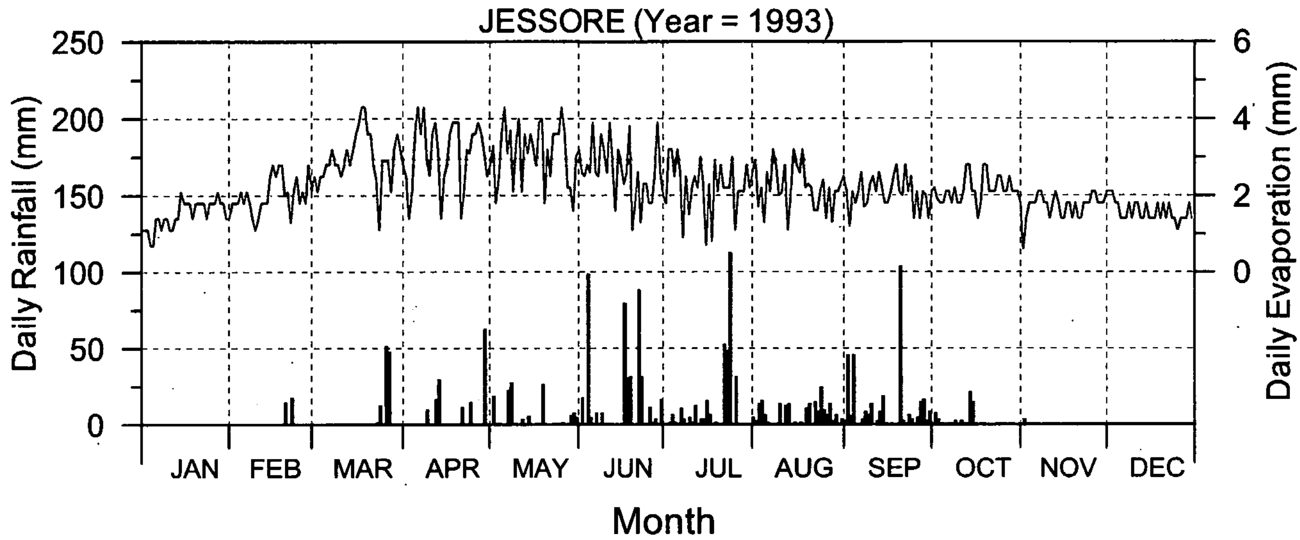


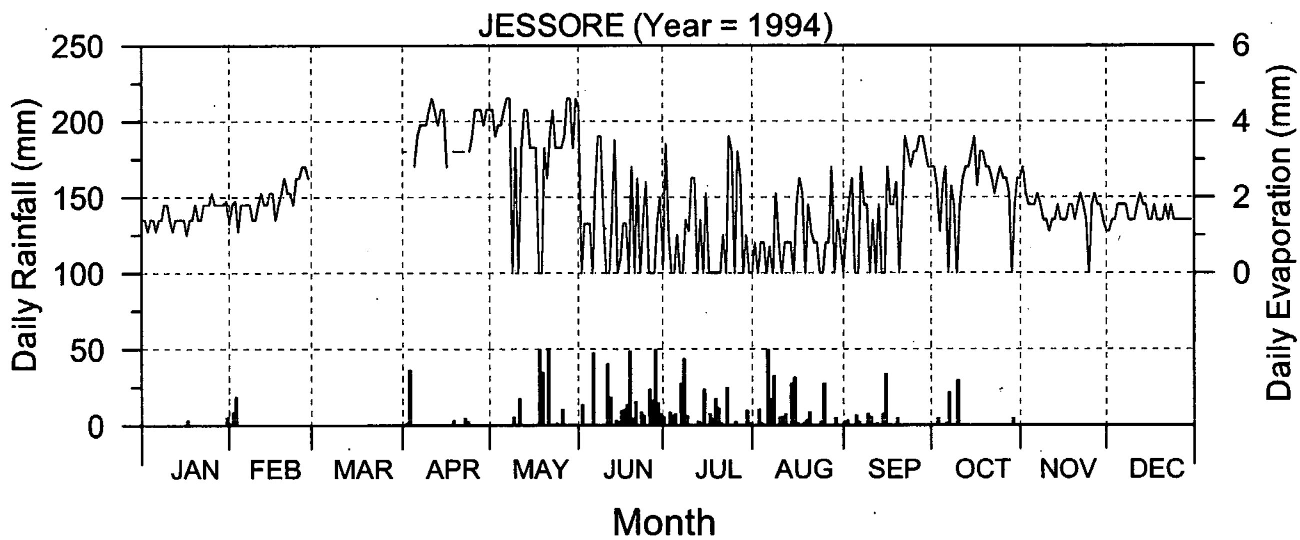
[Data Source: BMD & BWDB]

Figure 2.1.14	Daily Rainfall and Evaporation in Jessore (1990-1992)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)





[Data Source: BMD & BWDB]

LEGEND

Rainfall

Evaporation

Figure 2.1.15 **Daily Rainfall and Evaporation in Jessore (1993-1994)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

2.2 Hydrology

The study area is located on the right side of the Ganges River (known as the Padma River in Bangladesh). The Ganges River originates from the central Himalayas and flows about 2,500km to the Bay of Bengal. There are many tributaries of the Ganges River in the study area.

2.2.1 Drainage Pattern

Figure 2.2.1 shows the drainage map of Bangladesh. There are three (3) major rives in Bangladesh, viz. Padma River, Jamuna River and Meghna River. The Padma (Ganges) River flows along the Bangladesh-India border at Nawabganj and Rajshahi districts. Then the Padma River flows southeast and meets the Jamuna River at the junction of Pabna, Rajganj and Manikganj districts. The Meghna River joins the Padma River in the south of Munshiganj then flows to the Bay of Bengal.

The rivers and water bodies in the study area are shown in Figure 2.2.2. This map was prepared based on the LGED Thana Base Map (1994). The rivers in the study area generally flow from northwest to southeast. In the northern part, rivers flow from west to east, whereas the rivers in the southern part of the study area flow from north to south. Major rivers in the study area originate from Indian territory.

There are numerous water bodies such as lakes, beels, haors, and baors. Crescent lakes are distributed particularly in the western part and southern part of the study area. Shallow lakes, which are located at natural land depressions, are known as beels. The beels are also found in western to southern parts of the study area. Small lakes and tanks / ponds are mainly distributed in the central to eastern parts. Canals are developed mainly in the northern part of the study area.

2.2.2 River Flow

The flow rate of the Padma River has been monitored at Hardinge Bridge at Kushtia. The location of Hardinge bridge is shown in Figure 2.2.1.

Table 2.2.1 summarizes the mean flows of the Padma River measured for the period from 1934 to 1992. It should be noted that the Farakka Barrage in India was constructed in 1974. The barrage is located just before the Ganges River enters Bangladesh. The main role of the barrage is to keep the port of Calcutta open during summer. It is mentioned by Rashid and Kabir (1998) that the construction of the Farakka Barrage has drastically reduced the natural flow of the Ganges water downstream in Padma, Bangladesh.

Figure 2.2.3 shows the mean monthly average and minimum flows of the Padma River by pre-Farakka flows (1934 to 1974), post-Farakka flows (1974 to 1988) and post-agreement flows (1989 to 1992). It is obviously seen that the flow rates after the construction of Farakka Barrage were reduced in the dry season. Even after the agreement between Bangladesh and India in 1988, the mean monthly average flows from February to April are just only 25 to 35% of those in the pre-Farakka period. Both countries made a new agreement in 1998 to share the river water, however, it is said that the flow is still small and serious damage is caused in the dry season.

The reduction of flow rates in the rivers in the study area is not known so far, however, it would be possible that flow rates of some rivers might be reduced because those rivers are diverted from the Ganges River. If the flow rate and river water levels have declined in the study area after the construction of the Farakka Barrage, it would be possible that the groundwater levels in the study area have also declined particularly in the dry season.

Table 2.2.1 Mean Monthly Flows in the Padma River at Hardinge Bridge

Average Flow (in m^3/sec)

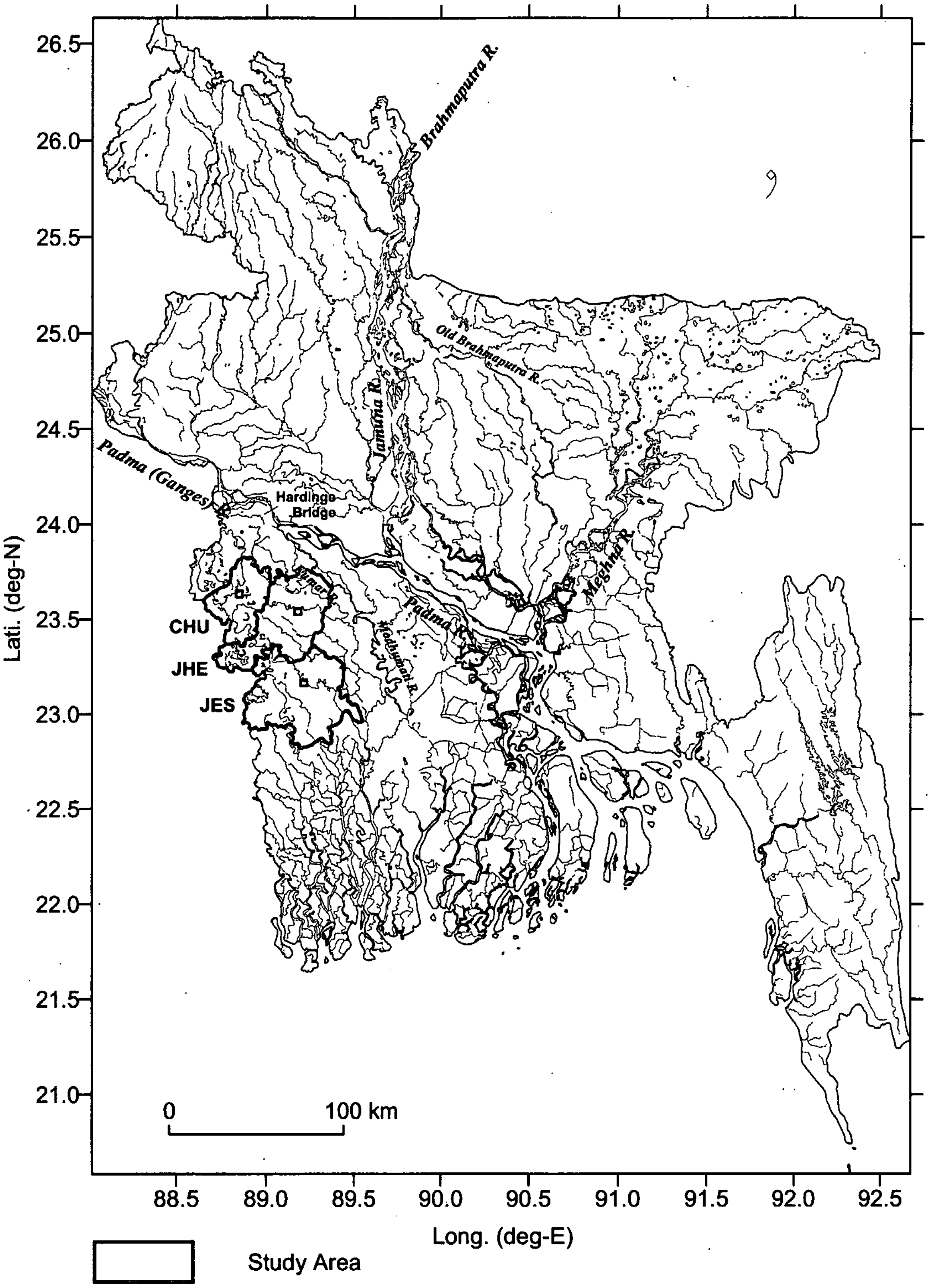
Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1934-1974	3090	2668	2287	2031	2176	4489	17290	38348	36063	17870	7091	4180	11685
1974-1988	1932	1482	1155	1063	1450	3569	20111	40183	39233	16685	5730	2943	11295
1989-1992	1436	788	576	712	1309	5016	20269	32596	32243	14798	4133	2151	9663

Minimum Flow (in m^3/sec)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1934-1974	2055	1897	1576	1260	1440	2344	9704	23584	20907	7714	4145	2869	7817
1974-1988	1249	884	742	263	706	1512	11725	26574	15360	7813	2864	1930	6839
1989-1992	1204	551	517	663	1187	4547	11636	26650	27035	8599	3519	2064	8534

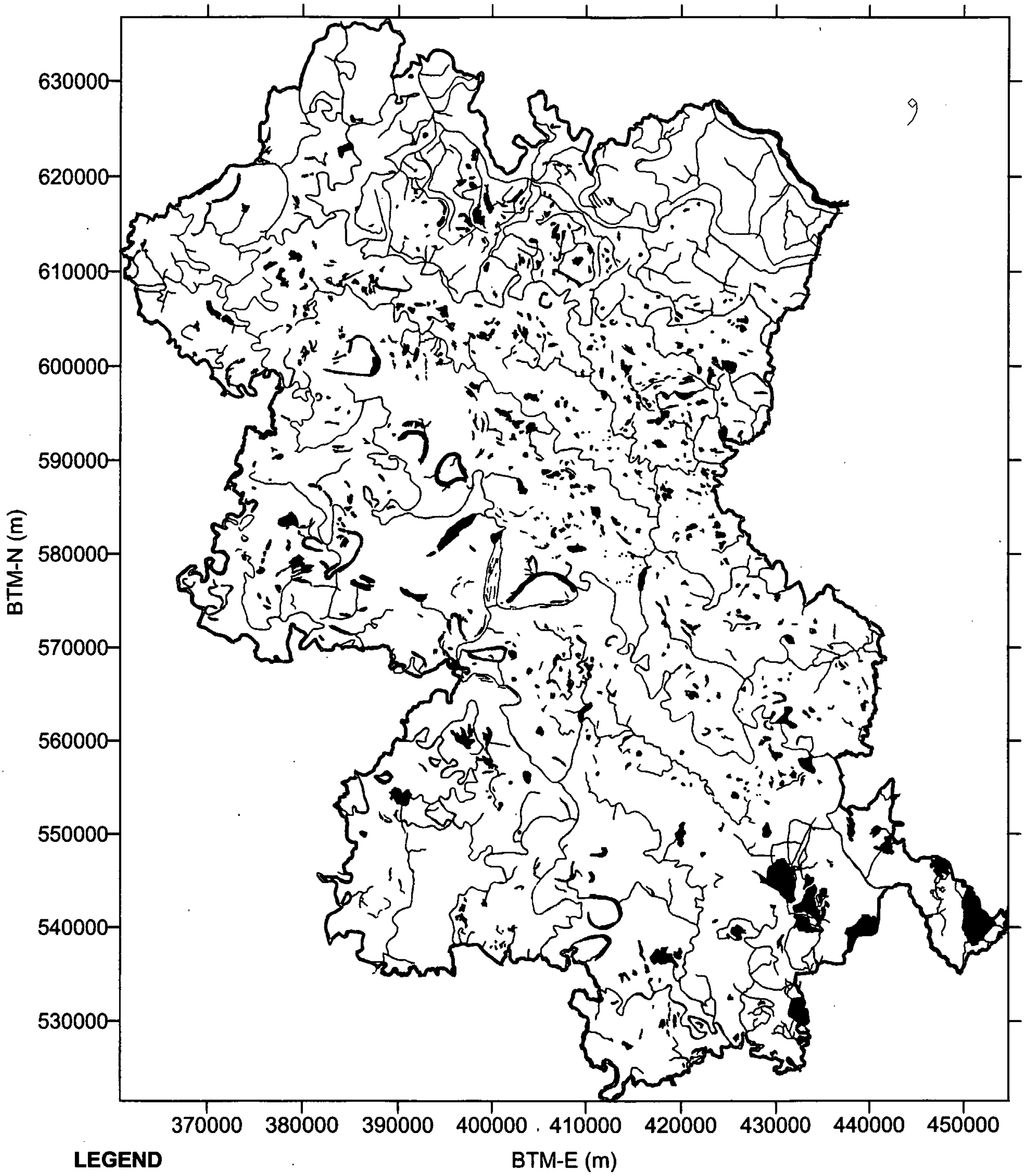
Note:
1934-1974: pre-Farakka flows
1974-1988: post-Farakka flows
1989-1992: post-Agreement flows

[Source: FPCO, Ministry of Irigation, GoB, FAP25 (1993)]



[Data Source: GIS Data Depot - Free GIS Data http://www.gisdatadepot.com/]

Figure 2.2.1	River Map of Bangladesh
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

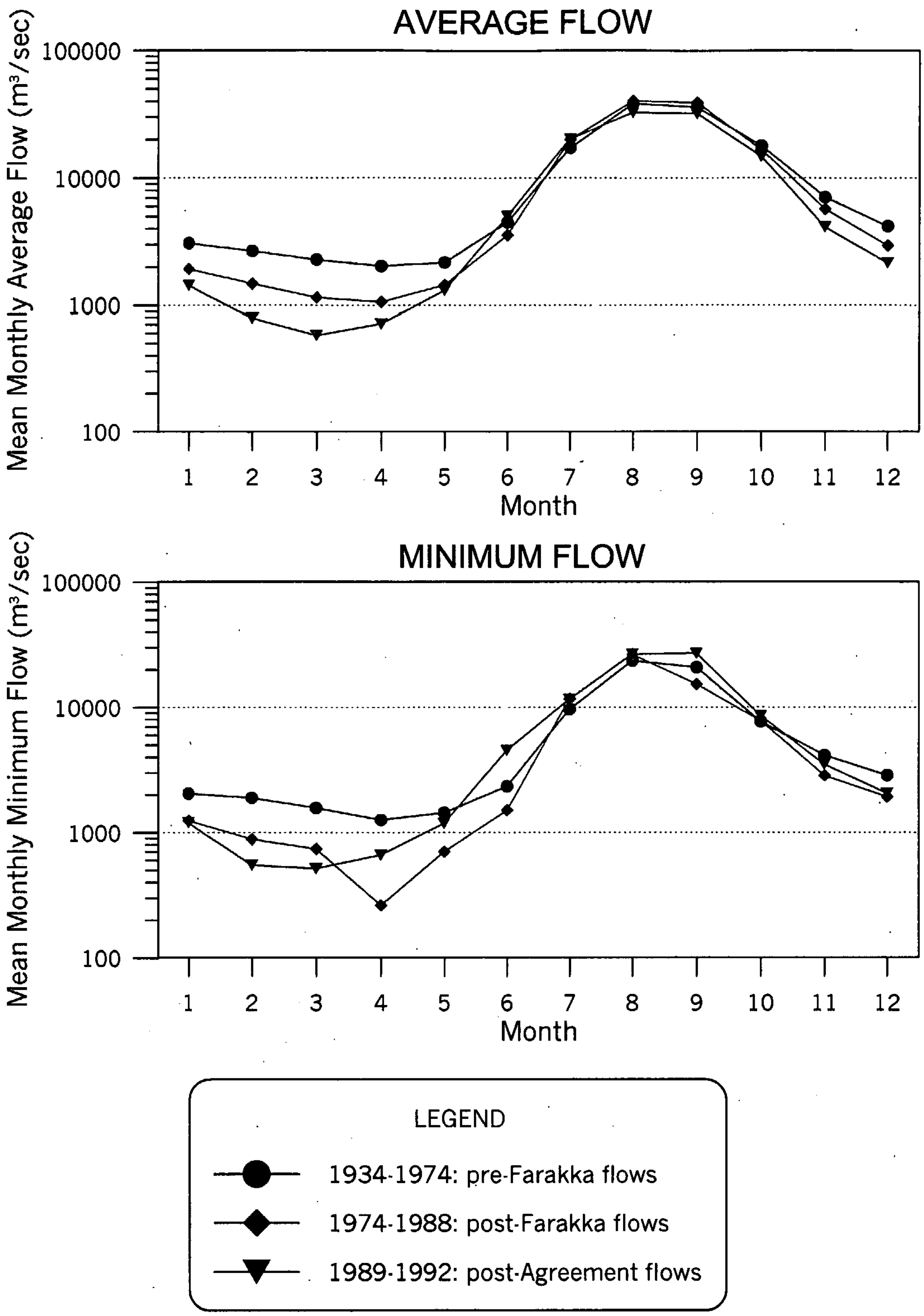


LEGEND

- River
- Khal / Canal
- Water Bodies (Lake / Beel / Haor / Baor)
- Tank / Pond
- Study Area

[Data Source: LGED Thana Base Map (1994)]

Figure 2.2.2	Rivers and Water Bodies in the Study Area
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[Source: FPCO, Ministry of Irigation, GoB, FAP25 (1993)]

Figure 2.2.3	Mean Monthly Flows in the Padma River at Hardinge Bridge

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

2.3 Topography and Geology

2.3.1 Topography

The territory of Bangladesh mostly consists of alluvial lowland, which is called the Bengal Lowland by Umitsu (1987). The Bengal Lowland is formed by a 200 to 300 kilometer-wide plain, bordered by mountains and highlands on three sides and by the Bay of Bengal to the south. In the Bengal Lowland, there are some Pleistocene plateaus such as Madhupur Jungle located north of Dhaka and Barind Plateau located north of Rajshahi. The rest of the Bengal Lowland is subdivided into the Ganges Delta, Brahmaputra-Jamuna Floodplain, and Sylhet Basin.

The Ganges Delta comes under the jurisdiction of the greater districts of Kushtia, Jessore, Faridpur, Khulna, Barisal, and Patuakhali. It comprises an area of approximately 40,450km^2, or 27 percent of Bangladesh's total area. It is bordered by India to the west, by the Ganges (Padma) and Lower Meghna rivers to the north and east, and by the Bay of Bengal to the south.

The study area occupies a part of the Ganges Delta. Figure 2.3.1 shows the LANDSAT imagery of the study area taken in February 1999. The ground elevations in the study area range from 0.5 to 15m above mean sea level. Figure 2.3.2 shows the distribution of ground elevation in the study area based on the GTOPO 30 digital elevation model and the data of SOB. The northwestern part of the study area is comparatively high to medium-high land with a rolling topography. The ground elevation in Chuadanga district ranges from 8 to 15masl. From Jhenaidah district to Jessore district, the topography starts off as gently sloping but soon becomes very flat. The eastern half of Jessore district and southern to southwestern parts of the district are lain by low lands with elevation of less than 5 masl.

2.3.2 Geology

1) Surface Geology

The geology of Bangladesh is characterized by Pleistocene to Tertiary bedrocks in the eastern hilly region and thick Holocene sediments in the rest of the country according to GSB (1990). The simplified geological map of Bangladesh based on GSB (1990) is shown in Figure 2.3.3

In Bangladesh, the bedrocks consist of sedimentary rocks of Tertiary to Pleistocene age. The facies is mainly sandstone and shale with minor limestone. The bedrocks occur in the Chittagong Hill Tracks and the marginal areas of the northeastern part of Bangladesh.

In the Bengal Lowland, relatively older sediments occur in the Pleistocene plateaus. These sediments are called “Old Alluvium”. The Barind Plateau located north of Rajshahi is underlain by Barind Clay Residuum. Similarly, the Madhupur Jungle located north of Dhaka is underlain by Madhupur Clay Residuum.

The surface geology of the study area is comprised of deltaic sediments from the Holocene age. The deltaic sediments are sediments that are deposited on the active delta, which is south of the

Ganges river and mostly west of the Meghna estuary. Most of the area is less than 15m above mean sea level. The delta is crossed by parallel south-southeast trending distributary channels.

Most of the study area is underlain by deltaic silt. Deltaic sand occurs at the northern part of the study area. Marsh clay and peat are distributed in the central to the eastern part of the study area. The geological description of the deltaic silt, deltaic sand, and marsh clay and peat by GSB (1990) are as follows:

Deltaic silt:	Light gray to gray, fine sandy silt to clayey silt. Fine overbank sediments deposited by distributaries in flood basins.
Deltaic sand:	Light to yellowish gray fine sand to silty sand. Deposited mainly during floods in channels, crevasse splays, natural levees and flood plains including channel bars and point bars.
Marsh clay and peat:	Grey or bluish gray clay, black herbaceous peat, and yellowish gray silt. Alternating beds of peat and peaty clay common in bils and large structurally controlled depressions. In the deepest parts peat is thickest.

2) Subsurface Geology

The subsurface geology is not fully understood in the study area. It is reported by Umitsu (1987) that the alluvial sediments shallower than 30m in depth in the northwestern part of the Ganges Delta is divided into upper silty layer and lower sandy layer. The upper layer has thickness of 8 to 10m with the N value by the standard penetration test of 5 to 15. The lower layer consists of medium to fine sand with silt, having an N value ranging from 15 to 45. Umitsu (1987) also reported that the upper layer occasionally contains peaty silt layers. At Dewlatpur located about 8km northwest of Khulna city, Umitsu (1987) reported that the alluvial sediments within 50m deep can also be divided into the upper layer consisting of silt and clay and the lower layer of sand. The N values within a depth of 46m range from 1 to 24. The facies of the upper layer tends to change from sandy facies to silty/clayey facies from north to south. However, the facies near the Bhairab River shows sandy. In addition, the facies of the upper layer becomes peaty or rich in organic materials near Khulna city.

The JICA Expert Team (2000) collected drilling records of the existing deep tube wells sunk by DPHE in the study area. Although the number of available data, drilling depths, and the accuracy of the geologic descriptions are limited, the JICA Expert Team drew several geological profiles in the study area.

According to the geological profiles made for Jhenaidah district as shown in Figure 2.3.4, a clay/silt layer occurs at a depth within 100ft from the ground surface throughout the district. The thickness of the clay/silt layer ranges from 20 to 100ft. This shallow clayey layer is underlain by a fine sand layer. The thickness of the fine sand layer ranges from 50 to 300ft. In some areas, the fine sand layer is intercalated by one or two clayey layer(s) or very fine sand layer(s). The bottom elevation of the fine sand layer comes down toward southwest. The fine sand layer is underlain by a medium sand layer. The medium sand layer has a thickness ranging from 50 to 200ft. In some area, several very fine sand layers are intercalated in the medium sand layer. The medium sand layer is underlain a bay coarse sand layer. The boundary between the medium sand layer and coarse sand layer exists at depths of 350 to 450ft. The coarse sand layer contains gravel in some areas; therefore, it is called as “stone layer”. At Jhenaidah town, the gravel is well rounded and is 3 to 4cm in diameter.

Figure 2.3.5 shows the geological profiles in Jessore district. The shallow clayey layer occurs in the district with a thickness of 10 to 50ft. The subsurface geology in Jessore district characterized by a thick clayey layer occurs in the southern part. The clayey layer occurs below depths of 200 to 400ft. In Keshabpur thana, the thickness is about 600ft. In the western part of Jessore district, the existing wells often encounter a deep clayey layer at depths 500 to 900ft.

