# CHAPTER 1

# INTRODUCTION

# 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 depends 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 researchers from Jadapur University in Calcutta were studying this problem, doctors from 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, NGOs, 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 a 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, the 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-year 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 the arsenic mechanism in groundwater resources, nor implemented any concrete countermeasures.

To determine a 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 NGOs. 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 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 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 third phase.

**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)

## 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 on the right side of the Ganges River (the Padma River in Bangladesh). It comprises an area of 5,686$km^2$ and lies between 22o 80’ and 23o 80’ north latitude, and between 88o 60’ and 89o 50’ east longitude (see Location Map).

The District is administratively subdivided into Thanas, Unions and Mouzas. The population of these three Districts and eighteen Thanas are shown in Table 1.1 The study area is made up of 197 Unions and 2,620 Mouzas with a total population of about 5,088,000.

## 1.4 Study Implementation

This study was 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. Ikkei Ishizuka | Survey and Mapping Supervision (2) |
| Mr. Masahiko Ikemoto | Coordination |

# *CHAPTER 2*

# *NATURAL ENVIRONMENT OF THE STUDY AREA*

*Summary Report*

# CHAPTER 2 NATURAL ENVIRONMENT OF THE STUDY AREA

## 2.1 Climate

### 2.1.1 Overview of Climatic Conditions

1) Precipitation

The distribution of the average monthly precipitation in Bangladesh is shown in Figure 2.1.1. It is common that the monthly precipitation in June, July and August are high in Bangladesh, however, the maximum monthly precipitation does not exceed 400 mm in Jessore, Khulna, Rajshahi and Dhaka. The pattern of the average monthly rainfall in Jessore is similar to that of Khulna, but it is different from Rajshahi where July has a clear peak of monthly precipitation.

2) Temperature

Figure 2.1.2 shows the distribution of the average annual temperature in Bangladesh with graphs of the average monthly mean and the maximum and minimum temperatures at selected stations. The lowest average annual temperature is 24.8 ºC in Sylhet and the highest average annual temperature is 26.6 ºC in Khulna. The study area is located in a relatively high-temperature zone in the country; the average annual temperature ranges from 26.0 to 26.4 ºC. The graph of the monthly average temperature in Jessore is characterized by the clear peaks of the monthly average maximum temperature in March, April and May; indicating hot and dry weather in the latter part of the dry season.

3) Potential Evapotranspiration (PETP)

Figure 2.1.3 shows the distribution of the average annual PETP with graphs of the average monthly PETP and average monthly precipitation at selected stations. The average annual PETP values range from 1,450 mm in the northeastern part to 1,850 mm in southwestern Bangladesh. The average annual PETP value in the study area is estimated to be from 1,750 to 1,850 mm. According to the data at the Jessore stations, the average monthly precipitation exceeds the average monthly PETP only from June to September.

### 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. Daily rainfall data have been recorded at 1 station in Chuadanga district, 3 stations in Jhenaidah district, and 4 stations in Jessore district. Evaporation data are only recorded at the Jessore stations.

#### 1) Rainfall

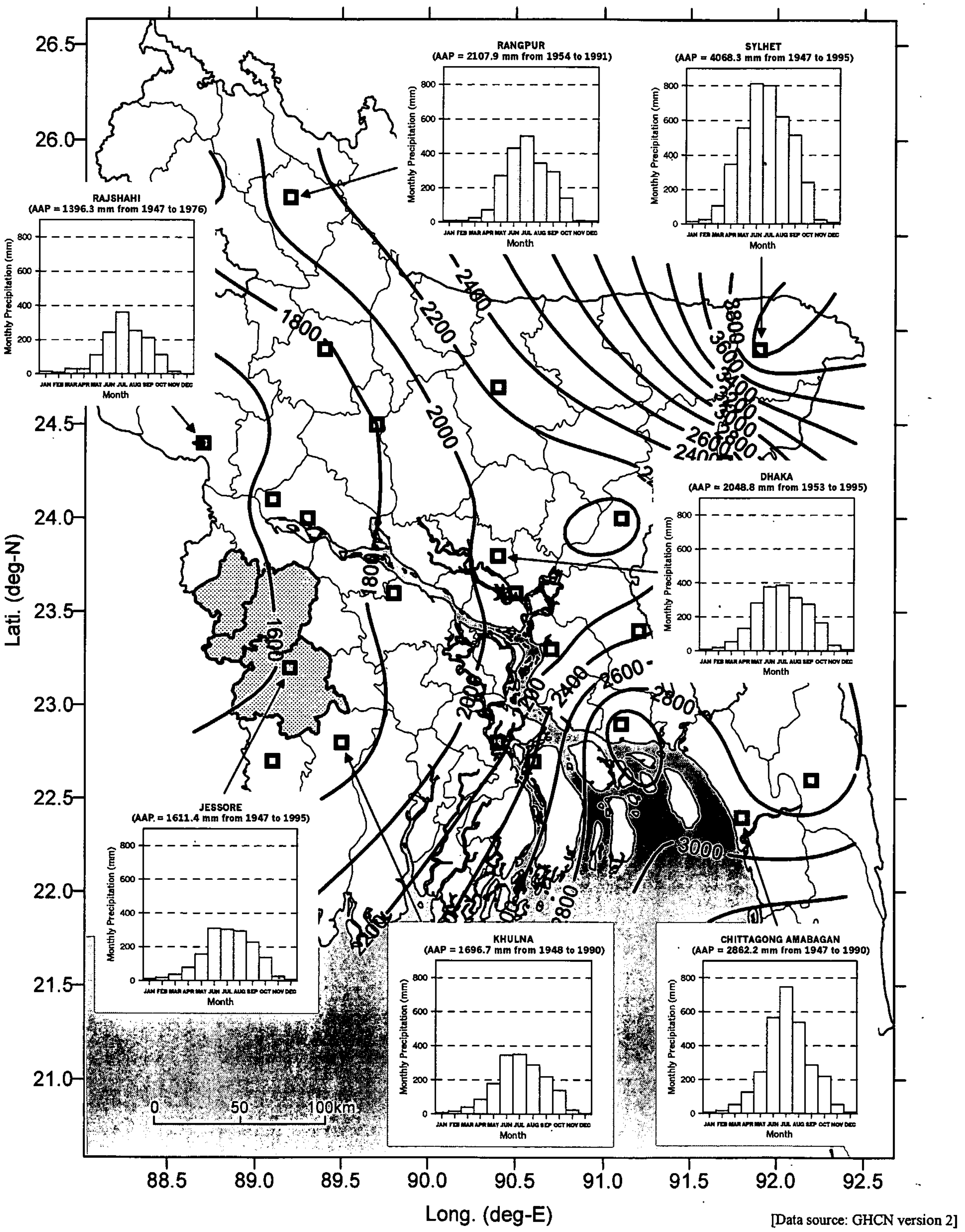
Figure 2.1.4 shows the distribution of the average annual rainfall in the study area. The blue contour lines indicate the average annual rainfall from 1991 to 1994. The red contour lines show the distribution based on the data from 1988 to 1999 with some missing data. The figure shows that the central 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.