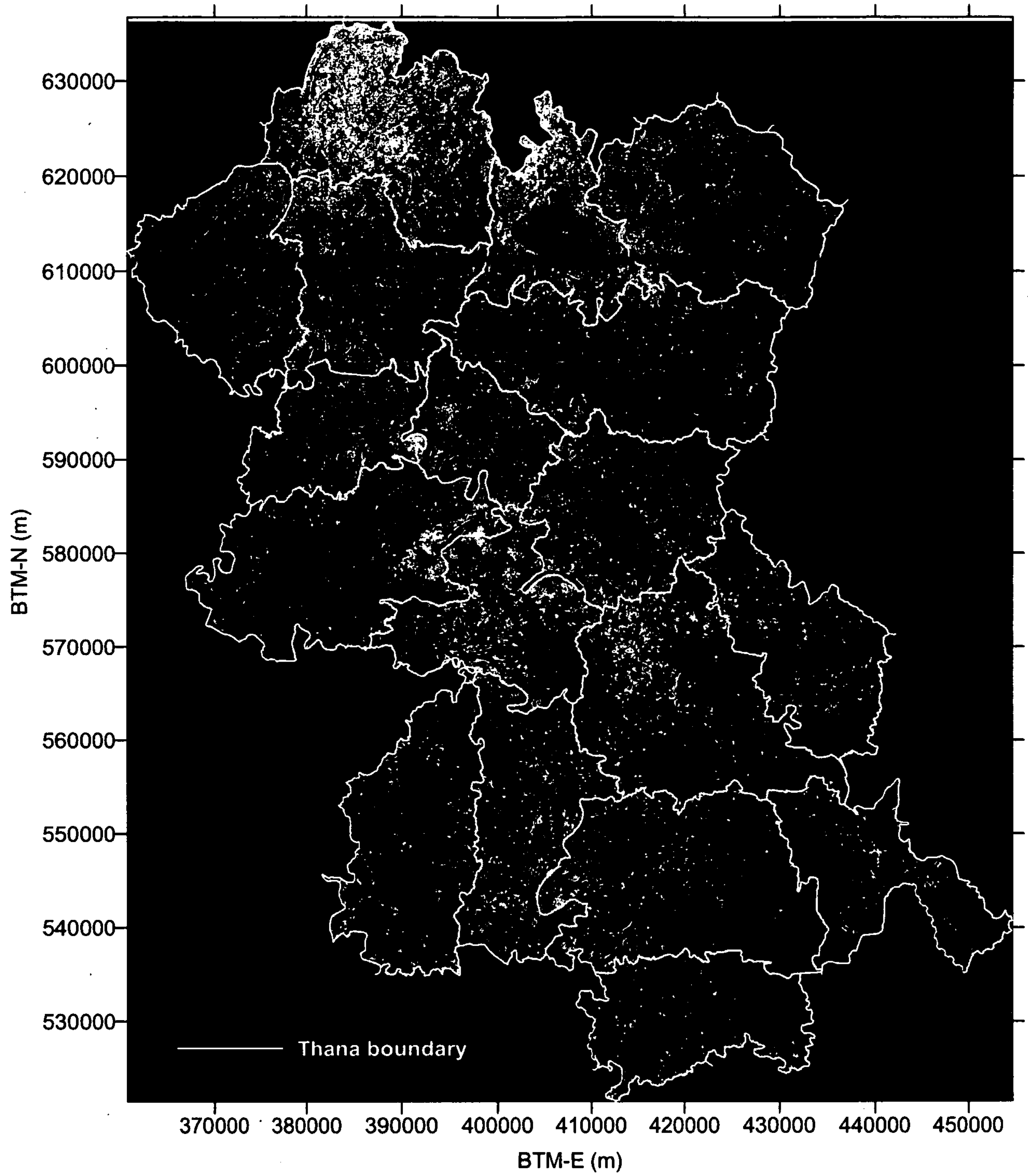


Figure 2.3.1	LANDSAT Imagery of the Study Area
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

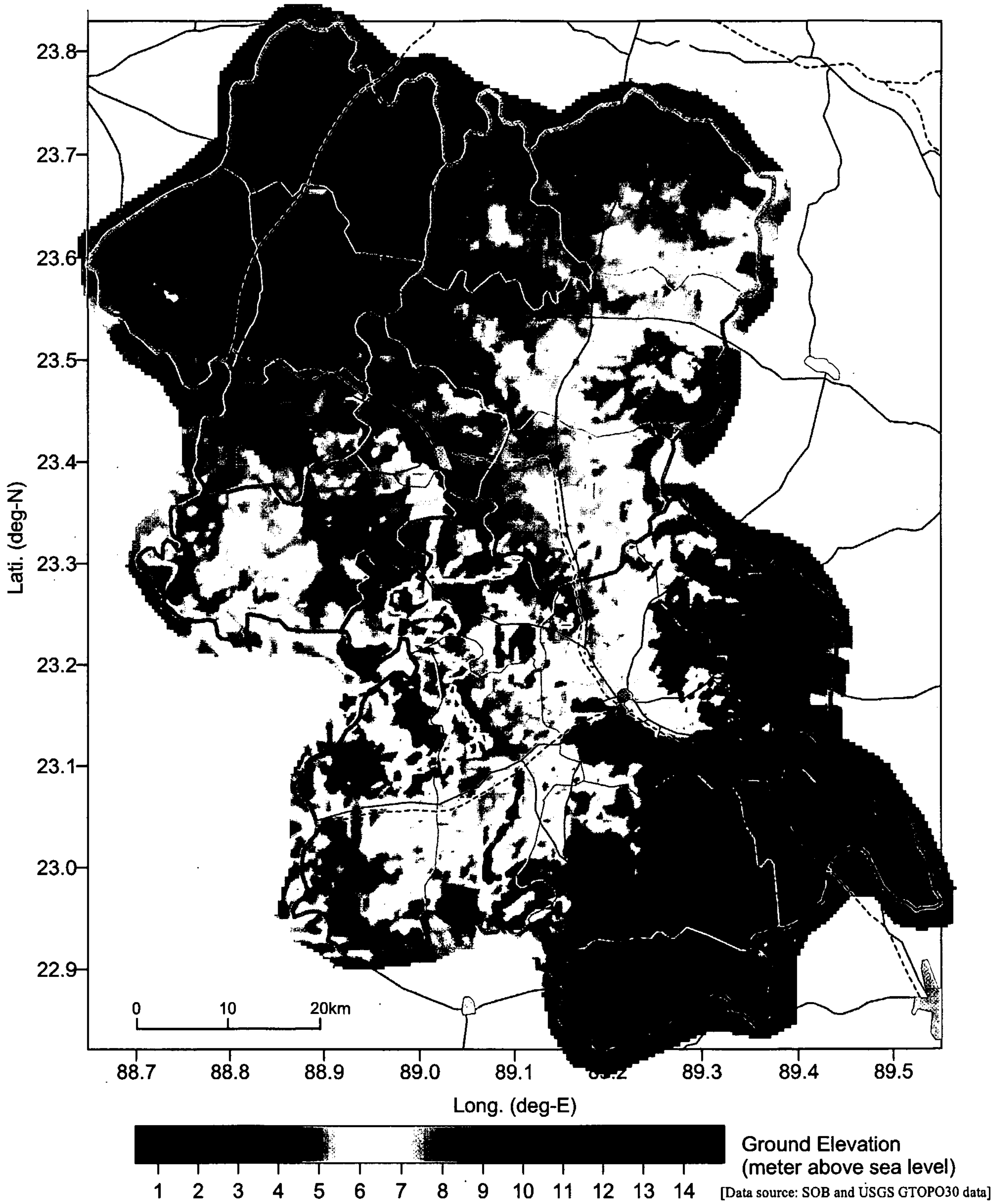
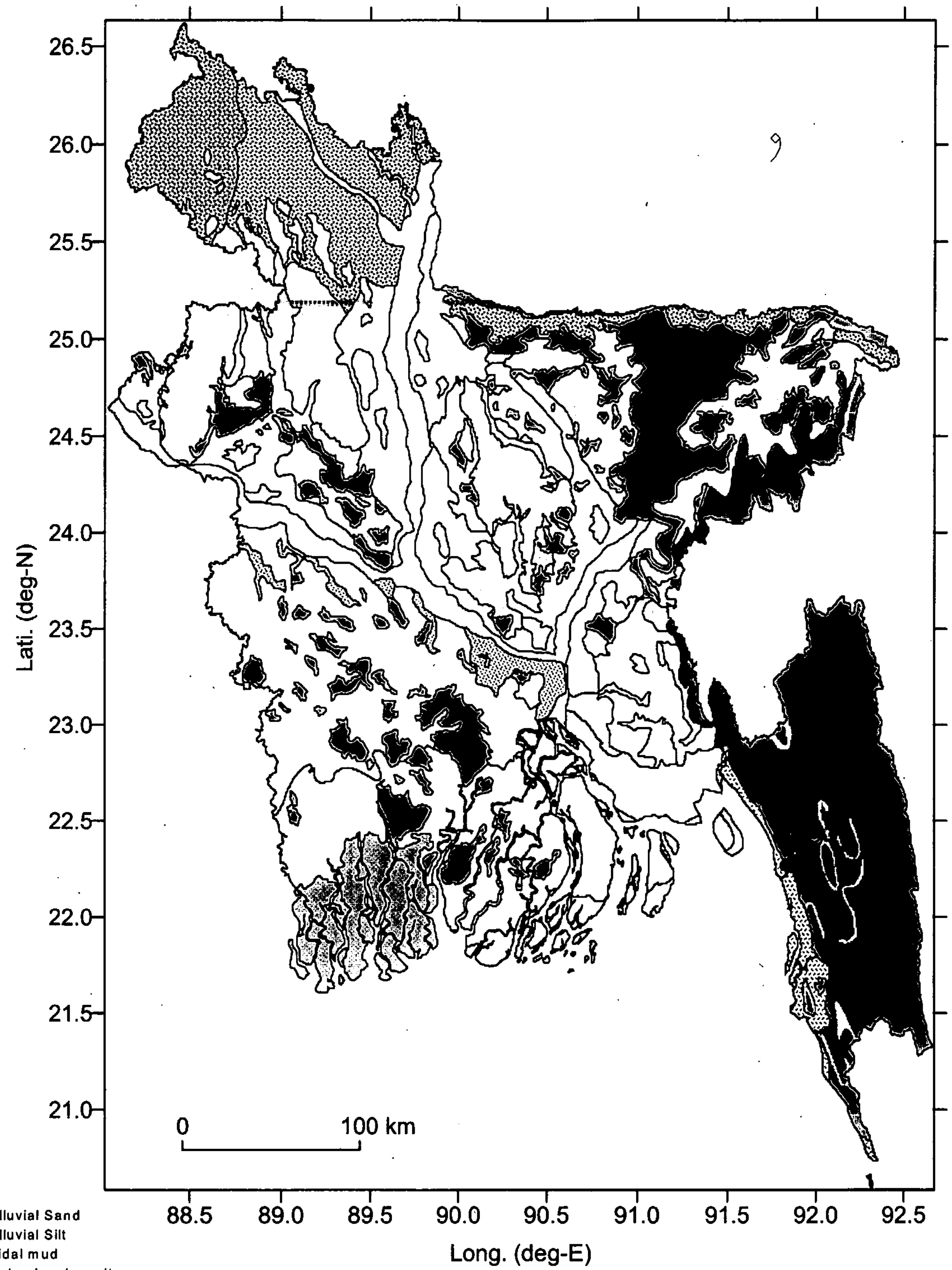
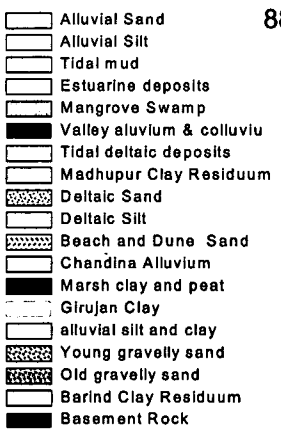


Figure 2.3.2	Ground Elevation of the Study Area

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



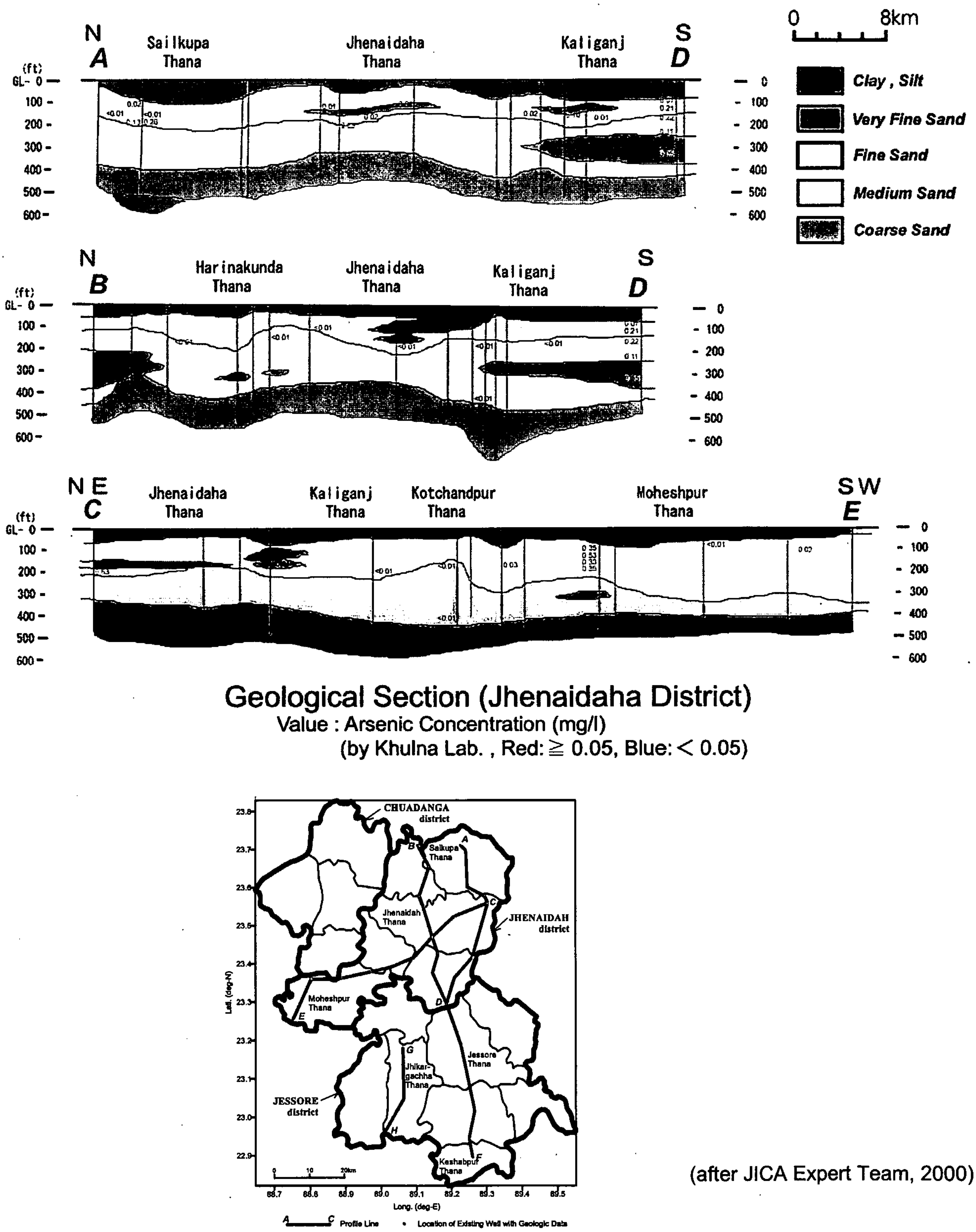


[Data source: GSB(1990)]

Figure 2.3.3	Simplified Geological Map of Bangladesh

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

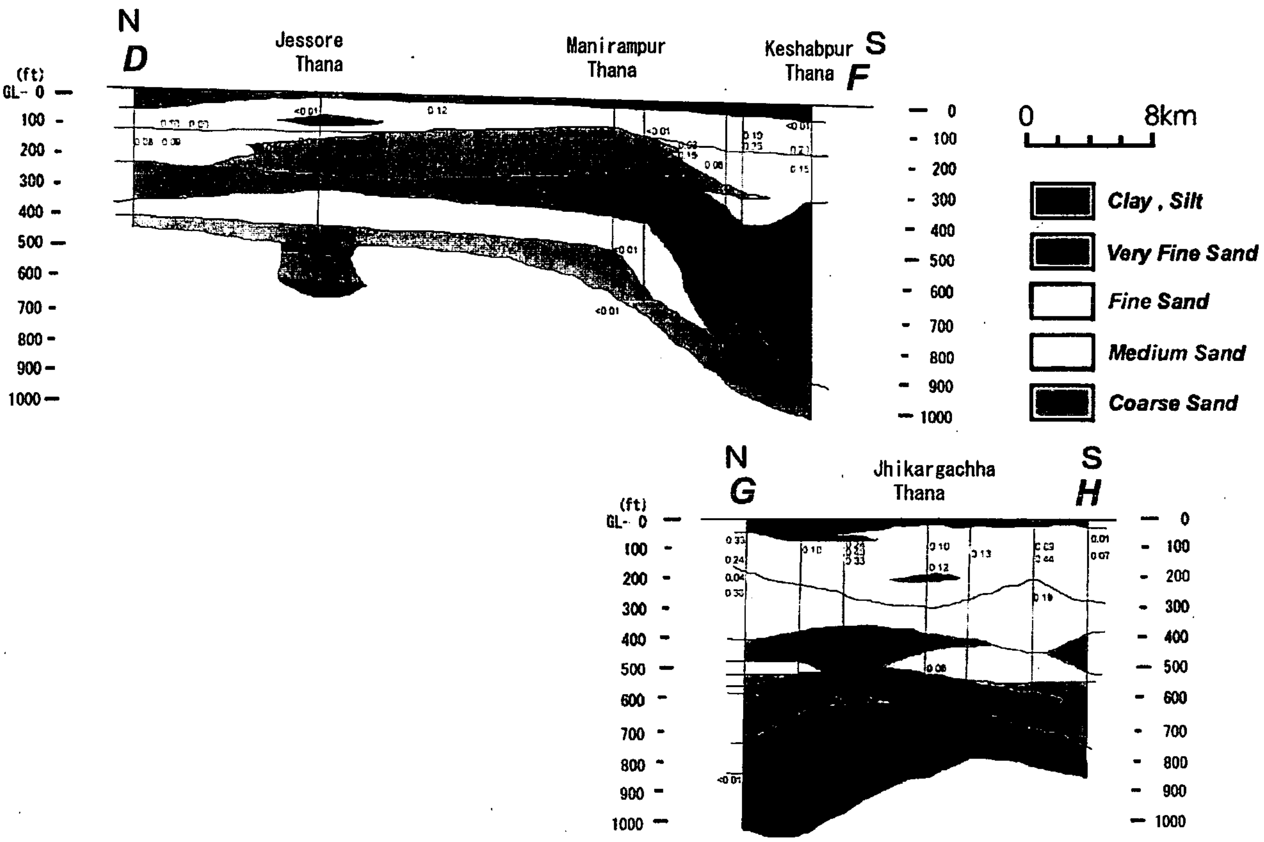
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Geological Section (Jhenaidaha District)
Value : Arsenic Concentration (mg/l)
(by Khulna Lab. , Red: ≧ 0.05, Blue: < 0.05)

(after JICA Expert Team, 2000)

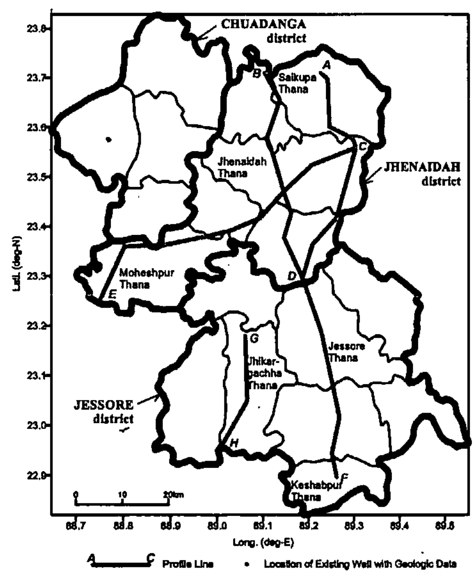
Figure 2.3.4	Geological Sections in Jhenaidah District
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



Geological Section (Jessore District)

Value : Arsenic Concentration (mg/l)

(by Khulna Lab. , Red: ≧ 0.05, Blue: < 0.05)



(after JICA Expert Team, 2000)

Figure 2.3.5	Geological Sections in Jessore District

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

2.4 Groundwater

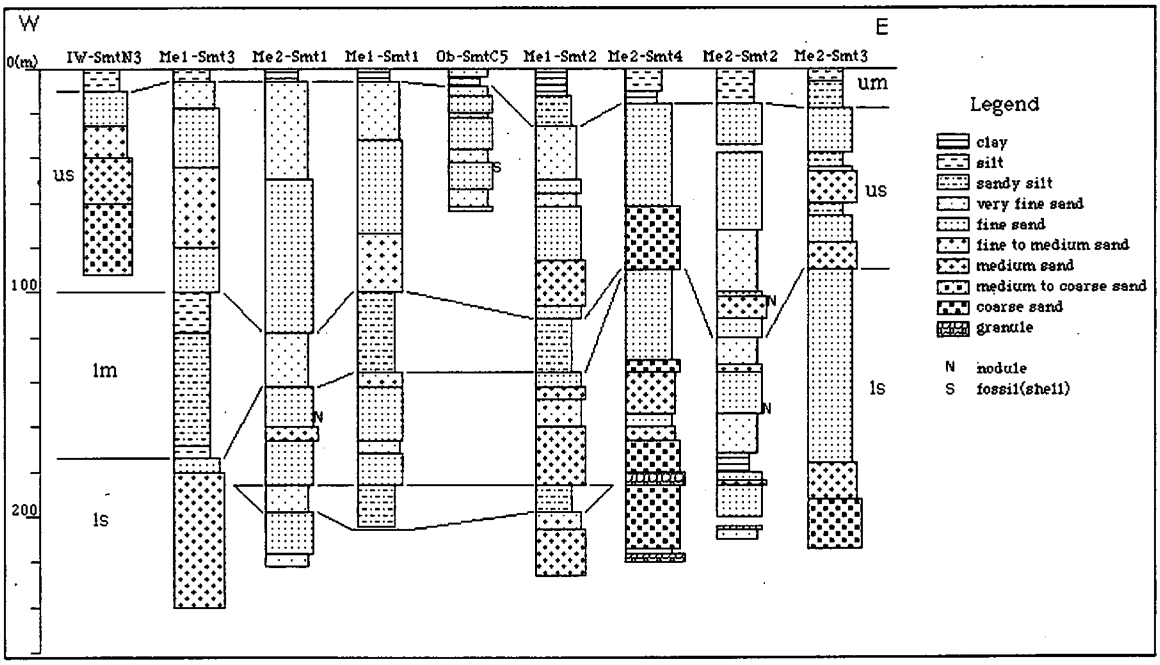
In most parts of Bangladesh, groundwater occurs in Quaternary aquifers except in the eastern hilly region. The aquifers are broadly divided into shallow aquifers and deep aquifers, however, the definition of shallow aquifer and deep aquifer is not clear due to the difference of hydrogeologic conditions from place to place. It is said that the shallow aquifer and deep aquifer are bounded by an aquitard at a depth about 150m in central Bangladesh, but the boundary is located in a deeper portion in the southern coastal districts.

The aquifers of the study area are also made up of Quaternary sediments. According to the geological profiles mentioned in the previous section, the boundary between the shallow aquifer and deep aquifer is not clear in Jhenaidah district. They may be separated by fine sandy or clayey layers occurred at depths of 200 to 350ft, but the continuity of the fine layers is not good. In the southern part of Jessore district, the deep aquifer is clearly bounded from the shallow aquifer by the thick clayey layer. In Keshabpur thana, the deep aquifer occurs at depths more than 900ft. On the other hand, the boundary of the shallow aquifer and deep aquifer is not clear in the western part of Jessore district.

In the study area, detailed hydrogeological investigations regarding the arsenic problem were carried out in Samta village of Jessore district by the Asia Arsenic Network and the Research Group for Applied Geology, Japan (RGAG & MURG, 2000). According to their results as shown in Figure 2.4.1, there are three (3) aquifers in Samta village. The aquifer system is identified as unconfined aquifer, first aquitard, first confined aquifer, second aquitard, and second confined aquifer within a depth of 200m based on their core borings and existing data of DPHE and BADC.

Layer	Lithological facies		Aquifer unit	Depth (m)	Thickness (m)
Embankment (b)		silt and clay		0 to 1.5	0 to 1.5
Uppermost muddy layer (umm)		silt and clay		0 to 4	0 to 3
Uppermost sandy layer (ums)		very fine sand	Unconfined aquifer	1 to 6	0 to 3
Upper muddy layer (um)		silt and clay with organic materials	First aquitard	1 to 15	0.8 to 12
Upper sandy layer (us)		fine to medium sand	First confined aquifer	10 to 110	80 to 120
Lower muddy layer (lm)		sandy silt to very fine sand	Second aquitard	90 to 170	0 to 60
Lower sandy layer (ls)		fine to coarse sand with silt and granule	Second confined aquifer	90+	130+

(after RGAG & MURG, 2000)



(after RGAG & MURG, 2000)

Figure 2.4.1	Stratigraphy and Aquifer Unit Classification in Samta, Jessore

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CHAPTER 3

SOCIO-ECONOMY AND WATER SUPPLY

Main Report

CHAPTER 3 SOCIO-ECONOMY AND WATER SUPPLY

3.1 Socio-Economy

3.1.1 Population

1) National Level

According to the latest census in 1991, the population in Bangladesh is approximately 111 millions. The latest data provided by the National Data Bank, Ministry of Planning, indicated that the Bangladesh population reached around 124 millions in FY 1996/1997.

The average annual growth rate of the population during 1993 to 1997 was 1.8%, which exceeded the expected growth rate of 1.32% in the Bangladesh Fifth Five-Year Development Plan.

The urban population covered around 21% of the total population in 1997, which has been gradually increasing due to rural-to-urban migration. The major population and demographic indicators at the national level are given in Table 3.1.1 below.

Table 3.1.1 Major Population and Demographic Indicators in Bangladesh

Item	FY93	FY94	FY95	FY96	FY97
Population (Million)	115.5	117.7	119.9	122.1	124.3
Male	59.3	60.5	61.6	62.7	63.9
Female	56.2	57.2	58.3	59.4	60.4
Age structure (Million)					
00-14			51.4	49.6	48.1
15-49			57.2	56.3	59.6
50+			11.3	16.2	16.6
Density (Sq.km)	783	798	812	827	842
Urban Population (% of total population)	20.58	20.85	21.13	21.38	21.67
Migration (Thousand)					
Rural to Rural	10.25	11.00	11.32	10.72	11.25
Rural to Urban	6.89	7.76	7.80	8.30	8.35
Urban to Rural	0.93	0.90	0.87	0.83	0.92
Urban to Urban	28.52	30.25	31.29	31.63	32.52

Source: Data Sheet 1999, National Data Bank, Ministry of Planning, Bangladesh

2) Population and Demography in the Study Area

The district-wise population data is only available from the 1991 Census. The Study Area covers three districts, namely Chuadanga, Jhenaidah, and Jessore. **Table 3.1.2** compares the key demographic indicators among those three districts.

Table 3.1.2 Comparison of Key Demographic Indicators among the Three Districts

District	Area (sq.km)	Population	Urban population Ratio (%)	Density (per sq.km)
Chuadanga	1,157	807,164	25.97	697
Jhenaidah	1,950	1,361,280	12.77	698
Jessore	2,578	2,106,996	13.41	817

Source: Population Census 1991, Bangladesh Bureau of Statistics.

Jessore is the most populated district in the Study Area while Jhenaidah and Chuadanga are almost similar in population density. Meanwhile, the urban population ratio is the highest in Chuadanga (more than 25% of the total district population). The total population of the above three districts reached around 4,275,000 in 1991.

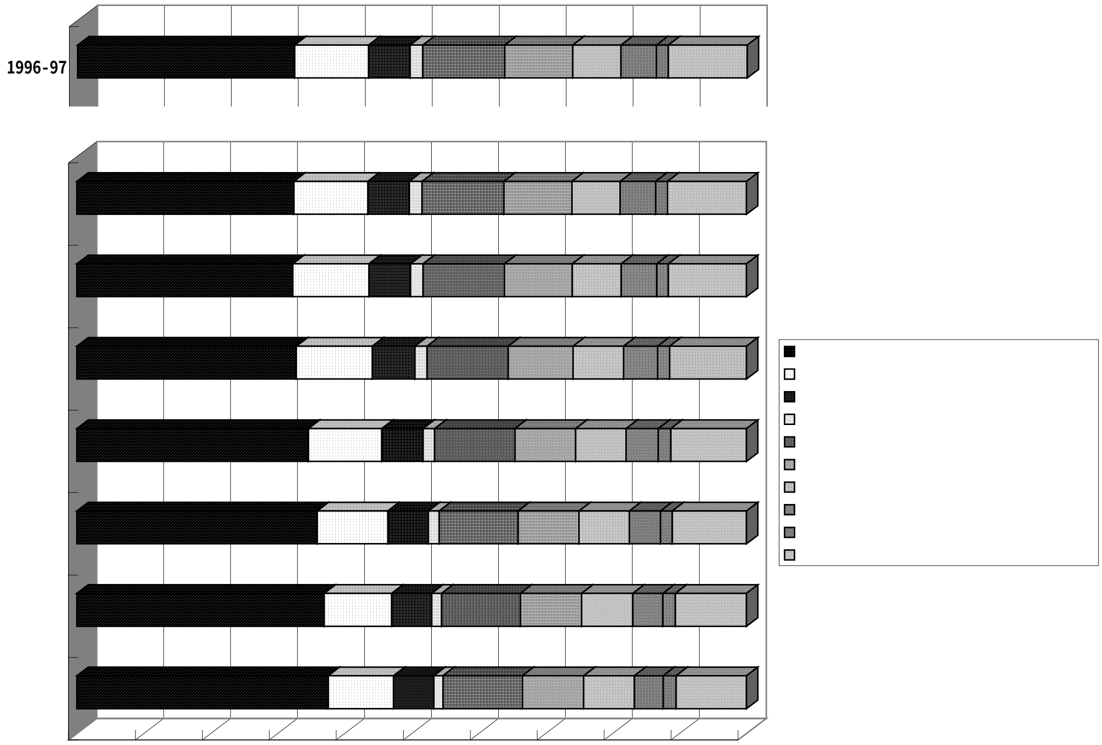
The detailed thana-by-thana demography of the above three districts is shown at the end of this Section (see Annex 3.1.1).

3.1.2 Socio-Economy

1) GDP

Gross Domestic Product (GDP) in Bangladesh is 679 billion Taka (Bangladesh Taka) at a constant price (1984/1985=100) in the fiscal year 1996/1997. The average annual growth rate of GDP from 1992/1993 to 1996-07 is about 4.8%, which is lower than the 7% per annum expected in the Bangladesh Fifth Five Year Development Plan (1997 to 2002). Per capita GDP in 1996/1997 is approximately 11,284 Tk (US$277).

The structure of GDP by industrial sector is shown in Figure 3.1.1 below. Agriculture is the largest sector in terms of GDP though its ratio has been gradually decreasing. The manufacturing and service industry sector shows a gradual increase in the share of GDP.



Source: Bangladesh Arthanoitik Samikkha 1997.

Figure 3.1.1 Structure of GDP by Industrial Sector in Bangladesh (1990/91-1996/97)

Other major macro economic indicators at the national level are given at the end of this section (see Annex 3.1.2).

2) District GDP in the Study Area

Due to recent reform of the regional administrative unit, the district-wise GDP data is only available for the former district of Jessore. Figure 3.1.2 below shows the district GDP and its sectoral structure in the former district of Jessore. The district GDP is approximately 31 billion Taka at a constant price. The district GDP per capita is about 11,511 Tk in FY 1997/1998, which is slightly higher than national level of FY 1996/1997.

Source: Statistical Yearbook of Bangladesh, 1999.

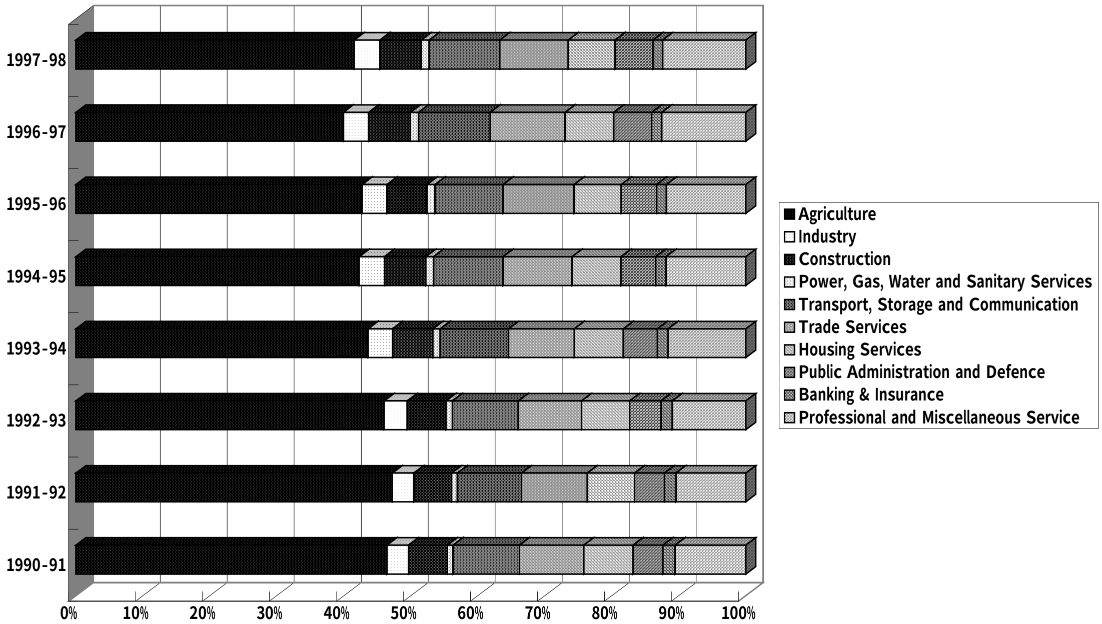
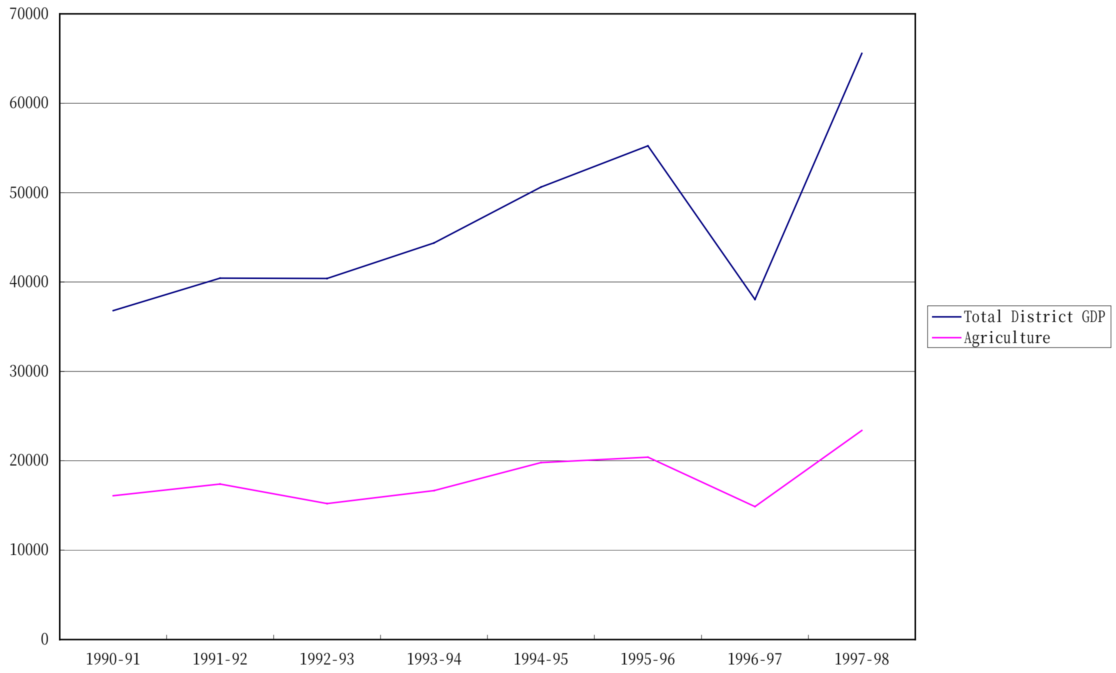


Figure 3.1.2 Structure of GDP by Industrial Sector in Jessore (1990/91-1997/98)

The ratio of agriculture to the total district GDP is more or less 40%, which is much bigger than the national average, while the share of the manufacturing and services industry is much lower. Looking into the flux of actual GDP, the former district of Jessore is unstable due to its dependency on agriculture, which is often affected by seasonal climate conditions. This unstable economic condition and dependency can be found in Figure 3.1.3 on next page, which indicate the correspondence between district GDP and GDP in agriculture.



Source: Statistical Yearbook of Bangladesh 1999.

Figure 3.1.3 Annual Change of District GDP and Agricultural Sector

3) Regional Characteristics of Economic Activities in the Study Area

The major economic activity in the Study Area is agriculture. Therefore, conditions of agricultural harvest directly impact the daily lives of the people. As the Study Area is identified as a very suitable area for agriculture, there are various crops and agricultural products including rice, wheat, sugarcane, tobacco, jute, tea, fruits, vegetables, etc. There are some regionally special products in the Study Area, e.g., sugarcane, tobacco, jute, etc. although rice is still the major product in all of the 3 districts. Livestock and inland fishery products are also important sources of income after agricultural crops.

The manufacturing industry is still very limited in the Study Area though there are some medium/large factories located in Chuadanga (e.g. sugar and soap factories), Jhenaidah (e.g. sugar and pharmaceutical factory), and Jessore (e.g. textile, jute, and leather industry).

4) Education

According to the latest data available in the UNICEF survey, the net primary school enrollment rate for the whole nation was 76.9% for boys and 17.9% for girls in 1999. This low school attendance of girls is similarly found in the Study Area as shown in Table 3.1.3 on the next page.

Table 3.1.3 Net Primary School Enrollment Rate in the Study Area

	Jessore	Jhenaidah	Chuadanga
Boys	87.9%	83.6%	74.7%
Girls	21.1%	20.7%	16.7%

Sources: UNICEF Survey 1999.

Among the 3 districts above, Jessore shows the highest primary school enrollment rate while Chuadanga is the lowest for both sexes.

There are also differences in the conditions of educational facilities among the 3 districts. Table 2.3.4 below compares the key indicators among the 3 districts.

Table 3.1.4 Comparison of Key Indicators on Primary Education among the Three Districts

	Jessore	Jhenaidah	Chuadanga
Number of primary schools	1,145	741	380
Number of teachers	4,343	2,674	1,459
Number of students	297,787	227,333	115,859
Teacher-student ratio (students / teacher)	68	85	79

Source: National Data Bank, Ministry of Planning 1999, Bangladesh.

All of the three districts show a very limited capacity of primary education as shown in the teacher-student ratio of between 70 and 80. This means the supply of teachers is short of demand. Current conditions of upper education in the Study Area are given at the end of this section (see Annex 3.1.3).

The next table below compares the adult literacy rate of the national average with that of the three districts in the Study Area. The difference in primary school enrollment between male and female reflects the gap in the literacy level between them.

Table 3.1.5 Comparison of Adult Literacy Rate

(Unit:%)

	Bangladesh	Jessore	Jhenaidah	Chuadanga
Male	35.32	36.82	28.92	28.16
Female	44.31	47.23	37.99	35.77
Total	25.84	25.61	19.31	20.14

Source: Population Census (1991), Bangladesh

5) Medical Facilities

Current conditions of medical facilities and human resources are also very limited in the Study Area. Table 2.3.6 compares the levels of medical facilities and available human resources of the national average with those of the three districts in the Study Area.

Table 3.1.6 Comparison on the Levels of Medical Facilities and Human Resources

Indicators	Bangladesh	Jessore	Jhenaidah	Chuadanga
Persons per hospital bed	3,348	5,241	3,845	4,862
Persons per doctor	4,684	14,734	14,959	16,472
Persons per nurse	8,124	5,820	7,520	7,473

Sources: Compilation of the data from National Data Bank, Ministry of Planning 1999, etc.

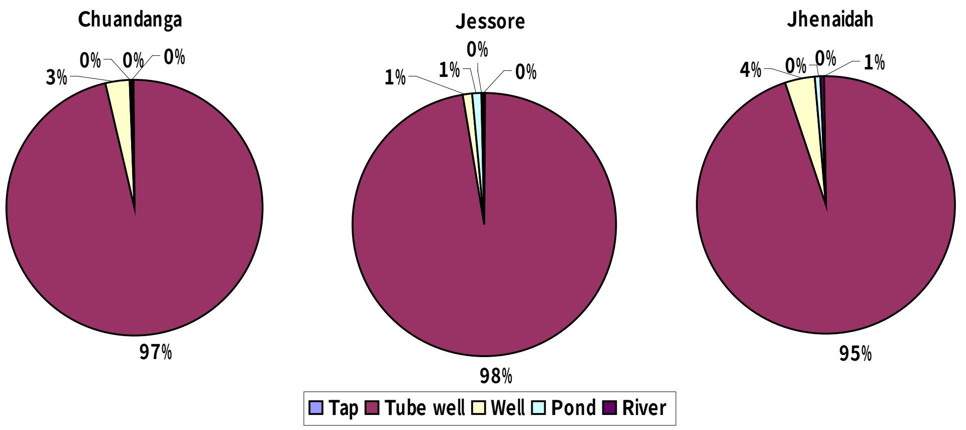
All three districts have a low level of medical facilities as represented in the number of persons per hospital bed. Regarding the medical human resources, the number of doctors in the three districts is much less than the national average while the number of nurses is more or less the same as the national level.

More detailed medical conditions in the three districts are given at the end of this section (see Annex 3.1.4).

6) Hygiene and Sanitation

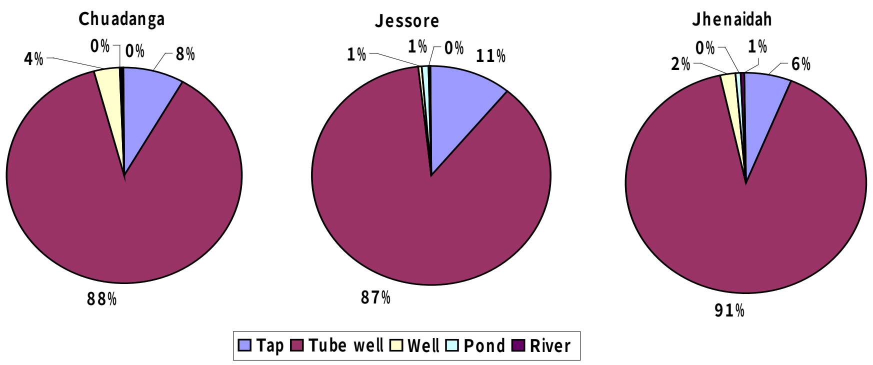
a. Source of Drinking Water

Water from tube wells is the main and sometimes the only source of drinking water for most of the households in the Study Area. Especially in the rural area, water from tube wells is almost the only source of drinking water while tap water is partially supplied to the households in the urban centers of the Study Area. This situation implies that the contamination of tube-well water in the Study Area may have serious impacts on the health and daily lives of the people on a large scale. Figures 3.1.4 and 3.1.5 below shows the sources of drinking water in the rural and urban areas of the three districts in the Study Area.



Source: Census 1991, Bangladesh

Figure 3.1.4 Sources of Drinking Water in Rural Areas of the Three Districts



Source: Census 1991, Bangladesh

Figure 3.1.5 Sources of Drinking Water in Urban Areas of the Three Districts

b. Toilet Facilities

According to the UNICEF Survey, toilet facilities are also not in good sanitary condition. Table 2.3.7 compares the national average latrine conditions with those of the three districts in the Study Area.

Table 3.1.7 Current Conditions of Household Latrine

Unit : % of total household

Type of Latrine	Banglades h	Jessore	Jhenaidah	Chuadanga
Water seal	12.1%	5.6%	12.9%	6.7%
Pit	28.2%	50.6%	42.6%	52.8%
Hanging	39.8%	4.6%	12.0%	4.7%
Open Defecation	24.5%	42.4%	50.5%	38.8%

Source: Progotir Pathey Achieving the Goals for Children in Bangladesh (UNICEF 1999)

As given in the table above, more or less half of the total households in the Study Area have no specific toilet facilities.

Other information from the 1991 Census indicated that more than half of the total households in the rural area have no toilet facility, as shown in the Figures 3.1.6 and 3.1.7 below.

Source: Census 1991, Bangladesh.

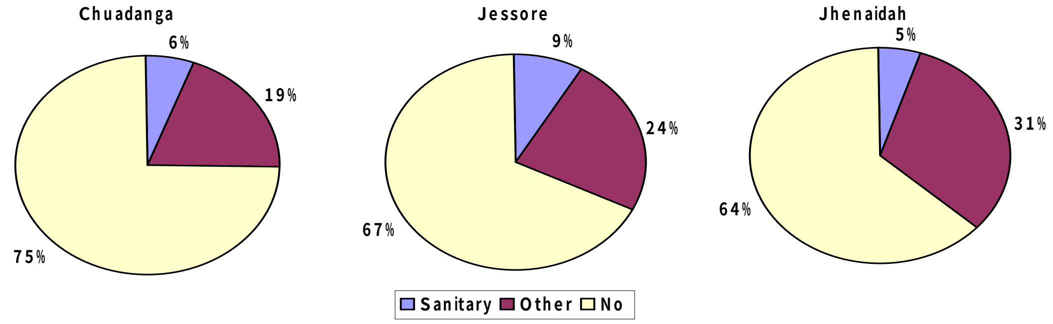


Figure 3.1.6 Conditions of Toilet Facilities in the Rural Areas of the Three Districts

Source: Census 1991, Bangladesh

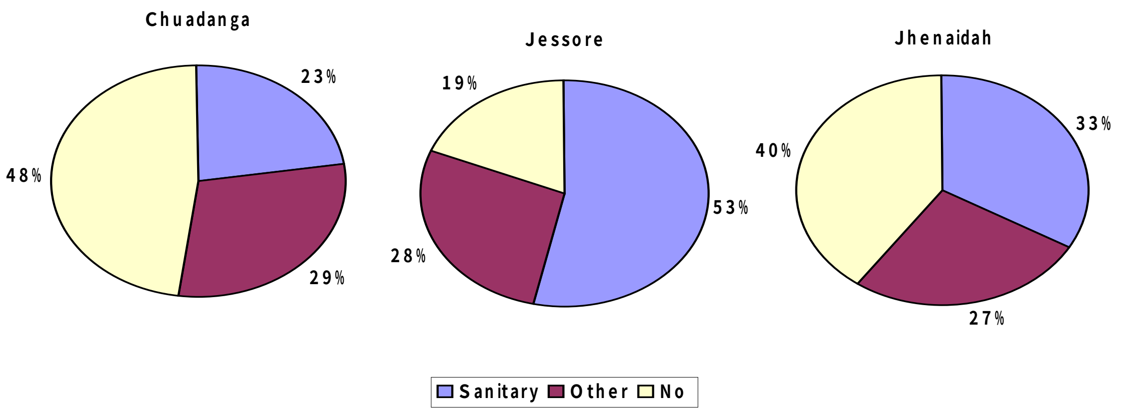
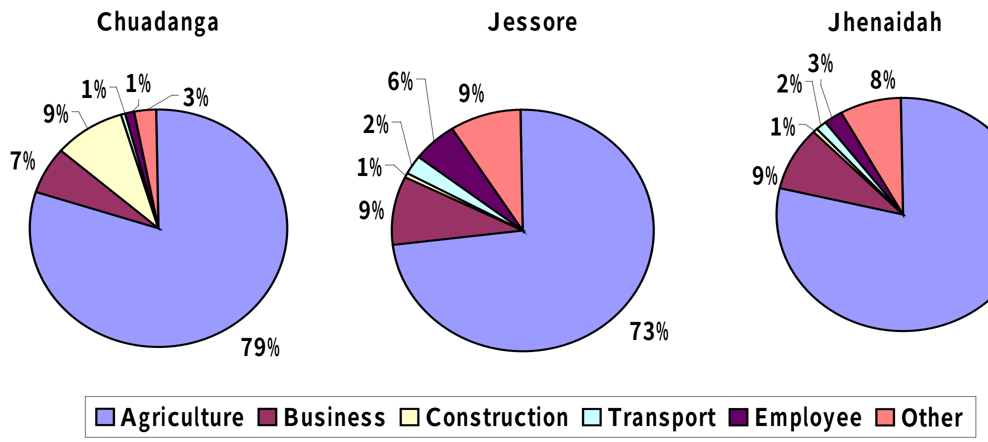


Figure 3.1.7 Conditions of Toilet Facilities in the Urban Areas of the Three Districts

7) Other Living Conditions

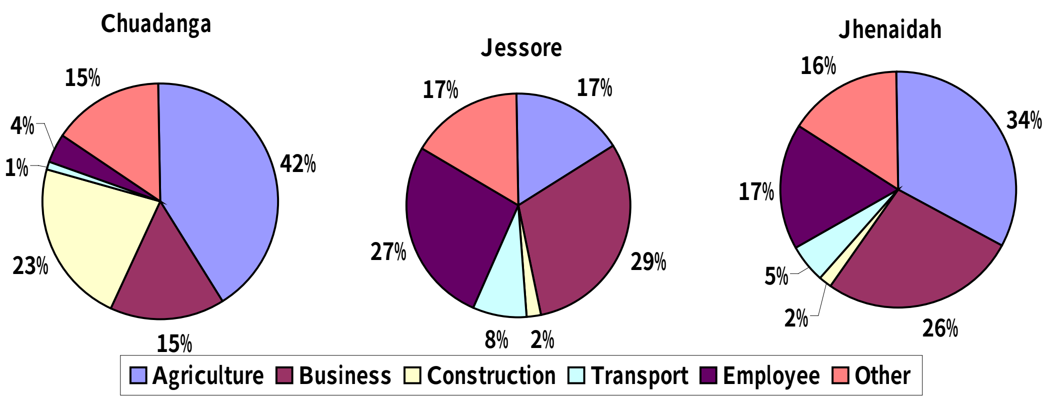
a. Sources of Income

In the rural areas of the three districts, agriculture is the main source of income for most of the households. 70 to 80% of the total households in the rural areas earn their income from agriculture. On the other hand, sources of income in the urban areas are different from those of rural areas. It is also found that some differences exist among the three districts although agriculture is still one of the main sources of income. Figures 3.1.8 and 3.1.9 shows the percentage distribution of income sources of the rural and urban households in the three districts.



Source: Census 1991, Bangladesh.

Figure 3.1.8 Sources of Income by Rural Households in The Three Districts



Source: Census 1991, Bangladesh.

Figure 3.1.9 Sources of Income by Urban Households in the Three Districts

c. Electricity supply

As shown in Table 3.1.8 below, electricity supply is also very limited in the Study Area. There is also a big gap found between urban and rural areas in terms of electricity connection to the household.

Table 3.1.8 Percentage of the Households with Electricity in Rural and Urban Areas of the Three Districts

	Jessore	Jhenaidah	Chuadanga
Rural	7.44%	1.9%	6.7%
Urban	57.0%	31.6%	27.4%

Source: Census 1991, Bangladesh.

3.1.3 National Account

1) National Budget

According to the annual budget statement by the Ministry of Finance, the state budget for FY2000/2001 is 385,240 million Taka, which is about a 12% increase from FY 1999/2000. The estimated resources and allocation of the budget is briefly shown in Table 3.1.9 below.

Table 3.1.9 Resources and Allocation of the State Budget in FY 2000/01

Unit : Crore TK

Description	Budget 2000/01	Revised 1999/00	Budget 1999/00
Resources			
Revenue Receipts	24,198	21,345	24,151
Foreign Grants	3,183	3,609	3,269
Foreign Loans	6,238	5,223	5,091
Domestic Capital (Net)	941	1,402	1,360
T & T Bond	200	171	171
Self Financing by Autonomous Bodies	250	250	250
Borrowing from Banking System	3,514	3,934	0
Total	**38,524**	**3,5934**	**3,4292**
Allocation (Use of Resources)			
Non Development Budget	19,633	18,444	17,800
Annual Development Programme (ADP)	17,500	16,500	15,500
Non-ADP FFW Included in Development Budget	583	806	571
Net Outlay for Food Account Operation	395	-9	224
Non ADP Projects	413	193	197
Total	**38,524**	**35,934**	**34,292**

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance.