The average monthly rainfall is presented in Figure 2.1.5. The monthly rainfall is clearly high in the rainy season from May to October. In Chaugacha and Kaliganj, rainfall in July is greater than that of other stations.

#### 2) Evaporation

At Jessore stations, the month of April has the highest average evaporation of 113.1 mm/month. The lowest evaporation is 48.6 mm/month recorded in January. The monthly average values of daily evaporation in January and April are 1.6 and 3.8 mm, respectively.

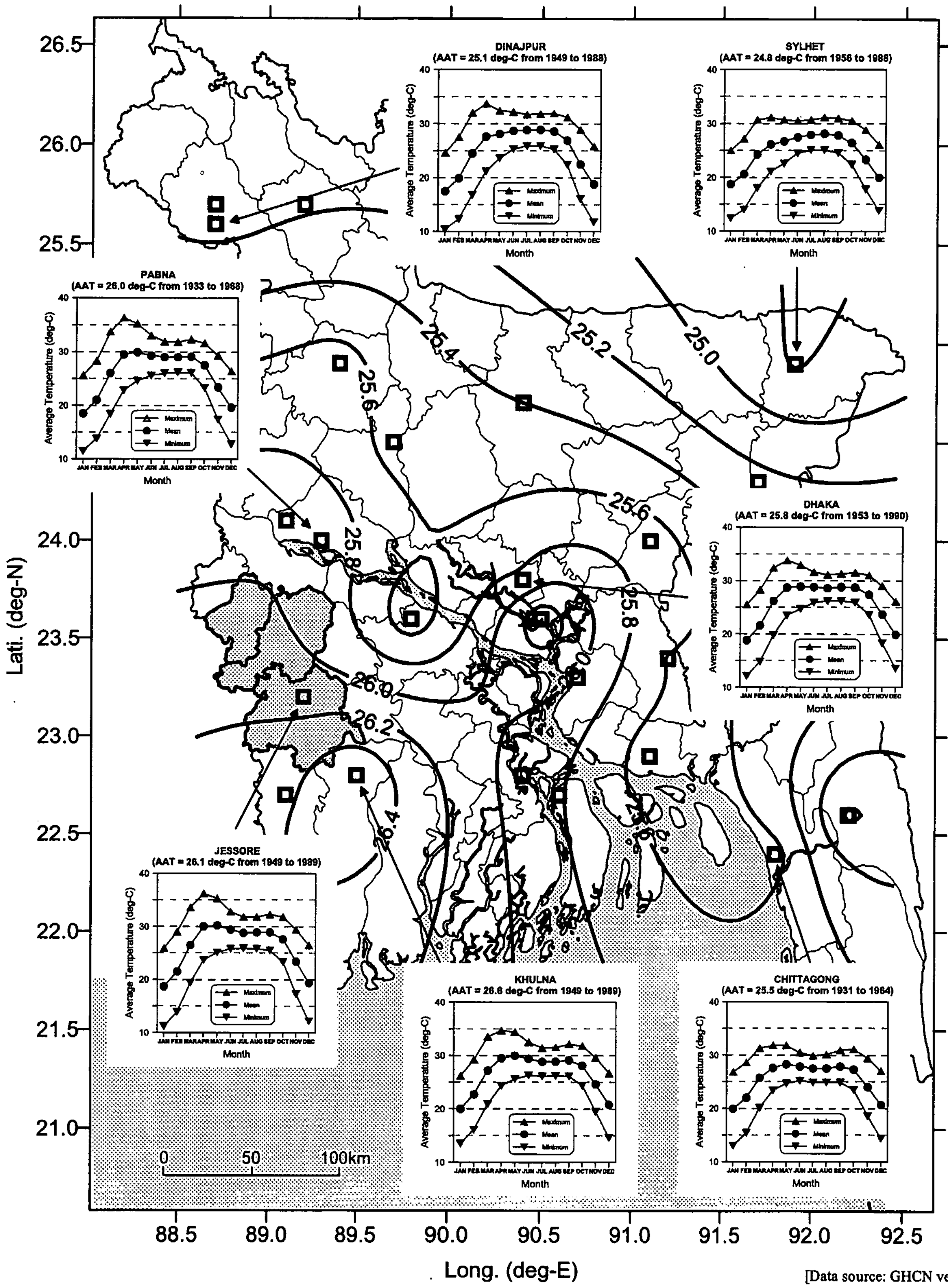
Figures 2.1.6 shows the daily rainfall and daily evaporation in Jessore from 1993 to 1994. It is seen that the daily evaporation is influenced by the occurrence of daily rainfall. The daily evaporation in the hot and dry period from April to May rises up to 5 mm/day.




[Data source: GHCN version 2]

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

| Figure 2.1.1 | 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 2.1.2 | Average Monthly Temperature in Bangladesh |
|---|---|

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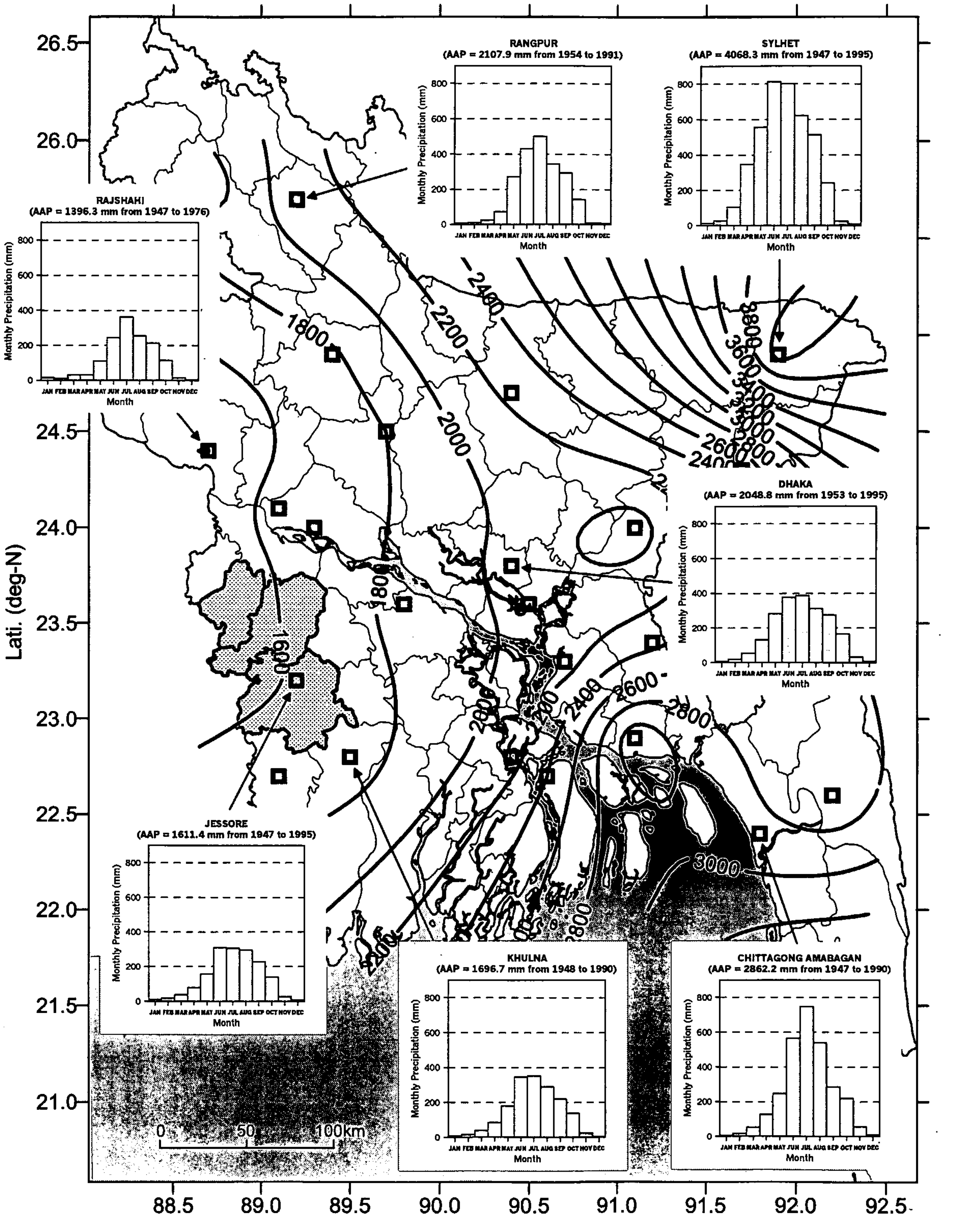