The development budget covers about 47% of the state budget, while foreign assistance in the form of grants and loans covers around 24% of the budget resources.

Looking into the details of revenue receipts given in Table 3.1.10 on the next page, tax revenue is the main source of the state budget, which covers about 80% of state revenue. Value added tax (VAT) is the largest source of revenue, which is followed by import duty. Tax on income and profit is only the third biggest sources of state revenue. Non-tax revenue covers the remaining 20% of the state revenue.

Table 3.1.10 Broad Details of Revenue Receipts

Unit : TK in Crore

Description	Budget 2000/01	Revised 1999/00	Budget 1999/00
Tax Revenue			
National Board of Revenue (NBR) Portion			
Taxes on Income and Profit	3,800	2,980	2,791
Taxes on Property and Wealth	1	2	11
Value Added Tax (VAT)	5,940	5,405	5,678
Import Duty	4,790	4,536	5,751
Excise Duty	275	240	227
Supplementary Duty	3,035	2,664	2,814
Electricity Duty	20	45	100
Other Taxes and Duties	139	128	128
Sub total	**18,000**	**16,000**	**17,500**
Non-NBR Portion			
Narcotics and Liquor Duty	40	27	45
Taxes on Vehicles	120	111	150
Land Revenue	301	266	265
Stamp Duty (Non Judicial)	817	692	675
Sub total	**1,278**	**1,096**	**1,135**
Total Tax Revenue	**19,278**	**17,096**	**18,635**
Non-Tax Revenue	**4,920**	**4,249**	**5,516**
Total	**24,198**	**21,345**	**24,151**

Remark: Grants, loans, and food account transactions are excluded.

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance.

Meanwhile, the allocation of the non-development budget is briefly given in Table 3.1.11 below.

Table 3.1.11 Allocation of Non-Development Budget

Unit : TK in Crore

Description	Budget 2000/01	Revised 1999/00	Budget 1999/00
Pay and Allowances	5,818	5,715	5,584
Goods and Services	2,653	2,456	2,353
Interest Payments	3,748	3,554	2,805
Subsidies and Current Transfers	4,648	4,846	4,642
Block Allocations	1,809	914	1,476
Acquisition of Assets and Works	1,005	1,014	985
Deduct	48	55	45
Total	**19,633**	**18,444**	**17,800**

Remark: Loans and food account operations are excluded.

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance.

More detailed allocation of the non-development budget is given at the end of this section (see Annex 3.1.5).

2) Annual Development Programme (ADP)

a. Resources for ADP

As shown in Table 3.1.12 below, the main resources for ADP in Bangladesh are revenue surplus, project aids, and borrowing from the banking system. The sum of these sources covers approximately 90% of the ADP budget.

Table 3.1.12 Resources for Annual Development Programme

Unit : TK in Crore

Description	Budget 2000/01	Revised 1999/00	Budget 1999/00
Internal Resources			
NBR Tax Revenue	18,000	16,000	17,500
Non-NBR Tax Revenue	1,277	1,096	1,135
Non-Tax Revenue	4,921	4,249	5,516
Total Revenue Receipts	**24,198**	**21,345**	**24,151**
Revenue Expenditure	19,633	18,444	17,800
Revenue Surplus	**4,566**	**2,901**	**6,351**
Net Domestic Capital Increase / (Decrease)	941	1,402	1,360
Net Food Outlay Increase / (Decrease)	-744	-432	-299
Departmental Financing	200	171	171
Self Financing by Autonomous Bodies	250	250	250
Internal Resources	**5,212**	**4,292**	**7,833**
External Resources			
Project Aid	7,461	6,750	6,426
Commodity Aid	888	940	922
Transfer from Food Deposit	350	513	244
Others	75	71	75
External Resources	**8,774**	**8,274**	**7,667**
Total Financing	**13,986**	**12,566**	**15,500**
Annual Development Programme	**17,500**	**16,500**	**15,500**
Borrowing from Banking System	**3,514**	**3,934**	**0**

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance.

b. Development Expenditure

Looking into the development expenditure by ministry and division in FY 2000/2001, the Local Government Division is the largest of all the ministries and divisions, followed by Roads and Railway Division and Energy Division. The Ministry of Local Government, Rural Development and Cooperatives (LGRD) is totally allocated with as much as 3,147 crore Taka in FY 2000/2001, which is about 18% of the development expenditure.

Detailed allocation of ADP is given at the end of this section (see Annexes 3.1.6).

3.1.4 Water Supply and Sanitation Sector in the Current Fifth Five-Year Plan

The on-going Fifth Five-Year Plan (1997 to 2002) set the current and future socio-economic framework in Bangladesh as follows.

Economic Growth Rate (1997 to 2002):	7% per annum
Population Groeth Rate (1997 to 2002):	1.32 % for 1997 to 2002
Piped water supply ratio:	65% in Dhaka
	50% in Chittagong
	51% in other district towns
	5% in thanas and pourshavas
	1 tube-well for 105 persons to supply drinking water in the rural areas

Regarding the water supply and sanitation sector, the Fifth Five-Year Plan set out the following development targets and programmes.

1) Water Supply and Sanitation in Rural Areas

i. In order to provide one tube well for 80 persons by the terminal year of the Plan period, 529,000 tube-wells will be installed by the public sector and 400,000 tube wells by the private sector;

ii. Emphasis will be given on improving water supply in the northern and hilly districts and coastal areas;

iii. Sanitation, hygiene and water supply in the rural areas will be extended widely and **a study on groundwater of the arsenic affected areas and remedial measures will be undertaken**;

iv. Rural sanitation and social mobilization programmes for sanitation will be geared up during the Plan period;

v. Sanitation facilities in the haor areas will be extended on a priority basis to avoid water pollution;

vi. About 80 percent of all rural households will be brought under the cover of sanitary disposal of excreta;

vii. Water supply and sanitation facilities to the poor will be given free of cost, while the rich will be given a tax concession for developing such facilities at their own cost;

viii. Local manufacture of tube wells will be encouraged through incentives; and

ix. Special emphasis will be given on proper maintenance and operation of tube wells and sanitary latrines.

2) Water Supply and Sanitation in Pourashavas and Thanas

i. Urban water supply and sanitation programmes in the districts and pourashavas will be implemented;
ii. Programme for piped water supply in thana towns will be undertaken;
iii. Environmental sanitation, hygiene and water supply projects in urban slums and fringes will be implemented;
iv. Water supply and sanitation projects for growth centres will be taken up; and
v. Construction of community latrines at the district and thana headquarters will be initiated.

Tables 3.1.13 and 3.1.14 below show the major achievements from 1990 to 1997 and projected development from 1997 to 2002 in the water supply and sanitation sector in Bangladesh.

Table 3.1.13 Major Achievements of Water Supply and Sanitation Sector in Selected Years (1990 to 1997)

Major Area	Unit	Position June '90	4th Plan (1990-95) Addition		Position June '95	Position June '97
			Target	Achievement		
Rural Water Supply and Sanitation						
1.Shallow hand tube-wells	Nos.	718,168	97,313	95,795	813,963	849,233
2.Deep tube-wells	Nos.	22,498	71,670	68,800	91,298	108,135
3.Tara Deep-set tube-wells	Nos.	27,231	28,718	28,255	55,486	75,623
4.Rehabilitation of Choked-up tube-wells	Nos.	56,374	100,000	88,356	144,730	179,730
5.Water supply coverage in the rural areas	psn./tw	125	95	107	107	105
6.Distribution of water sealed latrines	Nos.	918,125	15,000,000	1,209,624	2,127,749	2,557,749
7.Household7s Sanitation coverage in the rural areas (including home-made latrines)	%	11	-	25	36	40
Urban Water Supply and Sanitation						
a)Dhaka and Chittakgong cities						
1.Dhaka City water supply	MLD	546	250	227	773	850
2.Water supply coverage in Dhaka City	%	50	15	10	60	65
3.Sanitation coverage in Dhaka City through sewerage connection	%	25	10	8	33	35
4.Cittagong City water supply	MLD	136	68	23	159	168
5.Chittagong City water supply coverage	%	45	-	5	50	52
b)Pourashavas and thanas						
6.Water supply	MLD	250	227	45	295	518
7.Water supply coverage	%	41	35	8	49	51

Note: MLD (million liters per day)

Table 3.1.14 Projections of Development in Water Supply and Sanitation Sector for Fifth Plan (1997 to 2002)

Major Programmes/Projects	Unit	Benchmark of 1996/97 (Estimate)	Addition during Fifth Plan	Cumulative Total at Terminal Year of Fifth Plan
Rural Water Supply and Sanitation				
Shallow hand tube-wells	Nos.	849,233	-	-
Deep tube-wells	Nos.	108,135	529,000*	1,561,991*
Tara Deep-set tube-wells	Nos.	75,623	-	-
Choked up tube-wells	Nos.	179,730	150,000	329,730
Water Supply Coverage in the Rural Area	Psn. /well	105	-	80
Distribution of water-sealed latrines	Nos.	2,557,749	2,815,000	5,372,749
Sanitation coverage in the rural areas (including home-made latrines	%	36	34	70
Urban Water Supply and Sanitation				
a. Dhaka and Chittagong cities				
Dhaka City Water Supply	MLD	850	400	1,250
Water Supply Coverage in Dhaka City	%	65	15	80
Sanitation Coverage in Dhaka City through sewerage system	%	35	5	40
Chittagong City Water Supply	MLD	159	159	318
Chittagong City Water Supply Coverage	%	50	40	90
b. Pourashavas and thanas				
Water Supply	MLD	543	221	764
Water Supply Coverage	%	49	21	70
Thana Piped Water Supply	%	5	20	25

*Sum for Shallow, Deep and Tara Deep-set tube-wells.

Annex 3.1.1 Population and Other Socio-Economic Indicators in the Three Districts

1.Chuadanga

Thana	Area(ACRE)	Area(km2)	Total Household	Population			Literacy Rate (7+years)			Population Density
				Total	Male	Female	Total	Male	Female	
Alamdanga	89,056	360	44,699	245,524	126,828	118,696	23.2	28.3	17.7	681
Chuadanga Sadar	71,558	290	41,135	223,247	114,682	108,565	28.7	34.4	22.6	771
Damurhuda	76,132	308	37,279	213,291	110,257	103,034	25.6	30.5	20.2	692
Jiban Nagar	49,255	199	22,628	125,102	64,207	60,895	22.4	27.8	16.6	628
Chuadanga Total	286,001	1,157	145,741	807,164	415,974	391,190	25.2	30.5	19.6	697

2.Jhenaidah

Thana	Area(ACRE)	Area(km2)	Total Household	Population			Literacy Rate (7+years)			Population Density
				Total	Male	Female	Total	Male	Female	
Harinakunda	56,147	227	27,408	162,078	83,582	78,496	20.8	26.1	15.1	713
Jhenaidah Sadar	115,586	468	60,354	333,192	171,483	161,709	27.5	34.8	19.8	712
Kalliganj	76,642	310	219,126	219,126	113,410	103,034	29.7	37.1	21.6	707
Kotchandpur	40,929	166	19,773	107,193	55,102	52,091	26.9	33.4	19.9	647
Maheshpur	100,186	405	41,995	246,350	126,190	120,160	22.2	28.2	15.8	608
Shailkupa	92,276	373	51,595	293,341	150,858	142,483	26.3	32.2	20.0	786
Jhenaidah Total	481,766	1,950	420,251	1,361,280	700,625	657,973	25.9	32.3	18.9	698

3.Jessore

Thana	Area(ACRE)	Area(km2)	Total Household	Population			Literacy Rate (7+years)			Population Density
				Total	Male	Female	Total	Male	Female	
Abhayanagar	61,081	247	36,873	204,654	106,539	98,115	38.8	46.7	30.2	828
Bagher Para	66,951	271	28,677	168,938	86,521	82,417	34.5	41.8	26.9	624
Chaugachha	69,287	280	33,765	181,829	93,828	88,001	25.5	32.8	17.7	648
Jhikargachha	75,929	307	43,439	235,882	120,855	115,027	27.9	35.3	20.1	768
Keshabpur	63,883	259	37,513	200,229	102,438	97,791	27.5	35.8	18.8	775
Jessore Sadar	106,951	433	94,348	530,582	280,417	250,165	44.2	51.5	35.9	1,226
Manirampur	109,894	445	59,615	326,093	166,306	159,787	29.1	37.2	20.6	733
Sharsha	83,110	336	46,084	258,789	133,007	125,782	25.5	32.6	17.9	769
Jhenaidah Total	637,086	2,578	380,314	2,106,996	1,089,911	1,017,085	33.4	41.0	25.1	817

Source: Population Census 1991, Bangladesh

Annex 3.1.2 Macro Economic Indicators in Bangladesh

Indicators	FY93	FY94	FY95	FY96	FY97
GDP growth rate (%)	4.5	4.2	4.4	5.3	5.7
Per capita GNI (Tk)	8,544	9,167	10,225	11,152	11,810
Per capita GNI (US$)	218	229	254	273	277
Debt service ratio (%)	10.2	11.5	10.0	9.8	8.5
Inflation Rate	1.3	1.8	5.2	4.1	3.9
Foreign Currency Reserve (Million $US)	2,121	2,765	3,070	2,039	1,719
Exchange Rate (Tk./$US)	39.1	40.1	40.2	40.8	42.7

Source: National Data Bank, Ministry of Planning, 1999.

Annex 3.1.3 Current Conditions of Upper Education in the Study Area

	Jessore	Jhenaidah	Chuadanga
Junior High School			
Number of schools	92	100	16
Number of teachers	520	217	120
Number of students	16,249	6,433	4,085
Teacher-student ratio (students / teacher)	31	29	34
Secondary High School			
Number of schools	238	114	63
Number of teachers	3,012	1,327	583
Number of students	84,402	49,167	20,993
Teacher-student ratio (students / teacher)	28	37	36

Source: National Data Bank, Ministry of Planning 1999.

Annex 3.1.4 Medical Facilities in the Study Area

	Jessore	Jhenaidah	Chuadanga
Hospitals			
Number of doctors	65	42	25
Number of nurses	208	114	79
Number of beds	337	244	142
Clinics			
Number of doctors	37	15	13
Number of nurses	20	23	8
Number of beds	65	110	24
FWC			
Number of doctors	39	26	3
Number of nurses	131	31	18
Number of beds	-	72	24
Maternity Centre			
Number of doctors	1	3	-
Number of nurses	2	4	3
Number of beds	-	22	6
Primary Health Care			
Number of doctors	1	5	8
Number of nurses	2	9	-
Number of beds	-	-	-

Source: National Data Bank, Ministry of Planning 1999.

Annex 3.1.5 Detailed Allocation of Non-Development Budget

Unit : TK in Crore

Description	Budget 2000/01	Revised 1999/00	Budget 1999/00
Pay and Allowances			
Pay of Officers	604	586	564
Pay of Establishment	2,589	2,529	2,495
Allowances	2,625	2,600	2,525
Sub total	**5,818**	**5,715**	**5,584**
Goods and Services			
Supplies and Services	1,815	1,641	1,549
Repairs, Maintenance and Rehabilitation	838	815	804
Sub total	**2,653**	**2,456**	**2,353**
Interest Payments			
Domestic	2,928	2,769	2,055
Foreign	820	785	750
Sub total	**3,748**	**3,554**	**2,805**
Subsidies and Current Transfers			
Subsidies	611	594	619
Grants in Aid	2,865	3,126	2,794
Contributions to International Organization	19	18	17
Pensions and Gratuities	1,153	1,108	1,212
Sub-total	**4,648**	**4,846**	**4,642**
Block Allocations			
Unexpected	500	100	515
Others	1,309	814	961
Sub-total	**1,809**	**914**	**1,476**
Acquisition of Assets and Works			
Acquisition of Assets	741	709	698
Acquisition of Land	5	44	7
Construction and Works	259	261	280
Sub-total	**1,005**	**1,014**	**985**
Deduct			
Recoveries	48	55	45
Sub-total	**48**	**55**	**45**
Total	**19,633**	**18,444**	**17,800**

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance.

Annex 3.1.6 Development Expenditure by Ministry/Division

Ministry/Division	Budget 2000/01	Revised 1999/00	Budget 1999/00
Parliament	2	2	6
Prime Minister's Office	228	106	94
Cabinet Division	2	11	12
Special Affairs Division	5	5	5
Election commission	34	51	93
Ministry of Establishment	85	45	57
Finance Division	45	23	27
Internal Resources Division (IRD)	3	2	1
Economic Relations Division (ERD)	9	16	9
Planning Division	272	14	157
Implementation, Monitoring and Evaluation Division	3	1	0
Statistics Division	65	33	33
Ministry of Commerce	66	59	33
Ministry of Foreign Affairs	11	18	12
Ministry of Defense	14	30	30
Ministry of Law, Justice and Parliamentary Affairs	24	24	16
Ministry of Home Affairs	75	73	76
Primary and Mass Education Division	1,354	1,123	1,108
Ministry of Education	898	858	817
Ministry of Science and Technology	75	76	59
Ministry of Health and Family Welfare	1,577	1,391	1,446
Ministry of Social Welfare	83	70	81
Ministry of Women and Children's Affairs	60	47	59
Ministry of Labour and Employment	19	15	16
Ministry of Housing and Public Works	177	231	84
Ministry of Information	106	37	95
Ministry of Cultural Affairs	47	36	30
Ministry of Religious Affairs	34	25	28
Ministry of Youth and Sports	138	115	130
Local Government Division	**2,994**	**2,891**	**2,588**
Rural Development and Cooperatives Division	153	137	177
Ministry of Industries	197	120	65
Ministry of Jute	6	9	9
Ministry of Textiles	34	44	45

Petroleum and Mineral Resources Division	655	609	670
Ministry of Agriculture	493	490	522
Ministry of Fisheries and Livestock	258	178	205
Ministry of Environment and Forest	214	156	165
Ministry of Land	62	69	77
Ministry of Water Resources	1,221	1,102	1,085
Ministry of Food	41	84	53
Ministry of Disaster Management and Relief	596	1,336	831
Roads and Railway Division	2,304	2,238	1,889
Jamuna Bridge Division	109	152	304
Ministry of Shipping	33	158	97
Ministry of Civil Aviation and Tourism	135	207	138
Ministry of Post and Telecommunications	483	452	404
Ministry of Chittagong Hill Tracts Affairs	132	93	113
Energy Division	2,202	1,994	1,770
Total Development Expenditure	**17,883**	**17,056**	**15,821**
Self Financing by Autonomous Bodies	250	250	250
Non-ADP FFW included in Development Budget	-583	-806	-571
Annual Development Programme	**17,500**	**16,500**	**15,500**

Source: Budget in Brief, Annual Budget 2000-01, Ministry of Finance

3.2 Water Supply Conditions

3.2.1 Water Sources in the Study Area

The various water sources that can be found in the study area are enumerated below. General information on these water sources is arranged in Table 3.2.1.

1) Rainwater

Rainfall is concentrated in the wet season making water use quite difficult in the dry season. However, because the quality of the water is good, the adoption of measures that would enable the effective use of this water source is desired.

However, unlike every other country in Indochina, Bangladesh does not have the custom of collecting rainwater from rooftops in jars.

At present, UNICEF and other organizations are actively promoting the use of the Rain Water Harvester (RWH) in the villages as a measure against the use of water contaminated with arsenic.

2) Ponds

Numerous ponds of varying sizes can be found both in the urban and rural sectors of the study area. Most of these ponds are within the villages. In the rainy season, dirty water containing animal urine and domestic wastewater are considered to easily flow into these ponds. In terms of quality, pond water is considered to be contaminated with fecal coliform (bacteria). Some ponds, however, are used for fish breeding.

For use as a drinking water source, studies should be carried out on water quality and measures to prevent inflow from surrounding areas, water treatment measures, and measures against the decrease in water level in the dry season should be examined.

3) Rivers and Lakes

The study area is located at the downstream basin of the plains where rivers and crescent shaped lakes exist. As they contain a huge volume of water, these water sources are not as contaminated as the ponds. Considerations should be made, however, as to possible contamination due to flow from the upstream basin section. Being a farming region mainly cultivated with paddies, contamination by agricultural chemicals in the study area is also an issue to consider.

For use as a drinking water source, studies on water quality as well as countermeasures against the decline in water level during the dry season should be carried out.

In examining the large-scale extraction of water and the water supply facilities assumed to be required for regional water supply, the feasibility of the projects should be determined by comparing the present water rate and the operation and maintenance cost.

4) Groundwater from Ultra Shallow Aquifers (Dug Well)

There are some dug wells within the study area and the results of the DCH and BRAC tests indicate the absence of arsenic in the water of these wells. As these wells are considered to be contaminated with fecal coliform (bacteria), however, studies should be carried out on water quality and water treatment measures and measures against the decline in water level during the dry season should be examined.

5) Groundwater from Shallow Aquifers

Villages in Bangladesh acquire drinking water mostly from hand tube wells that extract groundwater from shallow aquifers. However, groundwater from shallow aquifers contains arsenic, and the resultant widespread arsenic poisoning has made the villagers' dependency on hand tube wells a major source of concern.

For use as a drinking water source, arsenic in the groundwater should be removed. At present, every relevant agency is looking into various arsenic removal techniques in order to select one that is most appropriate to local conditions.

Due to the shallowness of its location, the water source is also susceptible to fecal coliform (bacteria) contamination and hence should be subjected to studies on water quality as well as measures necessary to cope with water decline in the dry season.

6) Groundwater from Deep Aquifers

Groundwater from deep aquifers and shallow aquifers both originate from different aquifers. The former does not contain arsenic. DPHE is currently promoting the construction of deep tube wells to exploit groundwater from deep aquifers, with very positive results. However, even deep tube wells are not totally protected from arsenic contamination as unsatisfactory well sealing work could lead to the inflow of arsenic contaminated groundwater from shallow layers, consequently affecting deep well water quality.

For the use of groundwater from deep aquifers, the adoption of appropriate sealing techniques is essential to prevent the inflow of groundwater from shallow aquifers.

Table 3.2.1 General Information on Water Sources in the Study Area

Water Source	Water Quality		Seasonal Conditions
	Arsenic	Fecal Coliform (Bacteria)	
Rainwater	Free	Free	Not available in the dry season
Ponds	Free	Contaminated	Not available or decreases in the dry season
Rivers/Lakes	Free	Contaminated	Decreases in the dry season
Surface Groundwater (Dug Well)	Free	Contaminated	Not available or decreases in the dry season
Groundwater from shallow layers	Contaminated	Free	Water level declines in the dry season
Groundwater from deep layers	Free	Free	Water level declines in the dry season

3.2.2 Urban Water Supply

1) Water Sources

The urban water supply system in the study area is totally dependent on groundwater resources. Groundwater that is not contaminated with fecal coliform (bacteria) and is comparatively low in arsenic content is pumped up from a well and conveyed through the distribution main without treatment.

2) Water Sources & Facilities

Water is supplied through wells fitted with motor pumps and directly connected to pipelines or stored in elevated water tanks prior to conveyance through the distribution main.
The water supply condition of every municipality in the study area is summarized in Table 3.2.2. Although the facilities used by these municipalities slightly differ depending on the location, by and large the specifications are as shown in the table below.

a. Tube Well

Depth	90-130m
Drilling Diameter	450mm
Casing Pipe (Upper)	Mild Steel Pipe, 350mm dia.
Casing Pipe (Lower)	Galvanized Steel Pipe, 150mm dia
Screen Pipe	Stainless Steel, 150mm dia
Screen Position	-70-120m
Screen Length	20-30m

b. Water Pump

Pump	
Type	Turbine/Submersible
Capacity	1.0-2.0m^3/min, (20-40HP)
Delivery Head	55m
Riser Pipe	150mm dia
Pump Position	-20m
Motor	
Type	Electric
RPM	1450
Voltage	440
Ampere	42
Power Source	Public Electric Power Supply

c. Overhead Reservoir Tank

Structure	Reinforced Concrete
Height	35m
Capacity	350-1,000m^3

d. Pipeline

Material	Cast Iron Pipe
	Ductile Iron Pipe
	Asbestos Cement Pipe
	Galvanized Steel Pipe
	PVC Pipe
Diameter	37.5mm(1-1/2”)
	75mm(3”)
	100mm(4”)
	150mm(6”)
	200mm(8”)
	250mm(10”)

e. Arsenic Removal Plant/Iron Removal Plant

Except for an iron removal plant in Jessore Sadar Pourashava, there are no water treatment facilities in the study area. In addition, even the said plant is actually not being operated as the iron levels are not significantly high and to curtail operation cost.

Outside of the study area, an arsenic removal plant was constructed in Manikganj and started operating in March 1998. The removal method entailed oxidation by aeration of pumped groundwater. Arsenic in the groundwater becomes hydroxide in the iron, facilitating sedimentation for removal using the sand filter. Water is conveyed after the completion of this process. When an elevated tank is used, backwash occurs during service breaks, and the sludge removed is discharged outside. Because the system does not require chemicals, operation and maintenance are easy to carry out. Arsenic removal by this system is reported to be effective. However, the need to operate pumping in two stages (groundwater extraction and water conveyance) intensifies the operation cost, and the resulting water rate is about 2.5 times higher than that of the system where pumping is operated only for groundwater extraction.

Table 3.2.2 Existing Urban Water Supply System in the Study Area

District	Jessore	Jhenaidah					Chuadanga
Pourashava (Municipality)	Jessore Sadar	Jhenaidah Sadar	Sailkupa	Kotchandpur	Kaligonj	Moheshupur	Chuadanga Sadar
Population	350,000	94,624	28,527	40,000	42,891	24,433	131,314
Service Connection	6,400	2,320	277	650	250	360	2,682
Coverage (%)	41	31.63	5	30	30	8	25
Commencement of the Service	1963	1981	1997	1996	1998	1996	1985
Water Production (m^3/day)	13,000	4,360	1,360	1,500	1,000	870	3,700
Production Well	17	7	3	3	3	2	5
Total Length of Pipeline (km)	108	59.425	10.22	13	10.33	8	42.5
Overhead Reservoir Tank	6	3	0	0	0	0	4
Water Treatment Plant	IRP* x 3	0	0	0	0	0	0

*IRP: Iron Removal Plant

3) Operation & Maintenance

The pourashavas (municipalities) are responsible for system operation and maintenance. Table 3.2.3 outlines the operation and maintenance staffs, Table 3.2.4 shows the operation timetable and water rates, while the revenue and expenditure from operation and maintenance are outlined in Table 3.2.5.

Maintenance in cases of malfunction or breakdown is directly handled by a mechanic from the concerned pourashava or consigned over to the manufacturer. If the pourashava cannot handle the problem, the assistance of DPHE is available.