[Data source: GHCN version 2]

**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 | |
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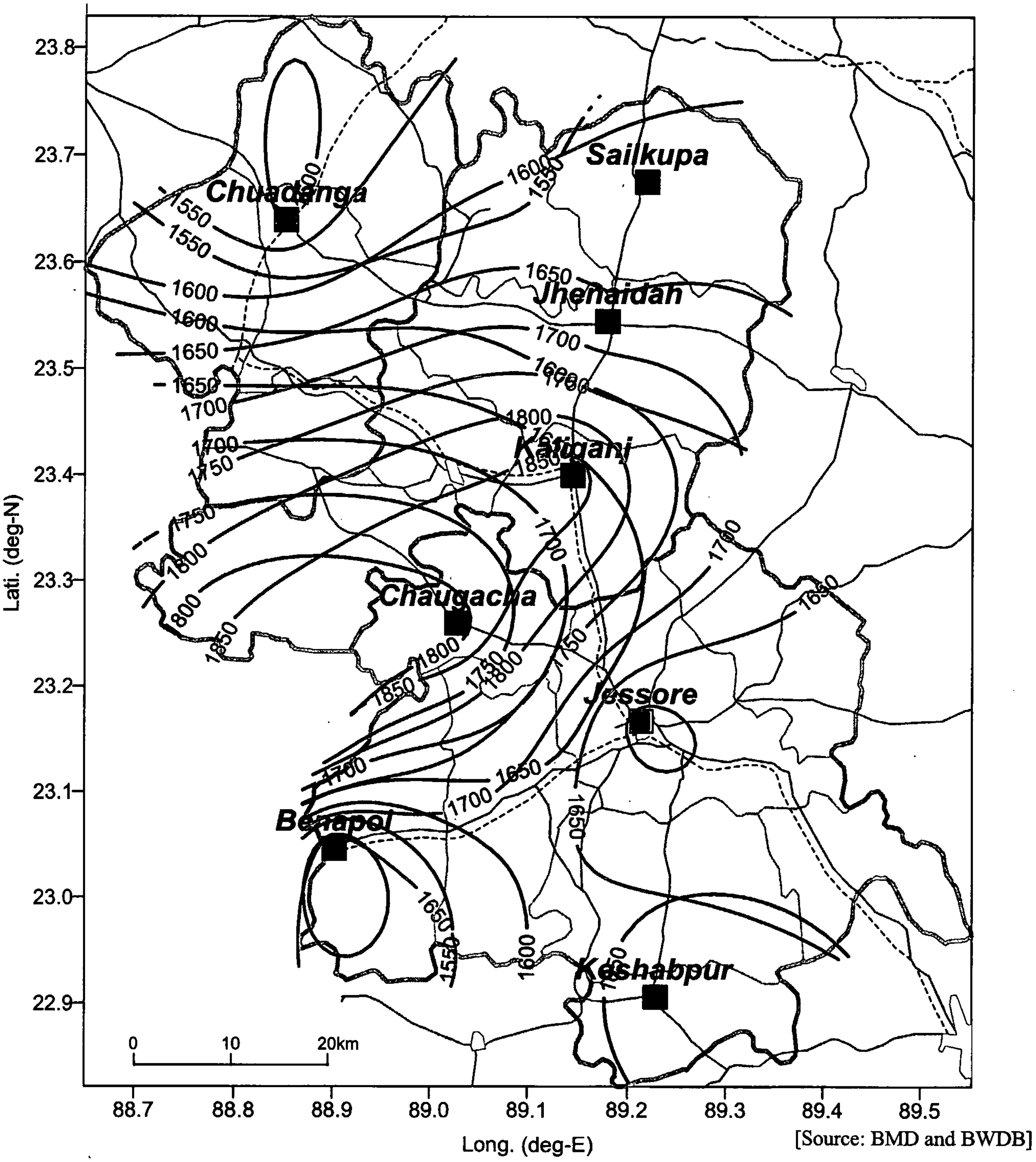


[Source: BMD and BWDB]

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 2.1.4 | 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 | |
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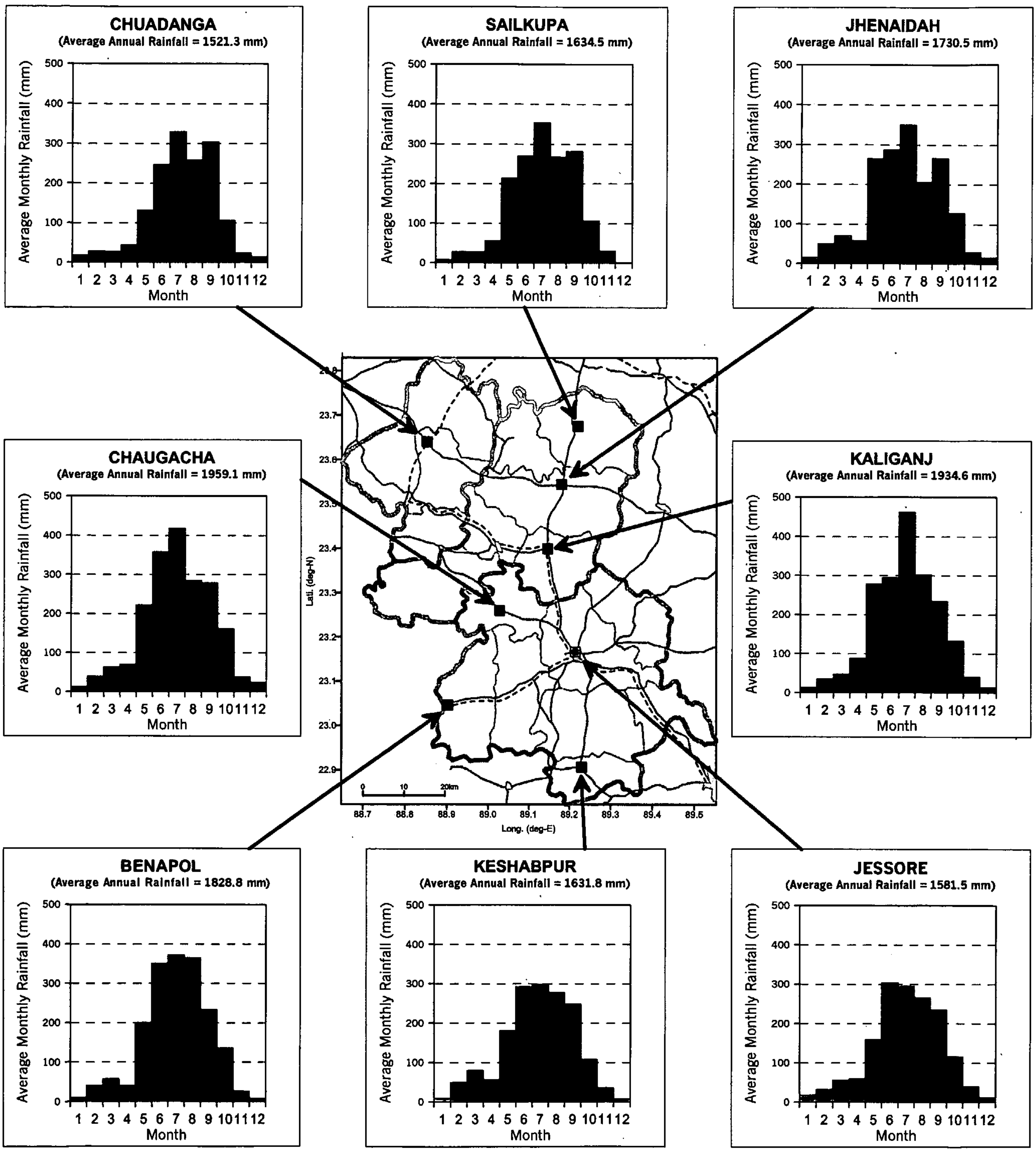


[Source: BMD and BWDB]