On the other hand, there is no water quality control system and water quality surveys are not regularly carried out. Although at a low level, arsenic has also been detected in the urban water supply source. These conditions point out the urgent need for the establishment of a water quality management system.

Table 3.2.3 Operation & Maintenance Staffs of Pourashava Water Supply System

District	Jessore	Jhenaidah					Chuadanga
Pourashava (Municipality)	Jessore Sadar	Jhenaidah Sadar	Sailkupa	Kotchandpur	Kaligonj	Moheshupur	Chuadanga Sadar
Waterworks superintendent	1	0	0	0	0	0	1
Assistant superintendent	1	0	0	0	0	0	0
Bill clerk	0	1	0	1	0	1	1
Pump operator	34	6	3	2	1	2	8
Pump mechanic	5	2	0	0	0	0	1
Tube well mechanic	3	0	1	0	1	2	1
Pipeline mechanic	5	4	0	1	1	0	2
Peon	4	1	0	0	0	0	1
Guard	18	0	0	1	0	0	3
Total	**71**	**14**	**4**	**5**	**3**	**5**	**13**

Table 3.2.4 Water Supply System Service Time & Service Charge

District		Jessore	Jhenaidah					Chuadanga
Pourashava (Municipality)		Jessore Sadar	Jhenaidah Sadar	Sailkupa	Kotchandpur	Kaligonj	Moheshupur	Chuadanga Sadar
Monthly Charge for Households (Tk)	1/2”	50	50	40	40	40	-	40
	3/4”	75	75	60	60	60	50	60
	1”	175	150	100	-	-	-	100
Service Time	Morning	06:00-09:00	06:00-08:00	06:00-07:30	06:00-08:30	06:00-06:40	06:00-08:30	05:30-09:00
	Noon	12:00-19:00	11:30-13:30	12:00-14:00	12:00-14:00	12:00-12:40	12:00-14:00	12:30-14:00
	Evening	-	17:00-18:00	17:00-18:00	17:00-18:00	16:30-17:00	17:00-18:00	17:30-18:30
	Hour/day	10	5	4.5	5.5	1.9	4	6

Table 3.2.5 Average Monthly Financial Statement for Operation & Maintenance of Water Supply System in the Study Area

(TAKA)

District	Jessore	Jhenaidah					Chuadanga
Pourashava (Municipality)	Jessore Sadar	Jhenaidah Sadar	Sailkupa	Kotchandpur	Kaligonj	Moheshupur	Chuadanga Sadar
Income	**449,700**	**148,000**	**16,700**	**17,000**	**20,100**	**18,000**	**136,100**
Water Charge	420,000	130,000	10,100	17,000	11,300	18,000	122,300
Connection Charge	27,300	16,000	1,600	-	4,200	-	13,600
Others	2,400	2,000	5,000	-	4,600	-	200
Expenditure	**564,700**	**140,000**	**21,300**	**40,800**	**17,600**	**36,000**	**157,000**
Staff Salary	267,300	45,000	9,300	15,400	7,200	16,000	74,700
Power Charge	289,300	85,000	9,000	23,300	10,000	13,000	52,300
Others	8,100	10,000	3,000	2,100	400	7,000	30,000
Balance	**-115,000**	**8,000**	**-4,600**	**-23,800**	**2,500**	**-18,000**	**-20,900**

3.2.3 Rural Water Supply

1) Water Source and Conditions of Use

The general water sources in the study area and their conditions of use are summarized in Table 3.2.6. The water sources are being used as the residents deem necessary, although groundwater from hand tube wells is mostly used for drinking and cooking. The drilling of hand tube wells is easy and cheap, and enables the pumping up of an abundant water volume anywhere. Consequently, there are many public wells and private wells in the study area.

Table 3.2.7 shows the number of DPHE wells in the study area, which are actually outnumbered by private wells.

Table 3.2.6 General Usage of Water Sources in the Study Area

Water Source	Use				
	Drinking	Cooking	Washing	Bathing	Irrigation
Rainwater	Δ	Δ	Δ	Δ	X
Ponds	Δ	Δ	O	O	O
Rivers and lakes	Δ	Δ	O	O	O
Groundwater from ultra shallow aquifers (Dug Well)	Δ	Δ	Δ	Δ	Δ
Groundwater from shallow aquifers	O	O	O	O	O
Groundwater from deep aquifers	Δ	Δ	Δ	Δ	X

Table 3.2.7 Existing DPHE Tube Wells in the Study Area

(As of June 1998, excluding the Pourashava Production Wells)

District	Thana	Type of Tube Well										
		Shallow				TARA				Deep		
		Running		Blocked		Running		Blocked		Running		Blocked
		1998	Changes*	1998	Changes*	1998	Changes*	1998	Changes*	1998	Changes*	
Jessore	Jessor Sadar	3,195	113	82	Δ4	545	108	12	6	0	0	0
	Abhoynagar	2,077	90	44	Δ7	17	0	0	0	77	57	0
	Bagarpara	1,742	94	36	1	46	Δ4	9	4	0	0	0
	Jhikargacha	2,782	111	41	0	227	49	7	0	0	0	0
	Monirampur	3,656	49	80	36	77	25	5	5	67	60	0
	Keshbpur	2,284	191	10	Δ15	10	0	2	0	43	10	0
	Sharsa	2,339	82	22	8	117	2	14	0	21	21	0
	Chowgacha	1,916	85	26	18	133	36	9	0	0	0	0
	Total	19,991	815	341	37	1,172	216	58	15	208	148	0
Jhenaidah	Jhenaidah	3,147	43	125	105	177	24	4	1	0	0	0
	Sailkupa	3,144	101	30	5	840	116	15	Δ2	0	0	0
	Hornakunda	1,719	187	30	Δ15	223	Δ7	13	7	0	0	0
	Kaligonj	2,690	64	63	11	148	11	4	0	0	0	0
	Kotchandpur	1,018	41	14	2	13	8	0	0	0	0	0
	Moheshupur	2,525	97	16	2	54	17	1	0	0	0	0
	Total	14,243	533	278	110	1,455	169	37	6	0	0	0
Chuadanga	Chuadanga	1,475	46	22	Δ4	263	54	5	0	0	0	0
	Alamdanga	2,466	74	41	14	23	23	0	0	0	0	0
	Dhamurhuda	1,816	20	66	13	426	23	36	10	0	0	0
	Jiban Nagar	1,221	35	14	Δ4	0	0	0	0	0	0	0
	Total	6,978	175	143	19	712	100	41	10	0	0	0
Total Study Area		41,212	1,523	762	166	3,339	485	136	31	208	148	0
Total No. by Type		Total Shallow Wells= 41,974				Total TARA Wells= 3,475				Total Deep Wells= 208		
Total DPHE Wells		45,657										

*: Changes from 1997 to 1998 (Δ= decreased)
[Data Source: DPHE P&C Division (1997, 1998)]

2) Water Sources & Facilities

As previously mentioned, the majority of the water facilities in the villages are hand tube wells that rely on groundwater resources

The water supply system to be constructed will consist of a tube well with hand pumps, a platform and a drain. The details are as shown below.

a. Tube Well

Shallow wells that are about 50m in depth are drilled using the manual "Sludger Method", while the "Donkey Method" (mud rotation and manual drilling) is used for 100 to 200m deep wells. Both are conventional and cheap drilling methods, but do not entail the filling up of permeable materials, e.g. gravel and cement milk, etc. for sealing, as the drilling and casing pipe diameters are the same.

b. Hand Pump & Platform

Suction pump No. 6 is the most popular type of hand pump in the study area, be it for private or DPHE wells, and is widely and inexpensively distributed in the city.

In recent years, the DPHE-UNICEF started using the lifting pump, TARA. As shown in Table 3.2.8, this pump type is more capable of extracting water from deeper levels than the No.6. It is strongly resistant to corrosion, easy to operate and maintain, and highly sustainable. Unfortunately, however, the purchase price and the construction cost, in total, exceed that of the No.6 pump twofold.

Along with the natural decline in the water table in the dry season, the groundwater level decreases due to excessive extraction for irrigation. The selection of a hand pump, therefore, should take draw-down into account.

Table 3.2.9 shows the DPHE standard specification for platform construction.

Table 3.2.8 Comparison of Hand Pumps

Model	No.6	TARA
Type	Suction pump	Lifting pump
Applicable water level	> -7m	> -18m
Discharge (liter/min)	35	27
Price (Tk)	3,900	7,700
Construction cost (Tk) of tube well including platform by DPHE Standard	6,000	14,000
Body & handle	Cast iron	Galvanized steel
Boring diameter	38mm	75mm (upper) 38mm (lower)
Casing pipe	PVC-38mm (Top pipe: GI38mm x 1.5m)	PVC-75mm (upper) PVC-38mm (lower)
Screen pipe	PVC-38mm	PVC-38mm
Riser pipe	-	PVC-50mm
Pump rod	-	PVC-32mm

Table 3.2.9 DPHE Standard for Platform Construction

Hand pump model	No 6 (Shallow well)	No.6 (Deep well)	TARA
Structure	Slab: 1:2:4 Brick Chip Concrete Wall: Brick Masonry		
Slab thickness	4”		
Wall thickness	3”		
Platform			
Width	72”	72”	66”
Length	54”	84”	66”
Drain			
Width	4”		
Depth	3”		
Length	36”		

c. Arsenic Mitigation Technologies

Every agency and group is now selecting from various technologies an arsenic mitigation technology most suited to local conditions by process of elimination (see Table 3.2.10). The following are among the various techniques to mitigate arsenic levels in the water: Safi Filter, Three Kolshi Filter, Home-based Surface Water Filter, Iron Oxyhydroxide Filter, Double Bucket Unit Aeration and Passive Sedimentation Filter, and Activate Alumina Adsorption. Projects to evaluate these techniques are also being carried out at present.

Table 3.2.10 Existing Arsenic Mitigation Technologies for Rural Water Supply

Water Source	Intake Facility	Treatment Technology	
		For Arsenic	For Fecal Coliform (Bacteria)
Rainwater	**Rain Water Harvester (RWH)***	Unnecessary	Unnecessary
Ponds	None	Unnecessary	**Pond Sand Filter (PSF)***
Rivers and lakes	None	Unnecessary	(Boiling)
Groundwater in ultra shallow aquifer	**Dug well***	Unnecessary	(Boiling)
Groundwater in shallow aquifer	Hand pump tube well	**Safi Filter***	Unnecessary
		Three Kolshi Filter*	
		Home-based Surface Water Filter*	
		Iron Oxyhydroxide Filter*	
		Double Bucket Unit*	
		Aeration and Passive Sedimentation Filter*	
		Activate Alumina Adsorption*	
		Etc.*	
Groundwater in deep aquifer	**Hand pump tube well***	Unnecessary	Unnecessary

*: Existing Arsenic Mitigation Activities in the Study Area

3) Operation & Maintenance

DPHE wells are constructed for community use. A caretaker is appointed during construction to manage the well. DPHE trains the caretaker in proper operation and maintenance using leaflets, manuals, etc., and provides the necessary spare parts.

The caretaker will carry out regular maintenance, inspection, and repair. The assistance of the mechanics (4) in the Thana offices (Assistant Engineer’s Office) of DPHE will be requested for work beyond the capability of the caretaker.

When spare parts run out, the caretaker will collect money from the users to purchase the required material from DPHE.

The operation and maintenance of private wells are the responsibility of the owners, who either carry out the repairs themselves or consign them over to a repair company or the manufacturer.

Table 3.2.11 shows the organization and staff of DPHE in the study area. Table 3.2.12 shows the overall organizational chart of DPHE.

The DPHE has only 4 (Khulna, Rajshahi, Mymensingh, Comilla) laboratories for water quality analysis nationwide. These laboratories are understaffed and under-equipped; hence the water quality management is in an extremely poor state.

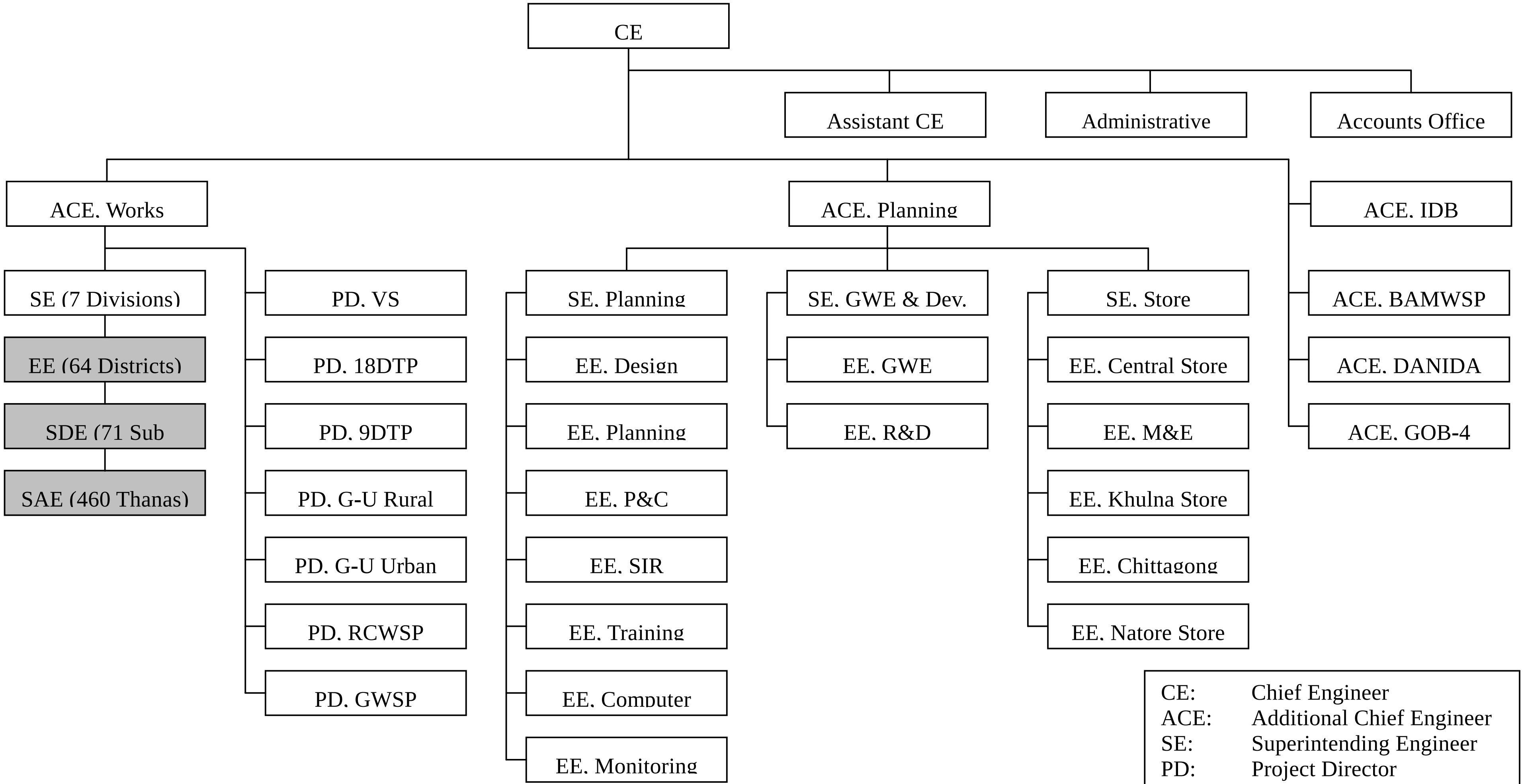
Not only are water quality tests that include arsenic level tests not conducted regularly, but the wells, mostly the numerous private wells, in the study area have never been subjected to arsenic level measurements despite the seriousness of the contaminated conditions of the water by arsenic. It is important to immediately carry out the screening of all wells to ward off arsenic inflow. Although every agency and group is presently working hand in hand to counteract arsenic contamination, their rate of accomplishment is low due to the huge number of wells in the study area.

Table 3.2.11 DPHE Organizations in the Study Area

Superintending Engineer's Office Khulna

Executive Engineer's Office Jessore District	Executive Engineer's Office Jhenaida District	Executive Engineer's Office Chuadanga Dist.
1 x Executive Engineer 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)	1 x Executive Engineer 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)	1 x Executive Engineer 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)
Sub-divisional Engineer's Office Jessore District	Executive Engineer's Office Jhenaidah District	Sub-divisional Engineer's Office Chuadanga Dist.
1 x Sub-divisional Eng. 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)	1 x Sub-divisional Eng. 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)	1 x Sub-divisional Eng. 1 x Estimator 1 x Draftsman 1 x Head Assistant 1 x Accountant 1 x Cashier 1 x LDAT (Asst. Account) 1 x MLSS (Office Boy)
Sub-assistant Engineer's Office Each Thana	Sub-assistant Engineer's Office Each Thana	Sub-assistant Engineer's Office Each Thana
1 x Sub-assistant Eng. 4 x Mechanic 1 x CCT (Clerk) 1 x Peon (Office Boy) 1 x Chowkidar (Security)	1 x Sub-assistant Eng. 4 x Mechanic 1 x CCT (Clerk) 1 x Peon (Office Boy) 1 x Chowkidar (Security)	1 x Sub-assistant Eng. 4 x Mechanic 1 x CCT (Clerk) 1 x Peon (Office Boy) 1 x Chowkidar (Security)

Table 3.2.12 DPHE Organizational Chart



CE: Chief Engineer
ACE: Additional Chief Engineer
SE: Superintending Engineer
PD: Project Director
EE: Executive Engineer
SDE: Sub-division Engineer
SAE: Sub-assistant Engineer

3.3 Village Conditions in the Study Area

3.3.1 Methodology of Information Collection

1) Interview with Village Leaders

Information on socio-economic conditions in rural areas was collected through interviews with village leaders who could provide necessary information, such as Union Parishad members, teachers, and Imams (Islamic religious leaders). Using the questionnaire shown in Annex 3.3.1, interviews in Bengali were conducted during June and July in the year 2000. Since this is not an opinion poll, interviewees were allowed to discuss with others if he or she did not have enough information to answer the questions.

The JICA Study Team held a two-day training session to train interviewers on how to ask questions in Bengali in a proper manner and record answers on the questionnaire.

2) Selection of Target Villages for Interviews with Village Leaders

The interviews with village leaders were conducted in the villages having the target tube wells for the survey on physical conditions and arsenic level analysis. Among the 300 target wells, 40 are production wells in Pourashava areas, and 260 are tube wells in rural areas. Therefore, the 260 villages having the target tube wells are selected as target villages for the socio-economic study: 53 from Chuadanga, 118 from Jessore, and 89 from Jhenaidah. Names of the target villages can be found in Table 4.1.2. The selection process of the target villages is described in Chapter 4, Section 4.1.

3.3.2 Village Conditions

1) General Features of the Villages

a. Population Size of the Villages

A “ Village” is defined as the smallest geographic area in rural areas which is known to the people as a village. A Village may be the same as a Mouza, or there may be more than one village in a Mouza (BBS, 1994). Since there is no requirement regarding population size to be a village, the size of the population in the villages has a wide range. Based on the interviews with the village leaders in the 260 villages, the average population of the villages is about 3,500 in Chuadanga and Jessore and about 2,500 in Jhenaidah (see Table 3.3.1). The largest population (20,000) is about 400 times as large as the smallest population (50) as in the case of Chuadanga. However, most of the villages have populations within the range from 1,000 to 5,000. Since population size varies by village, mitigation measures and education programs should be prepared taking population size of a village into account if a village is an implementation unit of the measures.

Table 3.3.1 Population Size of the Villages

	Chuadanga	Jessore	Jhenaidah
Average	3,631	3,437	2,570
Maximum	20,000	15,000	15,000
Minimum	50	400	250

b. Cultural Background

Islam is the major religion in most of the 260 villages but not the only religion in the villages. As shown in Figure 3.3.2, Muslims and Hindus live in the same village in most of the target villages, especially in Jhenaidah. There are some villages where Hinduism is major: 5 villages in Jessore (4.2%) and 6 villages in Jhenaidah (6.7%). Other religions such as Buddhism and Christianity are believed in some villages but are not major in the area. In Chuadanga, an indigenous religion called Sautal was listed in two villages where Islam is the major religion. Therefore, developers of the master plan and educational program should give consideration to the cultural diversity in each village.

c. Roof Materials

Roofs can be used for collecting rainwater; metal sheet such as (corrugated) tin plate is most appropriate for that purpose. Figure 3.3.3 shows the ratio of the villages where the corresponding roof material is used for a certain ratio of the houses in the village. Although the information presented here is not based on field investigation but interviewees' perception, it can be assumed that main roof materials vary by location. In Chuadanga, in 44% of the 53 villages, straw is a major roof material, and so is tin if more than half of the households in one village is defined as major. In Jessore, tile is major in 53% of the 118 villages, followed by tin. In Jhenaidah, tin is major in 70% of the 89 villages, followed by straw. In Jhenaidah, more than 80 % of the houses have tin roofs in 22% of the 89 villages. According to the information from a villager in Shailkupa Thana, Jhenaidah, soil in that area is too sandy to be used for making walls; therefore, bamboo or tin is used instead. It is assumed that tin plate or metal sheet is used for roofing because bamboo or tin walls cannot support heavy roof materials such as tile and straw.

d. Nutrition

Nutrition is regarded as one of the factors mitigating health damage due to arsenic water intake; foods rich in protein and vitamin A, E and C are especially helpful for arsenic patients to recover from arsenic poisoning with arsenic safe drinking water. The information from the interviews with village leaders indicates that most of the villagers eat rice, green leafy vegetables, and other vegetables every day, but not a protein source such as beans, meat, fish, or eggs (see Figure 3.3.4). It is assumed that most of the villagers do not take enough protein. Although villagers eat green leafy vegetables and other vegetables every day, traditional cooking methods such as heating up for a long time could destroy vitamins and boiling and draining the boiled water could deprive the vegetables of vitamins; the villagers might not ingest enough vitamins.

Knowledge dissemination on proper cooking methods could be one of the elements in education programs to be developed.

e. Community Activities

A community organization is indispensable for tackling arsenic problems in rural areas where villagers depend on tube wells for their drinking water. In the 260 villages, there are several kinds of community activities led by community organizations including local and national NGOs. The most common type of community organizations in the villages is the one in charge of managing a religious facility such as a Village Mosjid (mosque) Committee. More than 90% of the villages in Chuadanga and Jhenaidah have such community organizations (see Figure 3.3.5). In addition, community organizations for discussing school activities such as School Committees are also common. Experiences in managing these types of community organizations would be helpful to organize villagers to take actions to overcome arsenic problems. However, not all the villages have an organization to manage community activities by themselves. In these villages, assistance from experienced local and national NGOs to lead community activities to cope with arsenic problems would be possible.

Several local and national NGOs are active in disseminating knowledge about nutrition and sanitation and assisting the poor and handicapped. Active national NGOs in this field in the 260 villages are BRAC (Bangladesh Rural Advancement Committee), Grameen Bank, and Proshika. Active local NGOs are listed in Table 3.3.2. These NGOs could be precious resources for disseminating information on arsenic problems and prevention methods and assisting arsenic patients.

Table 3.3.2 Active Local NGOs

	Dissemination of Knowledge about Nutrition and Sanitation	Assistance to Poor and Handicapped
Chuadanga	ATMABISWAS, ASA, Karitas, WAVE	ATMABISWAS, ASA, Bittalin, Karitas, Janakallayan Shangstha, KDC, WAVE,
Jessore	AAN, Addin, ASA, Cormijibi Songstha, Gono Shahajjo Songstha, Gonobima, GOUF, ISDU, Jagonani Chakro, Nehalpur, Panchri Tarun Sangstha, Probal, Sacha Sebi Sangstha, Shebas, Shishu Nila, Uttaran,	Addin, Agragoti, ASA, Cormijibi Songstha, Gono Shahajjo Sangstha, GOUF, Jagonani Chakro, Karitas, Nehalpur, Probal, Protiva, R.R.C., Samaj Collayan, Shebas, Shishu Nila, Udayoan, Uttaran, VIVA
Jhenaidah	BASRO, Jagarani Chara, PRODIP, Sreejoni, Sours	Adara Club, AID, ALOURDISARI, ASA, Jagarani Chara, Sreejoni, Siddkia Sheba Sanga, Sonar Bangla, Sours

AID: Action In Development
ASA: Associates for Social Advancement
KDC: Kayra Donga Club
R.R.C.: Rural Reconstruction Center
WAVE: Welfare Association of Village Environment

f. Information Dissemination Tool

To disseminate information on arsenic problems, mass media and local media can be used. In the 260 villages, radio has been relatively prevalent. The ratios of the villages where more than half of the households have a radio are 68% in Chuadanga, 77% in Jessore, and 78% in Jhenaidah (see Figure 3.3.6). A TV set and newspapers are not as common as a radio. It seems that at least one TV set exists in every village, but the ratios of the villages where more than half of the households have a TV set are only 2% in Chuadanga, 3% in Jessore, and 11% in Jhenaidah. There is no village where more than half of the households read newspapers in Chuadanga and Jessore while more than half of the households read newspapers in 14 % of the villages in Jhenaidah. Therefore, radio is considered as an effective communication tool to disseminate information across villages at one time.

At the village level, a loudspeaker is commonly used to disseminate information although in Chuadanga village meetings are more popular (see Figure 3.3.7). Since the adult literacy rate in the study area is less than 40%, oral communication is considered as more effective.

2) Domestic Water Use

a. Water Consumption

Although information presented here is an estimate made by the interviewees for a household with six family members, daily water consumption for drinking and cooking purposes would be in the range from 70 to 80 liters (see Table 3.3.3). A more precise estimation of water consumption at the household level will be conducted in the baseline study.

Table 3.3.3 Daily Water Consumption for Cooking and Drinking per Household

	Chuadanga	Jessore	Jhenaidah
Average (liter)	66	83	80
Maximum (liter)	120	150	160
Minimum (liter)	40	30	36

b. Water Sources

The main source for drinking water is shallow wells in almost all the 260 villages (see Figure 3.3.8). Exceptions are one village in Jhenaidah where a deep well is the main source and one village in Chuadanga where ponds are also the main source for drinking water as well as shallow wells. As for cooking water, shallow wells are also the main water source, but ponds are the main source in 6% of the villages in Chuadanga, 16% in Jessore, and 3% in Jhenaidah. As for other activities such as washing, bathing, and flushing toilets, ponds and shallow wells are the main water sources, and rivers are also used for these purposes in more than 15% of the villages in Chuadanga and Jhenaidah. Although rainwater is arsenic free, only one village is using it for purposes other than drinking and cooking.

c. Water Fetching

In almost all the 260 villages, the wife is mainly in charge of water fetching in each household. One village in Jhenaidah answered that the servant is mainly in charge of water fetching. Therefore, information about water fetching collected from wives would be most appropriate, and there should be a system to reflect their opinions in the design of alternative water sources for arsenic safe water.