■ Rainfall Station

■ Rainfall & Evaporation Station

| Figure 2.1.5 | 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

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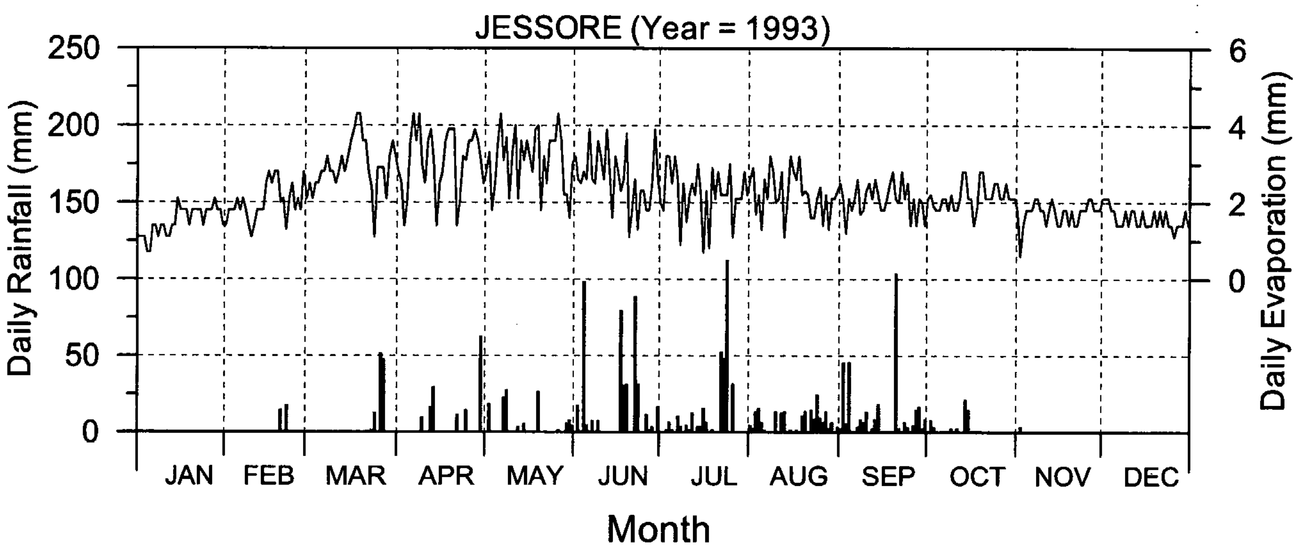
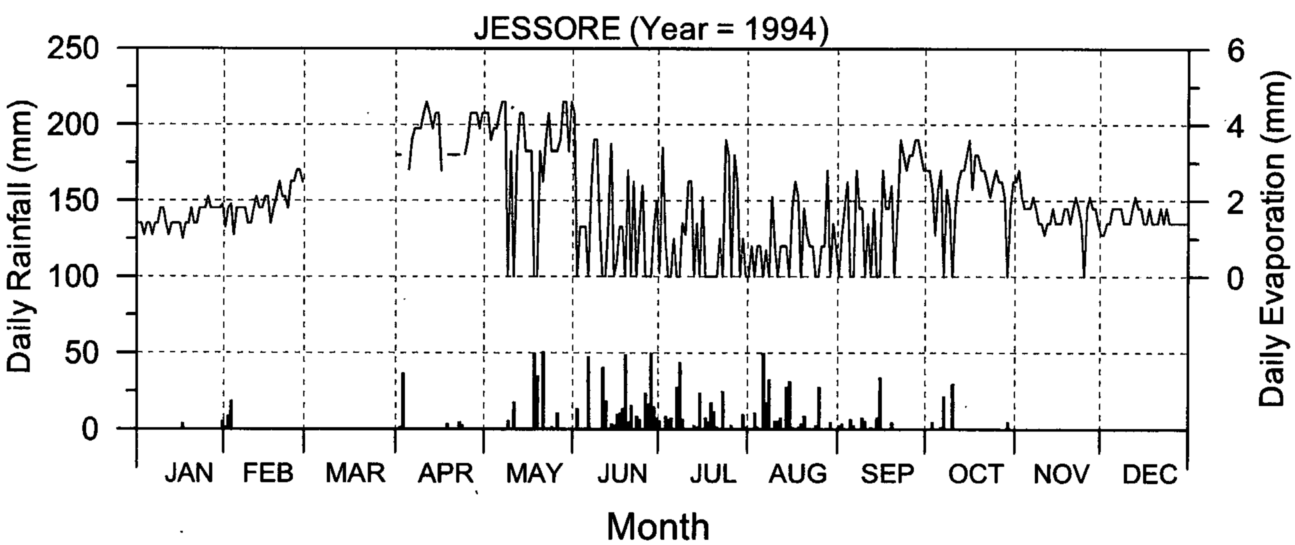



[Data Source: BMD & BWDB]

LEGEND

Rainfall

Evaporation

**Figure 2.1.6**

**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 in Nawabganj and Rajshahi districts. Then it 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 southern part of Munshiganj and then flows to the Bay of Bengal.

The rivers and water bodies in the Study Area are shown in Figure 2.2.2. The rivers 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 in 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 is possible that flow rates of some rivers might have been reduced because those rivers have been 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)

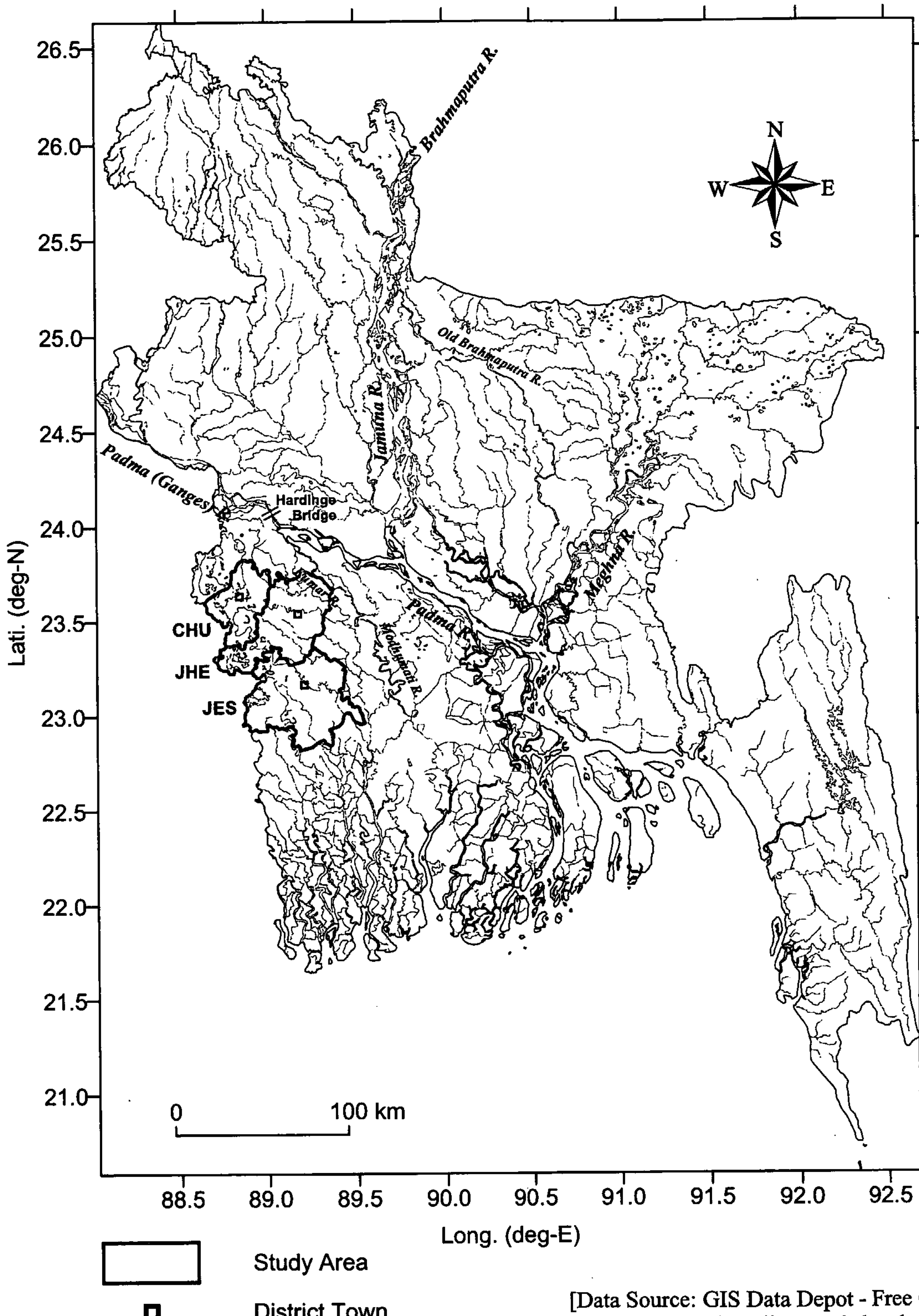
| Period | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1934-1974 | 3090 | 2668 | 2287 | 2031 | 2176 | 4489 | 17290 | 38348 | 36063 | 17870 | 7091 | 4180 | 11685 |
| 1974-1988 | 1932 | 1482 | 1155 | 1063 | 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