Villagers use several kinds of water containers such as earthen pots, aluminum pots, plastic buckets, and jugs. These containers are mostly carried by hand in Jessore; a handcart is also used in Jhenaidah and Chuadanga. Where water containers are carried by hand, special attention should be paid to the location of alternative water sources for arsenic safe water, and carrying tools should be introduced to reduce the workload of carrying water containers if the workload is to be increased.

d. Wells for Domestic Use

All the 260 villages have both communal and private wells for domestic water use. The number of wells varies by village; one village has more than 2,000 while another has about 20. The average number of users (population) per well also varies by village; there is almost one well per household in some villages while in one village there is only one well for almost 40 households (see Table 3.3.4).

Table 3.3.4 Number of Users per Well

	Chuadanga	Jessore	Jhenaidah
Average	79	23	19
Maximum	500*	95	161
Minimum	5	4	4

Notes: The largest number of users per well in Chuadanga is 500, but the second largest is 200, followed by 160 and 150.

Communal wells for domestic water use are not commonly managed by community groups; they are managed by individuals such as caretakers in most of the 260 villages. There is no village that has community groups to manage communal wells in Chuadanga, one in Jessore, and six in Jhenaidah (see Table 3.3.5).

Table 3.3.5 Community Groups to Manage Communal Wells for Domestic Water Use

	Chuadanga	Jessore	Jhenaidah
Number of Villages with Community groups	0	6	1
Ratio of Villages with Community groups to Villages with Communal Wells	0%	5.1%	1.1%

The community groups are engaged only in facility repair, except that one in Jhenaidah is also engaged in fee collection. In most of the cases members of these organizations are not paid in Jhenaidah but some are paid in Jessore. The main activity of the caretakers is facility repair as with community groups, but some caretakers conduct water quality test and monitoring of water withdrawal (see Figure 3.3.10). Almost all the caretakers in Chuadanga and Jhenaidah are not paid for their service, but some of them are paid in Jessore (see Figure 3.3.11). It is necessary to consider that most of the villages are not used to the maintenance of communal wells for domestic water use by establishing a community group and by contributing their financial resources to compensate caretakers for their services and recover repair costs.

e. Wells for Agricultural Use

It is not so common for a village to have communal wells for agricultural use. The ratio of the villages that have communal wells are within the range from 13 to 27%, and the average number of communal wells per village is less than 2 while that of private wells is about 40 to 60. The wells for agricultural use are in operation for 13 to 14 hours per day on average (see Table 3.3.6).

Table 3.3.6 Communal Wells for Agricultural Use in Village

	Chuadanga	Jessore	Jhenaidah
Ratio of Villages with Communal Wells	13.2%	19.5%	27%
Average Number of Communal Wells	1.4	1.7	1.7
Average Number of Private Wells	59.5	56.1	43.9
Average Operation Hours per Day	12.9	13.4	14.0

The ratio of management of communal wells for agricultural use by community groups is higher than that of communal wells for domestic water use (see Table 3.3.7).

Table 3.3.7 Community Groups to Manage Communal Wells for Agricultural Use

	Chuadanga	Jessore	Jhenaidah
Number of Villages with Community group	1	9	15
Ratio of Villages with Community groups to Villages with Communal Wells	14.3%	39.1%	62.5%

The community groups are engaged mainly in fee collection and facility repair except in Jessore where more than half of the community groups are engaged in monitoring water withdrawal (see Figure 3.3.12). There are communal wells managed by caretakers. The main activities of the caretakers for communal wells are the same as those of the community groups. Some of the caretakers in Jessore are also engaged in the monitoring of water withdrawal. Almost all the members and caretakers in Chuadanga and Jhenaidah are paid for their service while some are not paid in Jessore (see Figure 3.3.13). Some of the villages have experience in establishing a community group and contributing their financial resources to compensate members of the community group or caretakers for their services and recover repair costs through managing communal wells for agricultural use. This experience would be useful for the same kind of activity for managing communal wells for domestic water use.

3) Arsenic Problems

a. Arsenic Patients Reported from Village Leaders

Among the 260 villages, 19 village leaders reported that there are arsenic patients (see Table 3.3.8). The sources of information on the number of arsenic patients were often patients themselves or a patient's family members. Other information sources include a health worker, AAN (a Japanese NGO specializing in tackling arsenic problems), and CNN. The largest number of arsenic patients in one village is reported from Samta (Bagachra Union, Sharsha Thana, Jessore), which is 363 out of 4,750 residents (about 7.6%).

In most of the villages, the first patient was found less than 5 yeas ago while it was about 10 years ago in Marua (Jaradishpur Union, Chaugachha Thana, Jessore) (see Table 3.3.8).

The percentages of male and female patients are 54.2 and 45.8% respectively; the former is higher than the latter.

Table 3.3.8 Arsenic Patients Reported from Village Leaders

District	Thana	Union	Village	# of Patients			First patient found (years ago)
				Total	Male	Female	
Chuadanga	Damurhuda	Kuralgachhi	Kuralgachhi	1	1	0	0.5
Chuadanga	Chuadanga	Begampur	Jhajri	18	11	7	1
Chuadanga	Damurhuda	Howli	Dudhpatila	100	30	70	0.5
Sub-Total				119	42	77	
Jessore	Jhikargachha	Jhikargacha	Sagarpur	1	1		2 +
Jessore	Sharsha	Goga	Kalini	1	0	1	1
Jessore	Jessore Sadar	Churamankati	Asannagar	1	1		1
Jessore	Manirampur	Shyamkur	Sundalpur	1	1	0	3 +
Jessore	Manirampur	Kultia	Padmangthpur	1	1	0	1
Jessore	Manirampur	Dhakuria	Brahmapur	1	1	0	1
Jessore	Chaugachha	Pashapole	Durali	1	0	1	1
Jessore	Keshabpur	Mangalkot	Pancharohi	2	2	0	5
Jessore	Abhaynagar	Mahakal	Pombhag	2	1	1	1
Jessore	Chaugachha	Paulsara	Aradaha	4	0	4	3
Jessore	Chaugachha	Jaradishpur	Marua	22	16	6	10
Jessore	Sharsha	Bagachra	Samta	363	181	182	5
SUB-TOTAL				400	205	195	
Jhenaidah	Sailkupa	Umedpur	Taraf Umedpur	1	0	1	N/A
Jhenaidah	Moheshppur	Manderbari	Syamnagor	3	2	1	N/A
Jhenaidah	Jhenaidah Sadar	Padmakar	Achintyanagar	30	23	7	3
Jhenaidah	Kaliganj	Barobazar	Majdia	93	78	15	2
Sub-Total				127	103	24	2.5
Grand Total				646	350	296	

b. Medical Treatment of Patients

More than 80% of the patients have been medically treated in one village in Chuadanga, five in Jessore, and one in Jhenaidah. On the other hand, no patient has been medically treated in four villages in Jessore, and one in Jhenaidah (see Figure 3.3.14).

c. Community Attitude towards Arsenic Patients

Arsenic poisoning is sometimes misunderstood as being contagious or a curse due to one's misbehavior, which forces arsenic patients to be excluded from daily social life. In two villages in Chuadanga and one village in Jhenaidah it was reported that arsenic patients were treated unfairly in all of the following occasions (see Figure 3.3.15):

- going to school
- eating or drinking at a restaurant
- attending village meetings
- getting married

- getting a job

In one village in Jhenaidah, it was reported that arsenic patients were unfairly treated on the occasions of going to school and getting married. In Jessore, no village reported that arsenic patients were unfairly treated on the above-mentioned occasions, but one village reported that villagers do not want to shake hands of arsenic patients. That is, arsenic poisoning is misunderstood as being contagious in that village. Although arsenic problems are frequently reported in newspapers and causes and prevention methods are disseminated by various kinds of organizations such as DPHE, UNICEF, and NGOs, there is still a great need to improve the villagers understanding of arsenic problems. Therefore, the dissemination of information on the cause of arsenic poisoning should be emphasized in order to reduce the psychological stress of arsenic patients.

d. Access to Medical Facility

As early diagnosis and treatment are essential for reducing health damage due to arsenic poisoning, accessibility to a medical facility is important. In most of the 260 villages, people can go to the nearest medical facility within one hour. One the other hand, people have to spend more than one hour to go to the nearest medical facility in 11% of the villages in Chuadanga, 25% in Jessore, and 18% in Jhenaidah (see Figure 3.3.16). One village in Jessore reported that it takes more than 5 hours to go to the nearest medical facility by rickshaw, the most common transportation means.

The average transportation costs to go to the nearest medial facility are about 16 Tk in Chuadanga, 44 Tk in Jessore, and 32 Tk in Jhenaidah. The average daily wage of an agricultural laborer (male) was 50 Tk in December 1998, and the daily income of a rickshaw driver is said to be less than 100 Tk. Since a doctor’s fee is necessary in addition to the transportation costs, there is a relatively high hurdle for villagers to go to the doctor.

Because patient diagnosis has not been done in most of the villages, priority on dispatching medical teams to diagnose and treat arsenic patients should be given to the areas with low accessibility to a medical facility in terms of time and costs and high arsenic level of groundwater.

e. Knowledge about Arsenic Poisoning

Visible symptoms of arsenic poisoning are relatively known in the 260 villages. About 75% of the villages in Chuadanga answered that the symptoms are known to the villagers, and so did 58% in Jessore and 49% in Jhenaidah (see Figure 3.3.17). In these villages all the interviewees (village leaders) listed dark spots on skin as one of the visible symptoms of arsenic poisoning. In addition, almost all the interviewees in Jessore listed hardening of skin as one of the symptoms (see Figure 3.3.18). Priority on dissemination of information about arsenic problems should be given to the area with a high arsenic level in groundwater and a low awareness of arsenic problems.

f. Actions to Tackle Arsenic Problems by Villages

Some of the villages have already held village meetings to discuss arsenic problems: two villages in Chuadanga, 10 in Jessore, and four in Jhenaidah (see Table 3.3.9).

Table 3.3.9 Community Meeting on Arsenic Problems

	Chuadanga	Jessore	Jhenaidah
Villages that Held Community Meetings (ratio to all the villages in the District)	2 (3.8%)	10 (8.5%)	4 (4.5%)
(Breakdown of the Above Villages) Villages with Arsenic Patients / Villages without Arsenic Patients	1/1	2/8	2/2

Table 3.3.10 Actions to Tackle with Arsenic Problems in the Villages with Patients

District	Thana	Union	Village	Total # of Patients	# of Village Meetings	Village Actions	NGO Activities
Chuadanga	Damurhuda	Kuralgachhi	Kuralgachhi	1	3	-	-
Chuadanga	Chuadanga	Begampur	Jhajri	18	0	-	-
Chuadanga	Damurhuda	Howli	Dudhpatila	100	0	-	-
Sub-Total				119			
Jessore	Jhikargachha	Jhikargacha	Sagarpur	1	0	-	BRAC
Jessore	Sharsha	Goga	Kalini	1	0	-	G.B.C.
Jessore	Jessore Sadar	Churamankati	Asannagar	1	0	-	-
Jessore	Manirampur	Shyamkur	Sundalpur	1	0	-	-
Jessore	Manirampur	Kultia	Padmangthpur	1	0	-	-
Jessore	Manirampur	Dhakuria	Brahmapur	1	0	-	-
Jessore	Chaugachha	Pashapole	Durali	1	0	-	-
Jessore	Keshabpur	Mangalkot	Pancharohi	2	0	-	-
Jessore	Abhaynagar	Mahakal	Pombhag	2	2	*	CNN
Jessore	Chaugachha	Paulsara	Aradaha	4	0	-	-
Jessore	Chaugachha	Jaradishpur	Marua	22	0	-	-
Jessore	Sharsha	Bagachra	Samta	363	12	*	AAN
Sub-Total				400			
Jhenaidah	Sailkupa	Umedpur	Taraf Umedpur	1	0	-	-
Jhenaidah	Moheshppur	Manderbari	Syamnagor	3	0	-	-
Jhenaidah	Jhenaidah Sadar	Padmakar	Achintyanagar	30	2	*	AAN, AID
Jhenaidah	Kaliganj	Barobazar	Majdia	93	2	*	Goriber Ashroy
Sub-Total				127			
Grand Total				646			

Most of the villages with a large number of arsenic patients, such as Samta, Achintyanagar and Majdia, held the village meetings (see Table 3.3.10). Although eleven villages without arsenic patients held the meetings, about three fourths of the villages with arsenic patients have not held them yet. Based on the discussions at the village meetings, eleven villages (68.8% of the villages that held the village meetings) have taken actions to tackle arsenic problems (see Table 3.3.11).

Table 3.3.11 Actions Taken by Villages Based on the Community Discussions

Thana	Union	Village	Types of Actions				
			Establish a committee	Invite experts	Ask gov. for a new well	Ask gov. for arsenic test	Other
Chuadanga	Alokdia	Alokdia		○	○	○	
Jhikargachha	Bankra	Alipur		○	○	○	
Jhikargachha	Ganganandapur	Ganganandapur			○	○	○*1
Sharsha	Nizampur	Chandurlarghop		○	○		
Sharsha	Bagachra	Samta	○	○	○	○	
Sharsha	Dihi	Salkona	○	○	○		
Manirampur	Khanpur	Khanpur		○			○*2
Manirampur	Monoharpur	Monoharpur	○	○			
Abhaynagar	Mahakal	Pombhag			○	○	
Jhenaidah Sadar	Padmakar	Achintyanagar	○	○		○	
Kaliganj	Barobazar	Majdia	○	○		○	

Notes: *1 Ask government to put arsenic removal pots.
*2 Show drama series.

Out of these villages, four villages have arsenic patients. The actions taken by the villages are as follows:

- established a committee to deal with the arsenic problems
- invited a knowledgeable person to provide information about causes of and ways to prevent arsenic poisoning
- asked government organizations or politicians to dig a new well for arsenic safe water
- asked government organizations or NGOs to conduct arsenic tests on well water.

The actions taken by the villages shown in Table 3.3.11 are at the first stage of consecutive efforts; they have built a basis to tackle arsenic problems such as establishing a committee to deal with arsenic problems and understanding the cause of and ways to prevent arsenic poisoning. Supplementary information through interviews with villagers and relevant NGOs tells us that there are villages experienced in tackling arsenic problems by themselves with the help of NGOs. One example is Achintyanagar in Jhenaidah; the villagers contributed their financial resources to build a pond sand filter to obtain arsenic safe water. Arsenic patients who receive vitamin tablets from AAN as a remedy for the symptoms also started paying 10 Tk per month; the payment is reserved as a fund to cover some mitigation costs accruing in the future. This success story can be disseminated to other villages to encourage their self-reliant efforts to tackle arsenic problems.

g. Actions to Obtain Arsenic Safe Water at Household Level

At the household level, some kinds of actions to obtain arsenic safe water or reduce arsenic concentration of water have been taken although they are quite limited (see Figure 3.3.19).

In Chuadanga, using arsenic safe wells is the only action taken in the villages; more than 80% of households do so in almost all the villages. Other methods such as letting water sit in a pot or bucket overnight, using arsenic removal pots, adding chemicals to deposit arsenic, harvesting rainwater, using a pond sand filter, and boiling pond or river water are not practiced.

In Jessore, several kinds of methods are practiced. Using arsenic safe wells are practiced in 41% of the villages, letting water sit in a pot in 16%, using an arsenic removal pot in 5%, harvesting rainwater in 4%, using a pond sand filter in 1%, and boiling pond or river water in 1%. Except using arsenic safe wells, most of these actions are taken in less than 30% of the households in each village.

In Jhenaidah, the ratio of taking these actions at the household level is lower than that in the other two districts. Letting water sit in a pot is found in 12% of the villages, using arsenic removal pots in 1%, harvesting rainwater in 6%, and boiling pond and river water in 2%. Most of these villages have less than 30% of the households taking these actions. Since tin roofs are common in Jhenaidah (more than 80 % of the houses have tin roofs in 22% of the 89 villages where the socio-economic study was carried out), there is still room to increase the use of tin roofs to obtain arsenic safe water.

There are some households practicing rainwater harvesting in the study area. This suggests that there is a possibility to introduce rainwater harvesting as a practical method to obtain rainwater.

h. NGOs Activity related to Arsenic Problems

Several NGOs are carrying out the following arsenic specific activities in the study area:

- testing well water for arsenic
- dissemination of knowledge about symptoms and cause of arsenicosis
- dissemination of information on methods of arsenicosis prevention
- financial assistance to arsenic patients
- mental assistance to arsenic patients

Table 3.3.12 shows that local and national NGOs are supporting villagers in 28 villages out of the 260 villages. The most common activity by NGOs is the testing of well water for arsenic, followed by dissemination of information on symptoms and cause of arsenicosis (see Figure 3.3.20). Since these NGOs are experienced in assisting villages in tackling arsenic problems, they could provide the study team with precious inputs to the master plan and priority projects. In addition, most of these NGOs have been working on dissemination of knowledge about nutrition and sanitation and assistance to poor and handicapped in the same village. Therefore, the NGOs currently working in the villages but not in the field of arsenic problems have the potential to expand their activities to assisting the villagers to cope with arsenic problems.

Reference

BBS (Bangladesh Bureau of Statistics) (1994): *Bangladesh Population Census 1991*

Table 3.3.12 NGOs Activity related to Arsenic Problems

District	Thana	Union	Village	NGOs Activity related to Arsenic Problems							NGOs Other Activity	
				Water test	Diagnosis of patients	Info. on symptoms	Info. on prevention	Providing goods	Financial assistance	Mental assistance	Info on nutrition	Assistance to poor or handicapped
CHUADANGA	ALAMDANGA	JEHALA	Purba Kamalapur	BRAC							BRAC	
	CHUADANGA	ALOKDIA	Alokdia	ATMABI SWAS		ATMABI SWAS	ATMABI SWAS				ATMABI SWAS	ATMABISWAS
	CHUADANGA	PADDABILLA	Burapara	BRAC							BRAC	BRAC
	CHUADANGA	CHUADANGA POURASHAVA	Nurnagar	BRAC								BRAC
JESSORE	JHIKARGACHHA	MAGURA	Chanda				DCH					BRAC, R.R.C.
	JHIKARGACHHA	HAZIRBAG	Matikomra	BRAC		BRAC					BRAC	BRAC
	JHIKARGACHHA	BANKRA	Alipur	BRAC							BRAC	BRAC
	JHIKARGACHHA	PANISARA	Barni	BRAC							BRAC	BRAC
	JHIKARGACHHA	NABHARAN	Baysa	BRAC	BRAC	BRAC					BRAC	
	JHIKARGACHHA	NABHARAN	Cunnagar	BRAC		BRAC					BRAC	BRAC
	JHIKARGACHHA	GANGANANDAPUR	Ganganandapur				BRAC	BRAC				BRAC, Karitas
	JHIKARGACHHA	NIBASKHOLA	Arsingri	BRAC								BRAC
	JHIKARGACHHA	JHIKARGACHA	Sagarpur	BRAC				BRAC				BRAC, Grameen Bank
	SHARSHA	BAGACHRA	Samta	AAN	AAN	AAN			AAN	AAN	AAN	BRAC, Grameen Bank
	SHARSHA	GOGA	Kalini			G.B.C					J.C.	Jagorani Chakro (J.C.)
	JESSORE SADAR	CHANCHRA	Maidia	BRAC								BRAC
	JESSORE SADAR	NAOPARA	Ghurulia			BRAC					BRAC	BRAC
	MANIRAMPUR	MONOHARPUR	Monoharpur				G.U.G.				Addin	BRAC, ASA, Addin
	ABHAYNAGAR	MAHAKAL	Pombhag	CNN					CNN			R.R.C., Grameen Bank
JHENAIDAH	JHENAIDAH SADAR	PADMAKAR	Achintyanagar	AID	AAN	AAN	AID	AID		AID		
	KALIGANJ	JAMAL	Gutiani			BRAC						
	KALIGANJ	KALIGANJ PAURASHAVA	Arpara	Goriber Ashroy			Goriber Ashroy					
	KALIGANJ	KASHTABHANGA	Kumarhati			Sreejoni					Sreejoni	
	KALIGANJ	BAROBAZAR	Majdia	Goriber Ashroy	Goriber Ashroy	Goriber Ashroy	Goriber Ashroy			Goriber Ashroy	BRAC	Grameen Bank
	MOHESHPPUR	MANDERBARI	Sankehada		Gondsahaja							
	HARINAKUNDA	KAPASHATI	Ghoragachha	RHECO								Sreejoni, BRAC, Grameen Bank, RHECO
	SAILKUPA	FULHARI	Chandpur		Nari Federation							
	SAILKUPA	MIRJAPUR	Alamdanga			BRAC					BRAC	BRAC, ALOURDISARI

G.U.G. = Gano Unnayan Gronthagag, R.R.C. = Rural Reconstruction Center, RHECO = Rural Health Education & Credit Organization

Annex 3.3.1 Questionnaire for Interviews with Village Leaders

Basic Information

Zila		Survey Date	
Upazila		Interviewer	
Union		Interviewee1	( )
Mauza (No.)	( )	Interviewee2	( )
Village		Interviewee3	( )

<table>
<tr><th></th><th>Question</th><th colspan="6">Answer</th></tr>
<tr><td colspan="8">General Information on the Village</td></tr>
<tr><td>1</td><td>About how many people are living in this village?</td><td colspan="6"></td></tr>
<tr><td>2</td><td>Do you think population in this village is increasing, decreasing, or unchanged?</td><td colspan="6">1. Increasing
2. Unchanged
3. Decreasing</td></tr>
<tr><td>3</td><td>What language do the villagers use most?</td><td colspan="6">1. Bengali
2. Hindi
3. Other( )</td></tr>
<tr><td>4</td><td>What religions do the villagers believe?
If there is more than one, which is major?</td><td colspan="6">Multiple Answer(Circle the major religion)
1. Islam
2. Hinduism
3. Buddhism
4. Christianity
5. Other( )</td></tr>
<tr><td rowspan="6">5</td><td rowspan="6">About how many houses in the village use straw/grass, earthen tile, tin, and concrete for roof materials? Please answer in either more than 80 %, more than 50%, more than 30%, less than 30% or none.</td><td rowspan="2">Material</td><td colspan="5">Ratio of Houses</td></tr>
<tr><td>80%+</td><td>50%+</td><td>30%+</td><td>30%-</td><td>none</td></tr>
<tr><td>Straw/grass</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Earthen tile</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tin</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Concrete</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>How many times per day do the villagers have meals?</td><td colspan="6">( ) times / day</td></tr>
<tr><td>7</td><td>Do most of the villagers eat following food almost every day? Please answer either yes or no.
(read the answer options)</td><td colspan="6">Multiple Answer
1. Rice
2. Green leafy vegetables
3. Other vegetables
4. Beans
5. Meat
6. Fish
7. Eggs
8. Milk
9. Fruits
10. Other ( )</td></tr>
<tr><td rowspan="6">8</td><td rowspan="6">If there is any community group that conducts any of the following activities, please provide information on its name and approximate years of experiences. (read the activities)</td><td colspan="3">Activity</td><td colspan="2">Name</td><td>Year</td></tr>
<tr><td colspan="3">1. to maintain communal facility such as a village hall</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">2. to maintain commercial or facility such as a market</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">3. to maintain religious facility such as mosque, temple, or church.</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">4. to discuss school activities such as P.T.A</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">5. to disseminate knowledge about nutrition and sanitation</td><td colspan="2"></td><td></td></tr>
</table>

	Question	Answer
		6. to provide assistance to the poor/disabled
9	When a villager wants to inform other villagers (more than 100 people) of something important, what means are used?	Multiple Answer 1. Sign board 2. Community meeting 3. Other ( )
10	About how many households have a radio (TV)? Please answer in either more than 80%, more than 50%, more than 30%, less than 30%, or none. About how many households read a newspaper?	Ratio of Households: 80%+ | 50%+ | 30%+ | 30%- | none Radio TV Newspaper
Domestic Water Use		
11	About how many pots/ buckets of water does one household with 6 people consume for drinking and cooking every day? About how many litter/gallon does one pot/bucket contain?	Number of pot/bucket ( ) Size of pot/bucket ( )liter Total amount ( )liter/day Note: 1gallon = about 4 liter
12	What is the main source of drinking water in the village?	1. Shallow well 4. Pond 2. Deep well 5. Rain water 3. River 6. Other( )
13	What is the main source of cooking water in the village?	1. Shallow well 4. Pond 2. Deep well 5. Rain water 3. River 6. Other( )
14	What is the main source of washing / bathing/ toilet water in the village?	1. Shallow well 4. Pond 2. Deep well 5. Rain water 3. River 6. Other( )
15	Who is mainly in charge of obtaining water in most of the households?	1. Husband 4. Daughter 2. Wife 5. Servant 3. Son 6. Other ( )
16	What kind of container is mostly used for carrying water from the water sources to each household? How do most of the villagers carry the container?	Water container: Multiple Answer 1. Earthen pot 2. Aluminum pot 3. Plastic bucket 4. Other( ) Carrying tool: 1. By hand 2. Handcart 3. Other( )
17	About how many communal and private wells for domestic water use are in the village?	Communal ( ) Private ( )
18	Who takes care of the communal wells?	Multiple Answer 1. Community group → go to Q.18-2, 18-3, 18-4 2. Individual (e.g. care taker) → go to Q.18-3, 18-4 3. Government organization→ go to Q.19 4. None → go to Q.19
18-2	About how many community groups that take care of communal wells are in the	( )groups

	Question	Answer		
	village?			
18-3	What do the community groups (care takers) do? Please answer either yes or no to the following activities. (read the activities)	Activity	Community group	Care taker
		1. Monitoring water withdrawal amount by each user		
		2. Fee collection and other financial affairs		
		3. Water quality test		
		4. Repair of the facility		
		5. Other ( )		
18-4	Are the community group members (care takers) paid for their service?	Community Group	Care taker	
		1. Yes 2. No 3. Some are paid, and some are not	1. Yes 2. No 3. Some are paid, and some are not	
Agricultural Water Use				
19	About how many communal and private wells for irrigation are in the village?	Communal ( ) Private ( )		
20	About how many hours are the irrigation wells in operation per day on average during the irrigation period?	( )hours per day		
21	Who takes care the communal wells for irrigation?	Multiple Answer 1. Community group → go to Q.21-2, 21-3, 21-4 2. Individual (e.g. care taker)→ go to Q.21-3, 21-4 4. Government organization → go to Q.22 5. None → go to Q.22		
21-2	About how many community groups are taking care of the communal wells for irrigation?	( )groups		
21-3	What do the community groups (care takers) do? Please answer either yes or no to the following activities. (read the activities)	Activity	Community Group	Care taker
		1. Monitoring water withdrawal amount/ hours by each user		
		2. Fee collection and other financial affairs		
		3. Water quality test		
		4. Repair of the facility		
		5. Other ( )		
21-4	Are the community group members (care takers) paid for their service?	Community Group	Care taker	
		1.Yes 2.No 3.Some are paid and some are not	1. Yes 2. No 3. Some are paid and some are not	
Arsenic Problems				
22	Are there patients of arsenic poisoning in the village?	1. Yes → go to Q.22-2, 22-3, 22-4, 22-5		

	Question	Answer
		1. No → go to Q.23
22-2	About how many patients of arsenic poisoning are identified in this village?	Total( ) Male( ) Female( )
22-3	When was the first patient identified?	
22-4	About what ratio of the patients has been medically treated? Please answer in either more than 80%, more than 50%, more than 30%, less than 30%, or none.	1. 80%+ 2. 50%+ 3. 30%+ 4. 30%- 5. none
22-5	In the village, was there an incident that the patients were unfairly treated on the following occasions? Please answer either yes or no. (read the sentences)	1. Going to school 2. Eating/drinking at a restaurant 3. Attending village meetings 4. Getting married 5. Getting a job 6. Other( )
23	About how long does it take to go to the nearest medical facility from this village? What transportation means are mostly used? How much would it cost to go to the medical facility by the transportation means?	Travel time from the village: 1. less than 30 min. 2. about 1 - 2 hours 3. about 3 - 5 hours 4. more than 5 hours Transportation means: 1.Rickshaw 2.Auto rickshaw 3.Motorcycle 4.Bus 5.Other ( ) Transportation costs (one way): ( ) Tk.
24	Are symptoms of arsenic poisoning known to the villagers?	1. Yes → go to Q.24-2 2. No → go to Q.25
24-2	Please list visible symptoms. (do not read the answers)	1. Dark spots on skin 2. Wart-like hardening of skin 3. Ulcer 4. Gangrene 5. Other ( )
25	Have village meetings been held to discuss arsenic problems in the village?	1. Yes → go to Q.25-2, 25-3 2. No → go to Q.26
25-2	About how many times have the meetings been held?	( )times
25-3	Based on discussions of the meetings, has any action taken by the community?	1. Yes → go to Q.25-3-2 2. No → go to Q.26
25-3-2	What are the actions? Please answer either yes or no to the following actions. (read the answers)	Multiple Answer 1. Establish a committee to deal with the arsenic problems 2. Invite a knowledgeable person to provide information about causes of and ways to prevent

<table>
<tr><th></th><th>Question</th><th colspan="6">Answer</th></tr>
<tr><td></td><td></td><td colspan="6">arsenic poisoning
3. Ask government organizations / politicians to dig a new well for arsenic-safe water
4. Ask government organizations / NGOs to conduct arsenic test of well water
5. Other ( )</td></tr>
<tr><td rowspan="10">26</td><td rowspan="10">About how many households in the village use the following methods to prevent arsenic poisoning? Please answer in either more than 80%, more than 50%, more than 30%, less than 30%, or none. (read the methods)</td><td rowspan="2">Method</td><td colspan="5">Ratio of Households</td></tr>
<tr><td>80% +</td><td>50% +</td><td>30% +</td><td>30% -</td><td>none</td></tr>
<tr><td>Let water sit in a pot/bucket overnight</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Use arsenic-safe wells</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Use an arsenic removal pot</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Put chemicals in a bucket to deposit arsenic</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Harvest rain water</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Use a pond sand filter</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Boil pond/ river water</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other ( )</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="9">27</td><td rowspan="9">If there are NGOs conducting any of the following activities in the village, please provide information on names of the NGOs. (read the activities)</td><td colspan="3">Activity</td><td colspan="3">Name of NGO</td></tr>
<tr><td colspan="3">1.Arsenic test of well water</td><td colspan="3"></td></tr>
<tr><td colspan="3">2.Diagnosis of patients</td><td colspan="3"></td></tr>
<tr><td colspan="3">3.Dissemination of knowledge about symptoms and causes of arsenicosis</td><td colspan="3"></td></tr>
<tr><td colspan="3">4.Dissemination of information on prevention methods</td><td colspan="3"></td></tr>
<tr><td colspan="3">5.Selling/giving goods to obtain arsenic-free water such as arsenic removal pots and chemical packets</td><td colspan="3"></td></tr>
<tr><td colspan="3">6.Financial assistance for patients of arsenic poisoning</td><td colspan="3"></td></tr>
<tr><td colspan="3">7.Mental assistance for patients of arsenic poisoning</td><td colspan="3"></td></tr>
<tr><td colspan="3">8. Other
( )</td><td colspan="3"></td></tr>
</table>

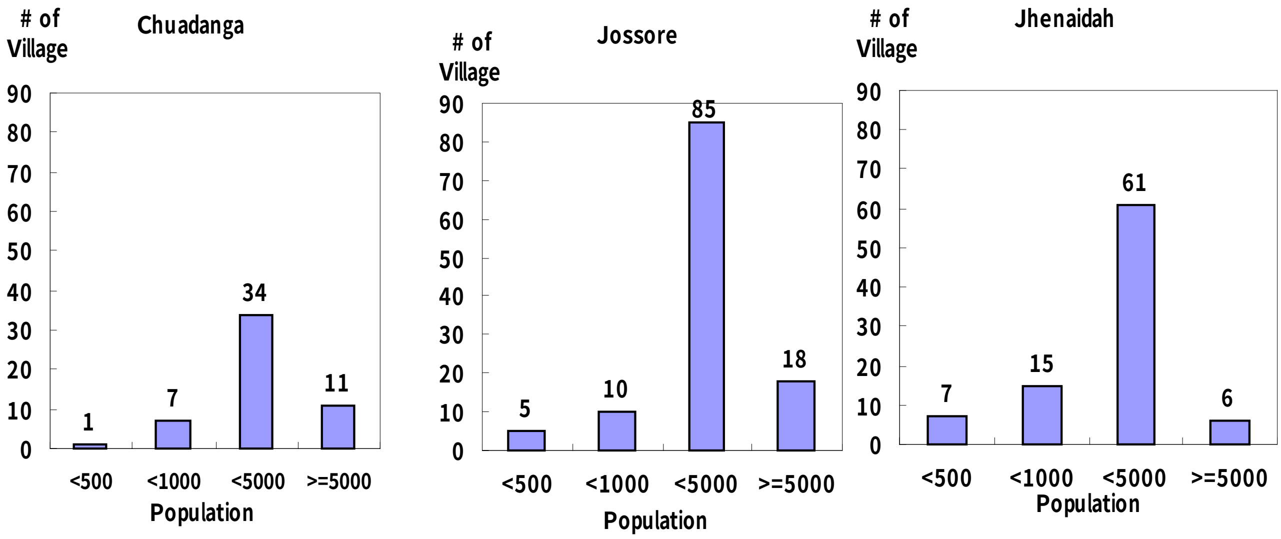
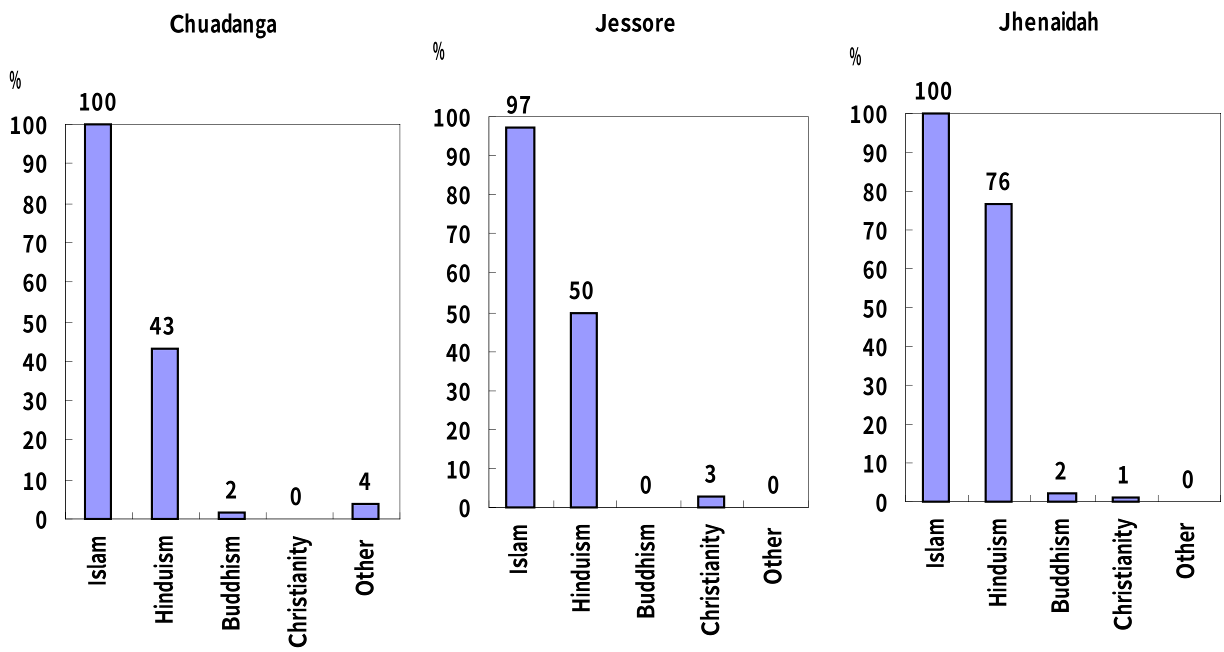
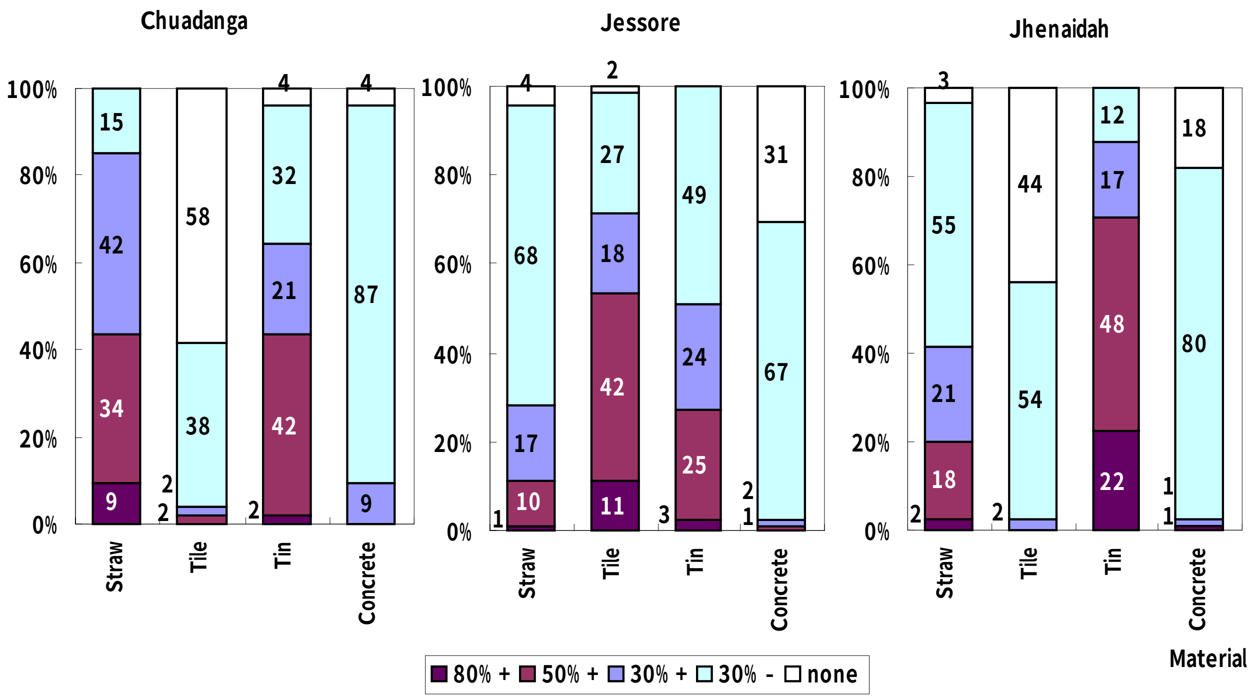


Figure 3.3.1 Population Size of the 260 Villages



Notes: Since there are villages where villagers believe more than one religion, the total figure does not become 100%.

Figure 3.3.2 Ratio of Villages by Religion



Notes: The percentage in the legend reflects the ratio of households using corresponding roof materials.

Figure 3.3.3 Village Ratio by Prevalence of Roof Materials

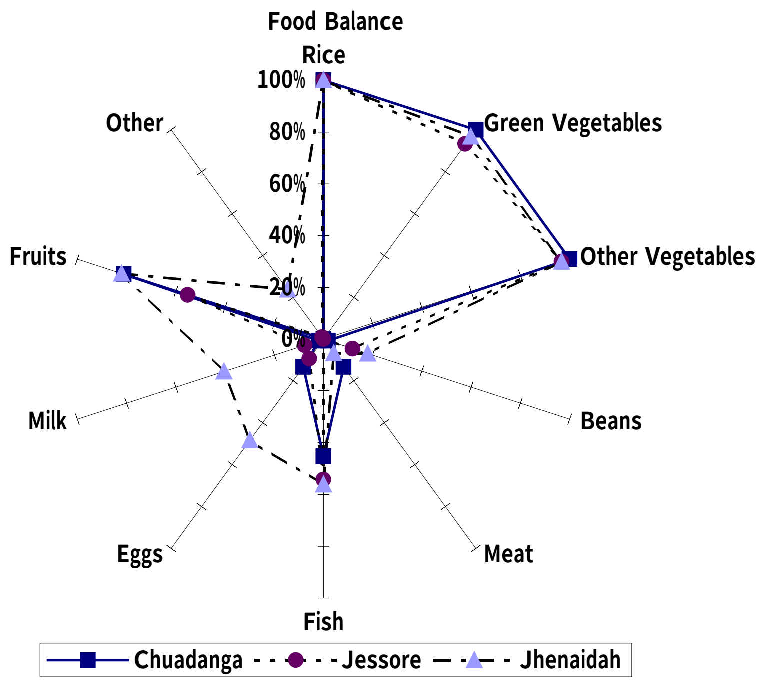


Figure 3.3.4 Ratio of Villages with Daily Food Intake

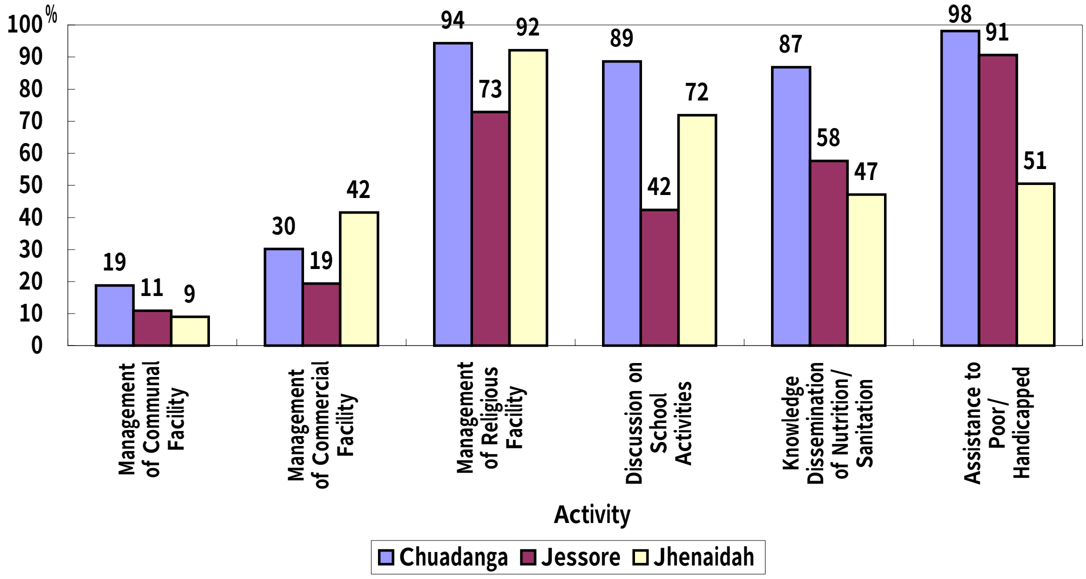
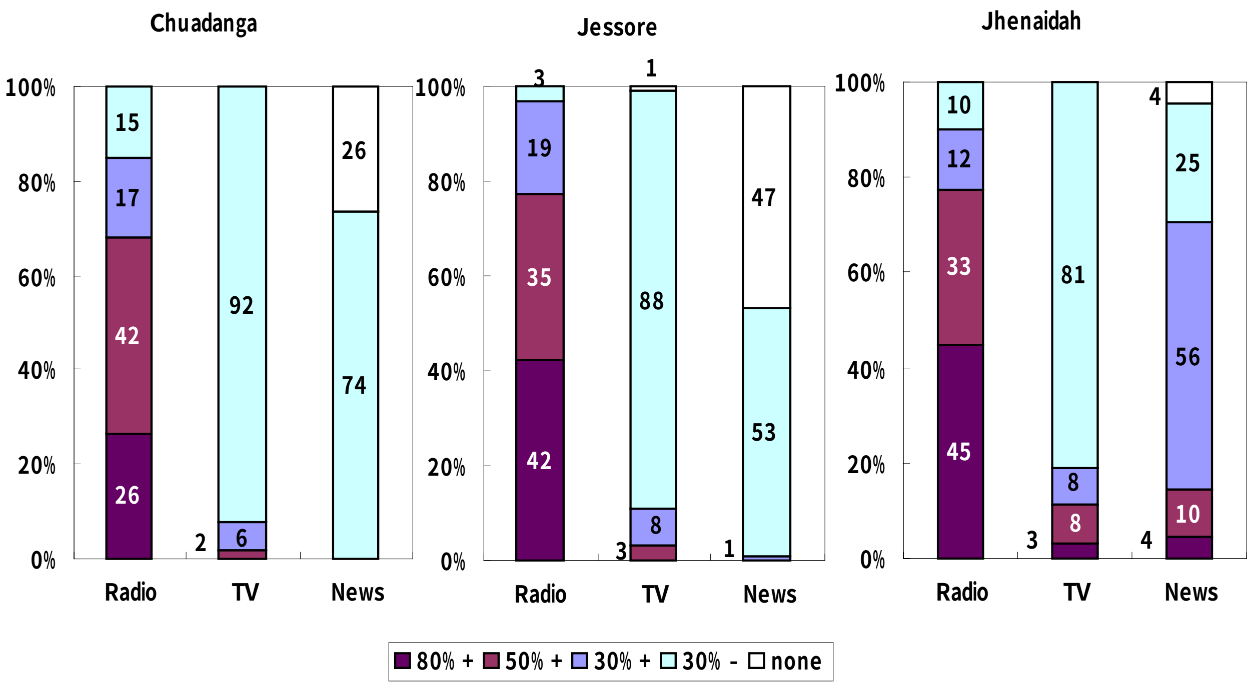


Figure 3.3.5 Ratio of Villages with Community Groups



Notes: The percentage in the legend reflects ratio of households using corresponding roof materials.

Figure 3.3.6 Ratio of Villages with Mass Media

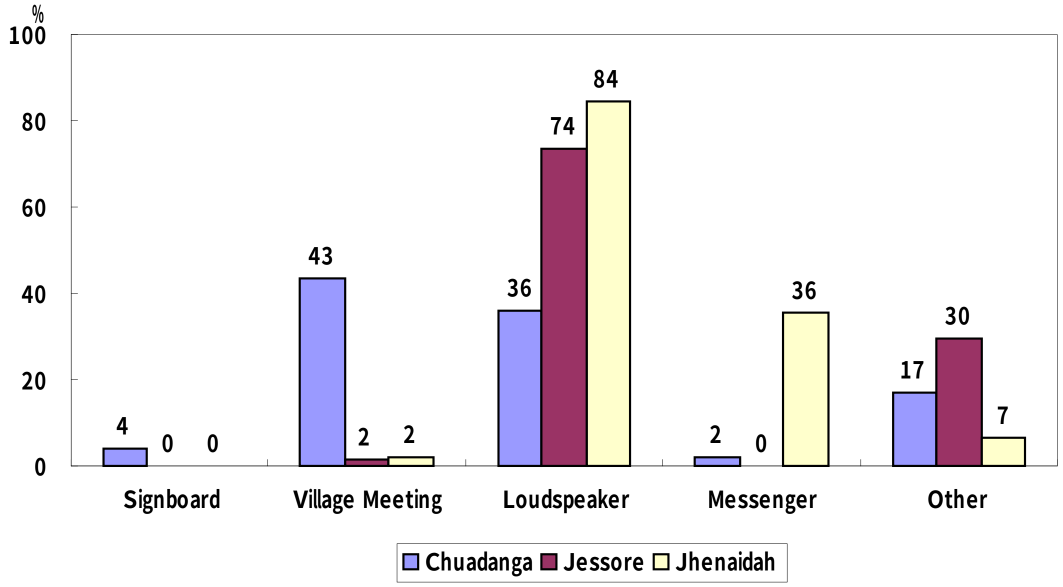


Figure 3.3.7　Ratio of Villages by Common Communication Tools

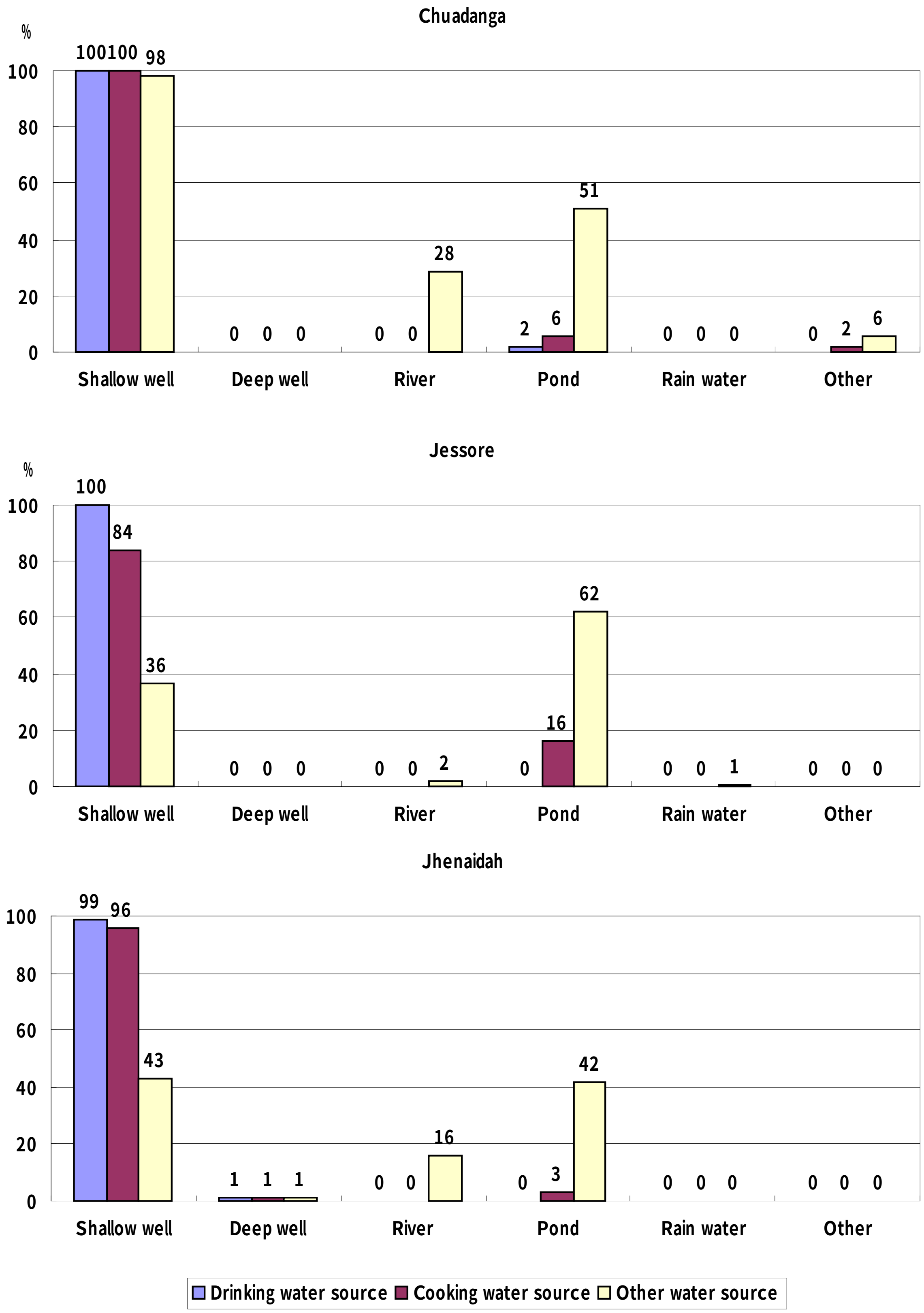


Figure 3.3.8 Main Sources of Water

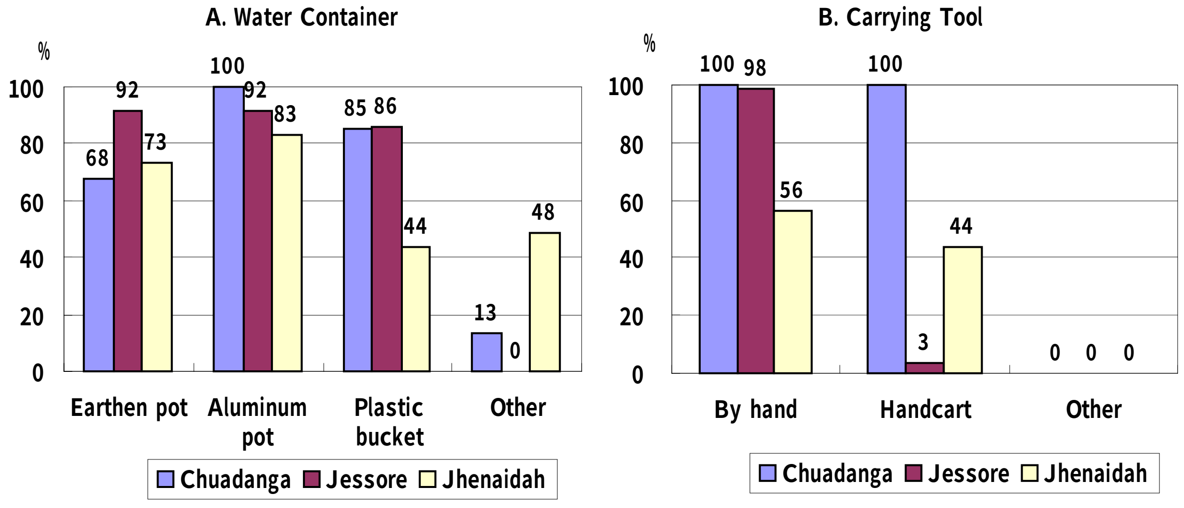


Figure 3.3.9 Water Container & Carrying Tool

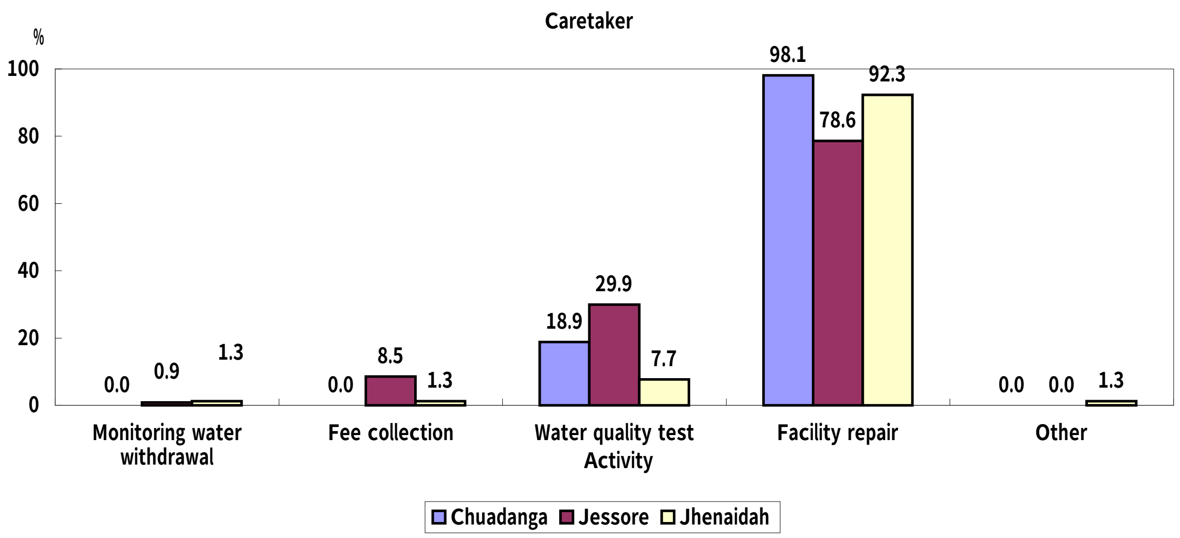


Figure 3.3.10 Activity of Caretaker (Communal Wells for Domestic Water Use)

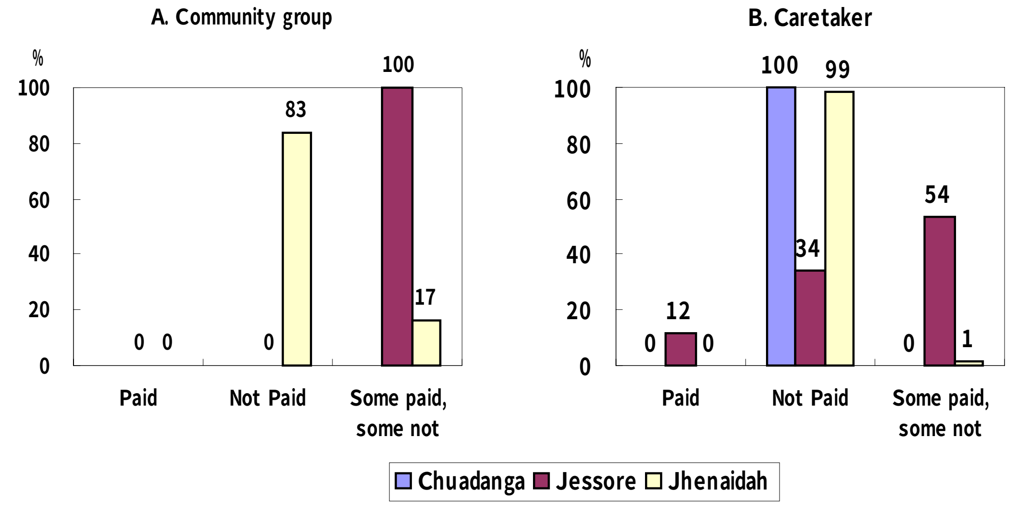


Figure 3.3.11 Reward to Management (Communal Well for Domestic Water Use)

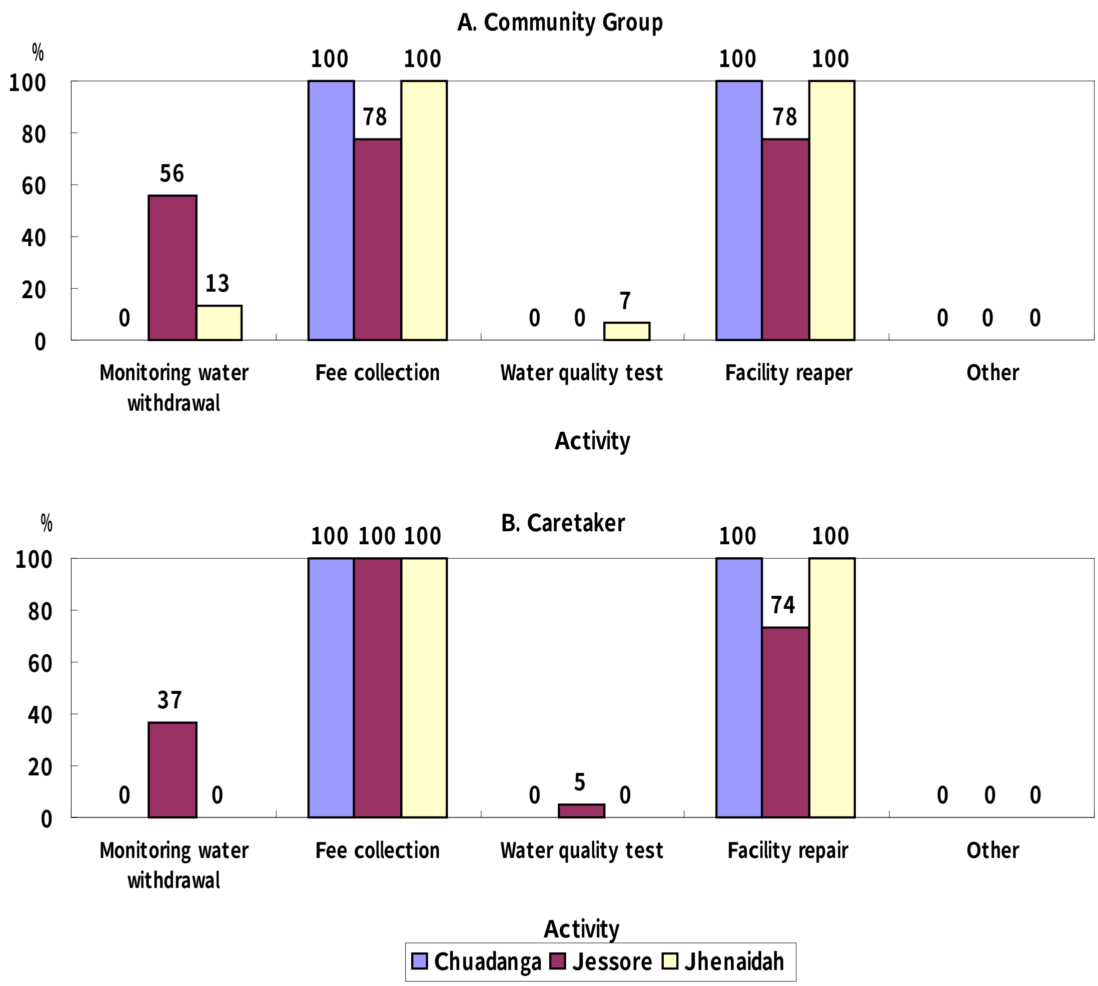


Figure 3.3.12 Activity of Community Group/Caretaker (Communal Wells for Agricultural Use)

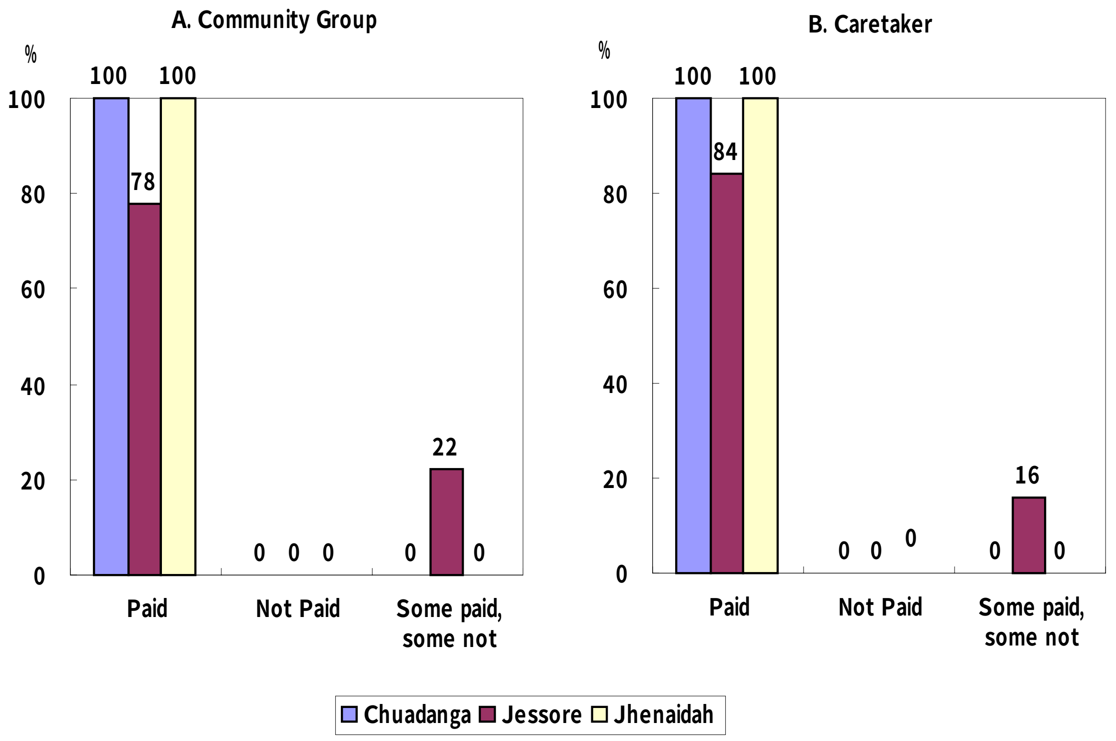
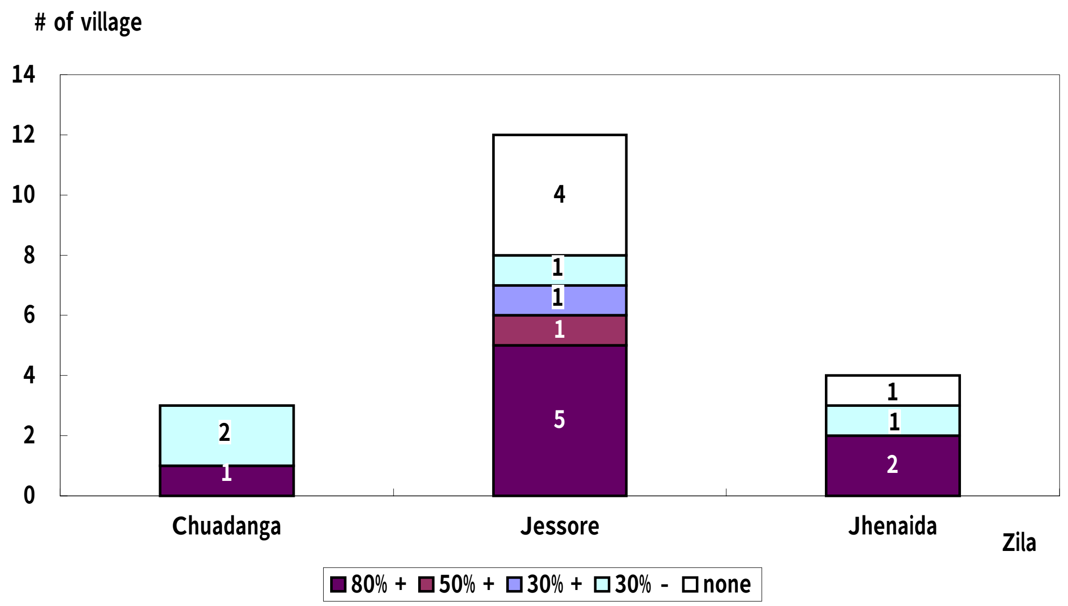


Figure 3.3.13 Reward to Management (Communal Wells for Agricultural Use)



Notes: The percentage in the legend indicates the ratio of arsenic patients who have been medically treated.

Figure 3.3.14 Medical Treatment of Arsenic Patients

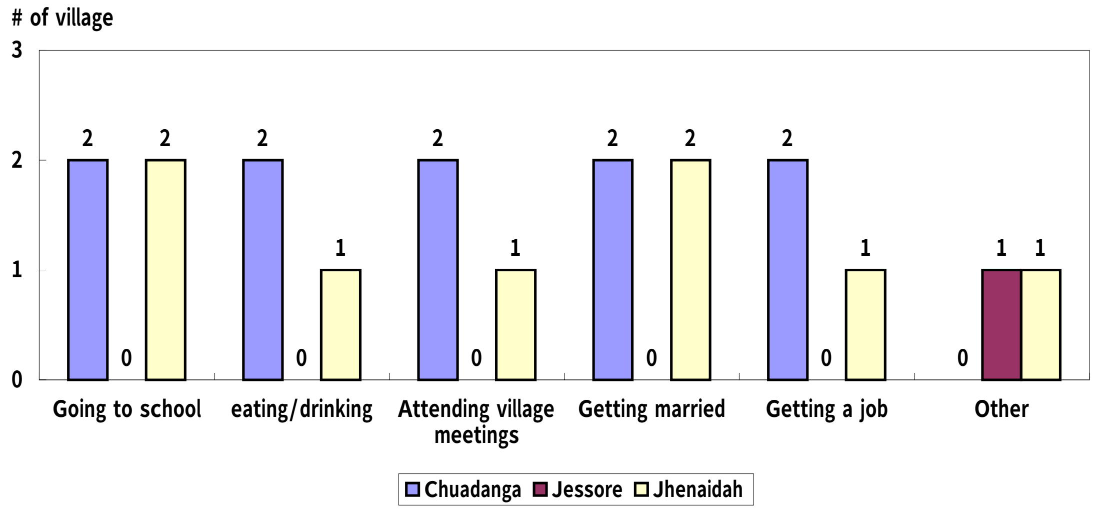


Figure 3.3.15 Unfair Social Attitude toward Arsenic Patients

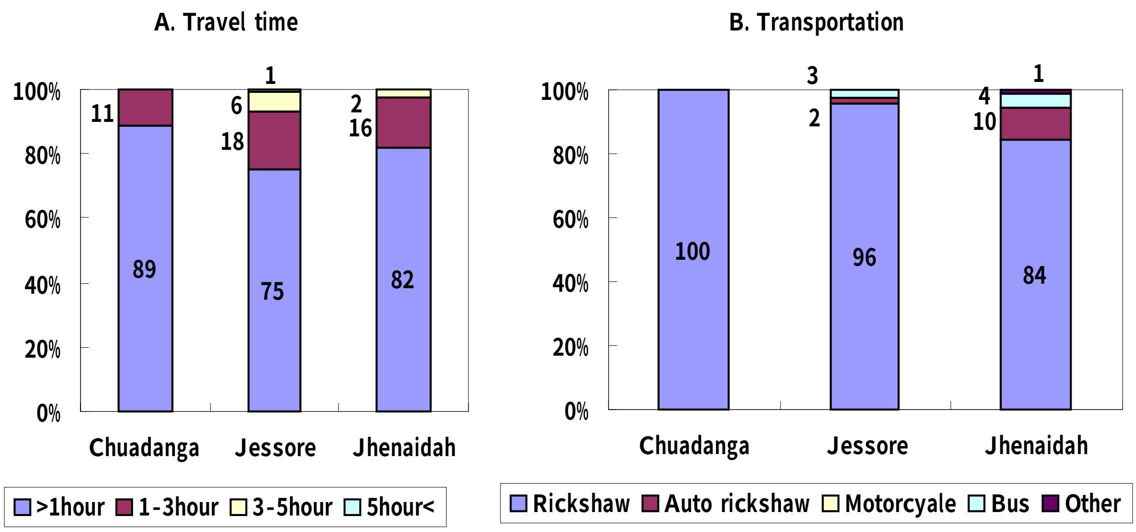


Figure 3.3.16 Access to the Nearest Medical Facility

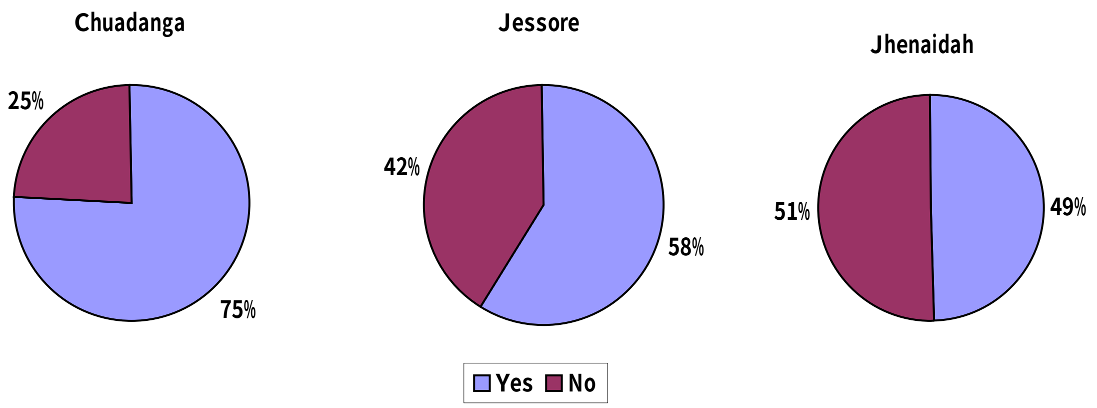
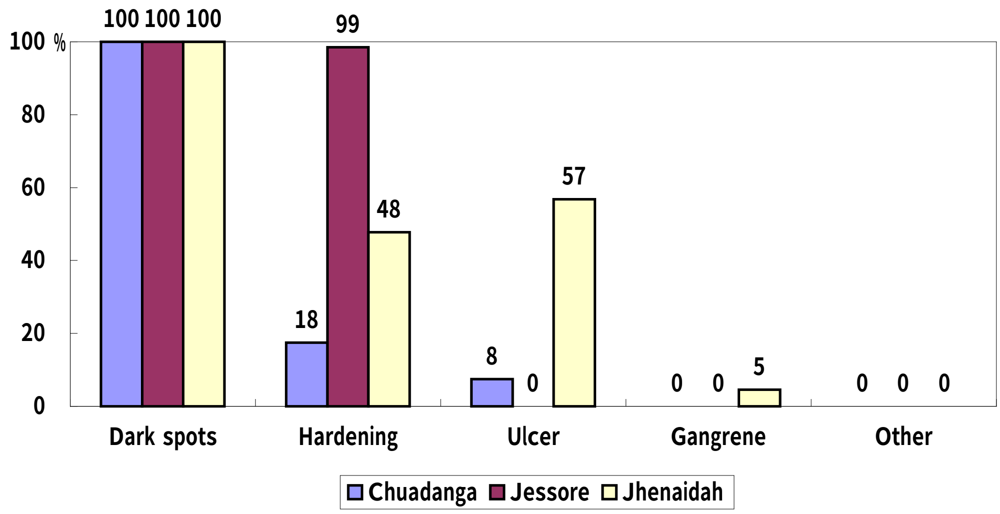
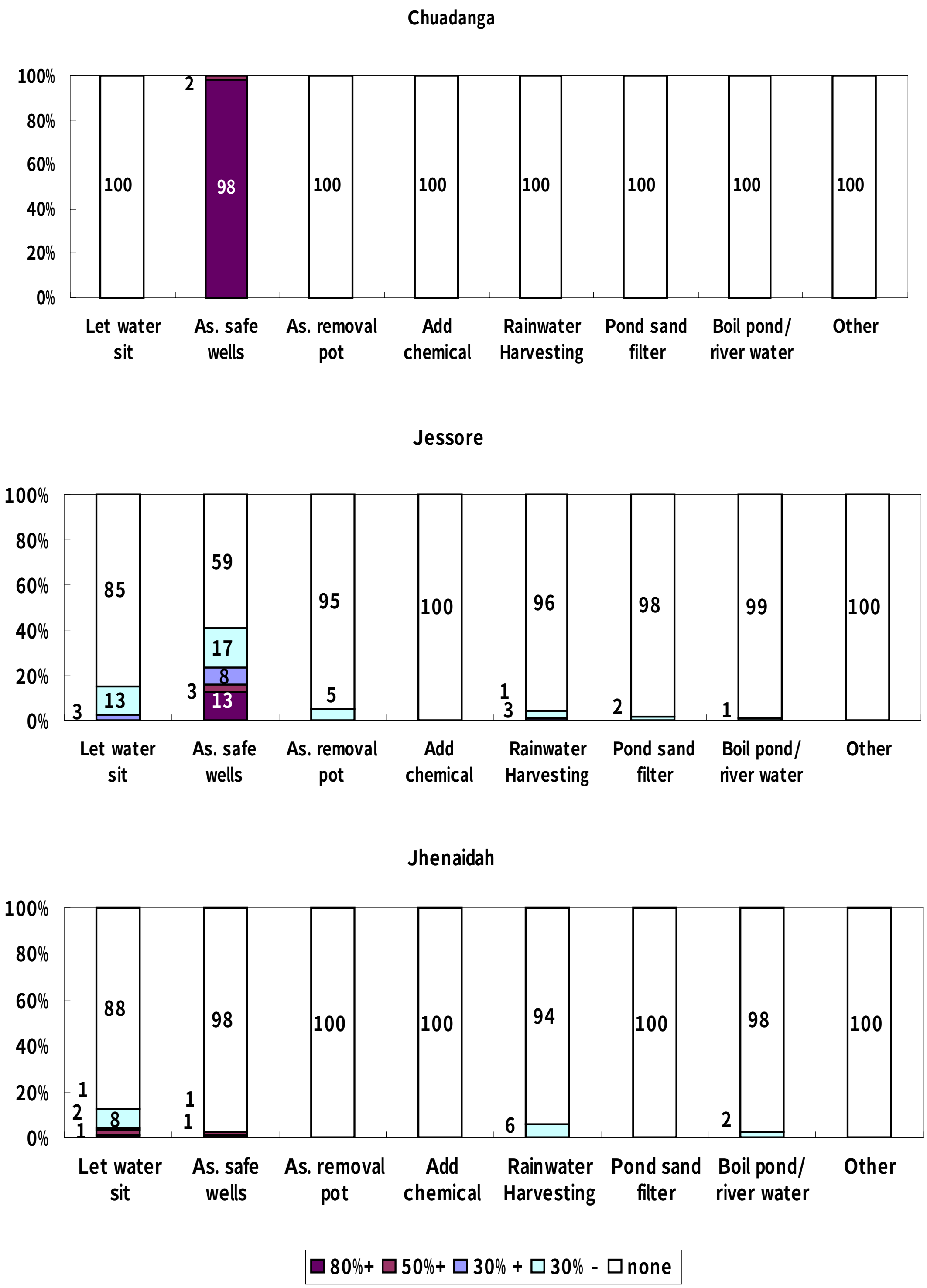


Figure 3.3.17 Knowledge about Symptoms of Arsenic Poisoning



Notes: The question was asked only to the interviewees who answered "Yes" to the above question.

Figure 3.3.18 Known Symptoms of Arsenic Poisoning



Notes: The percentage in the legend indicates the ratio of household practicing the corresponding activity.

Figure 3.3.19 Actions to Obtain Arsenic Safe Water

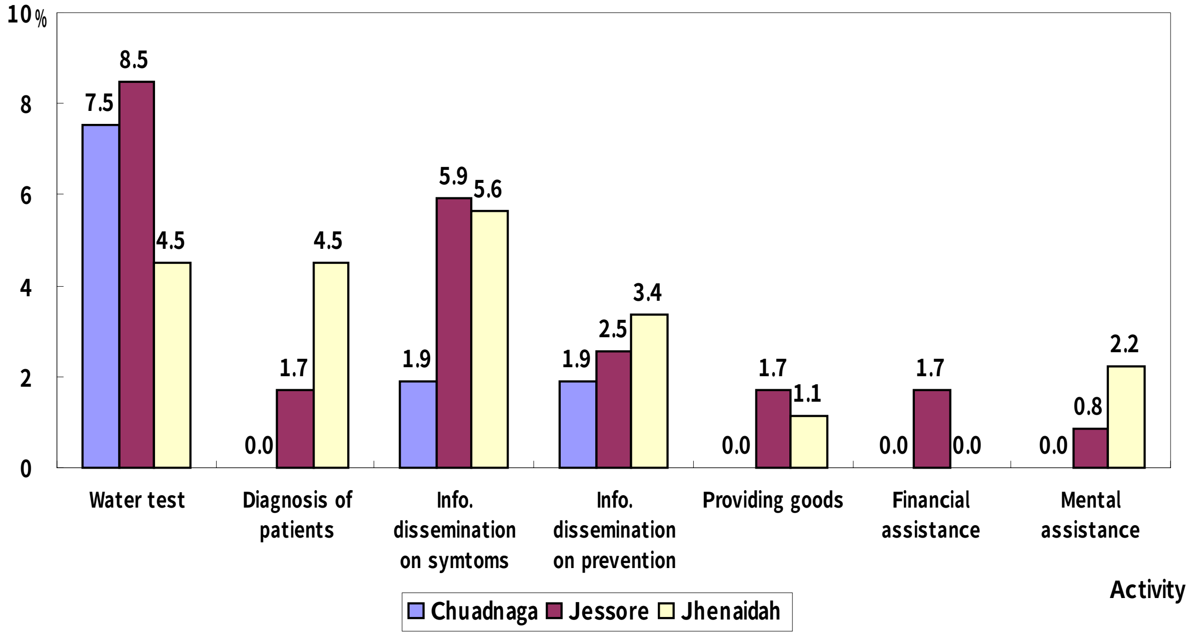


Figure 3.3.20 Villages with NGOs Activity related to Arsenic Problems