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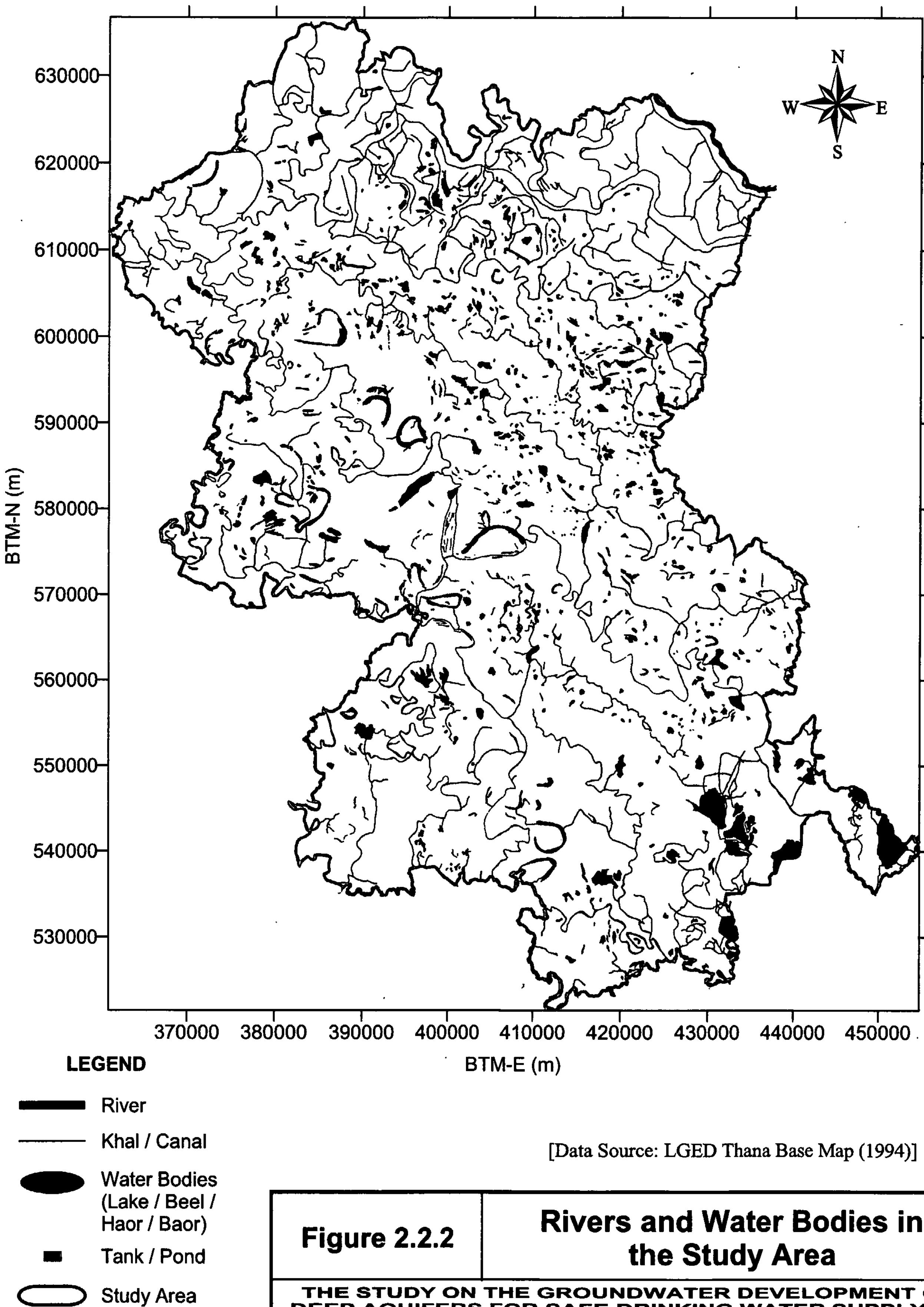
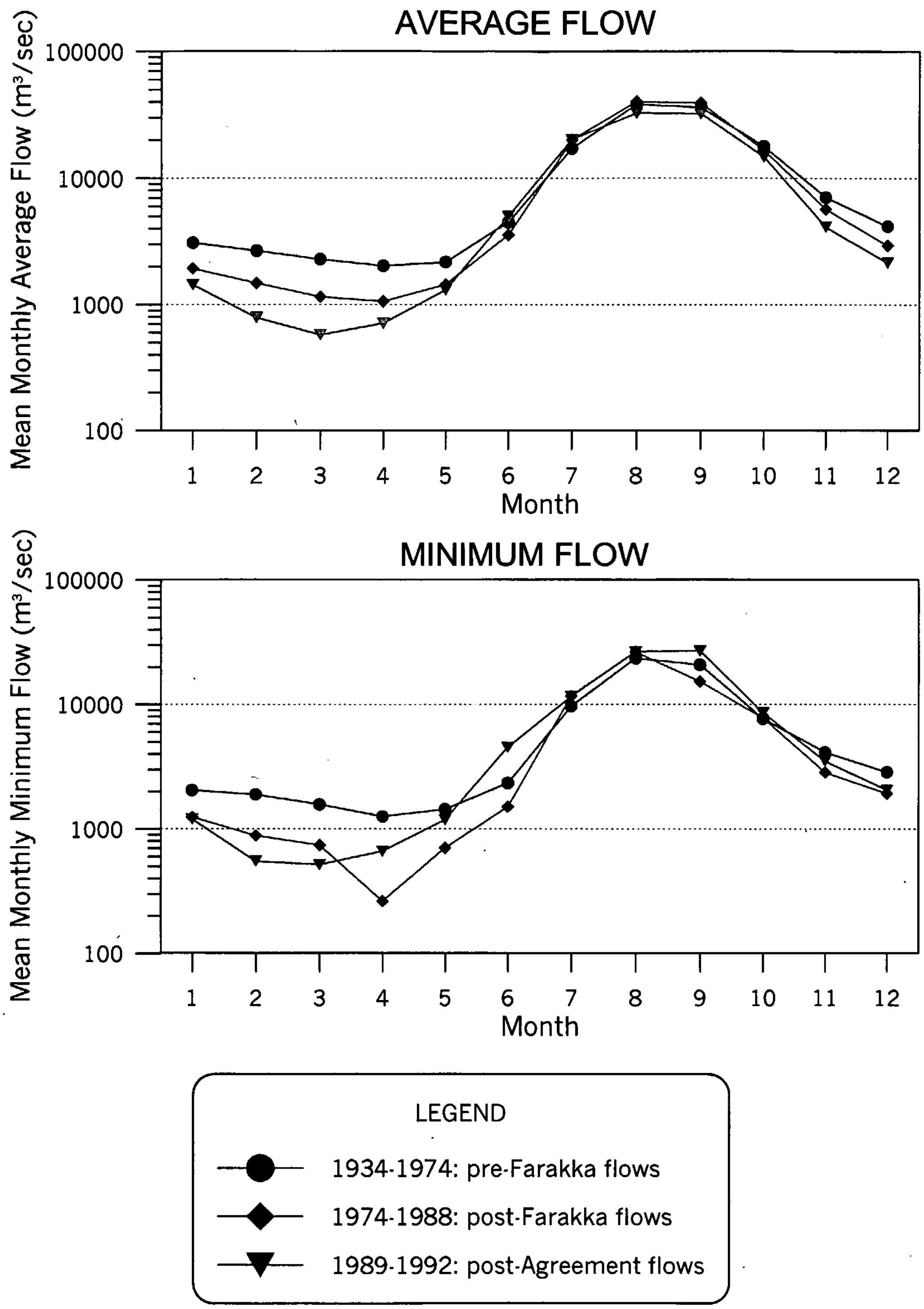



| Figure 2.2.2 | Rivers and Water Bodies in the Study Area |
|---|---|

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 | |
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## 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. 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 5masl.

### 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 the 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 the 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 in 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: Gray 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.

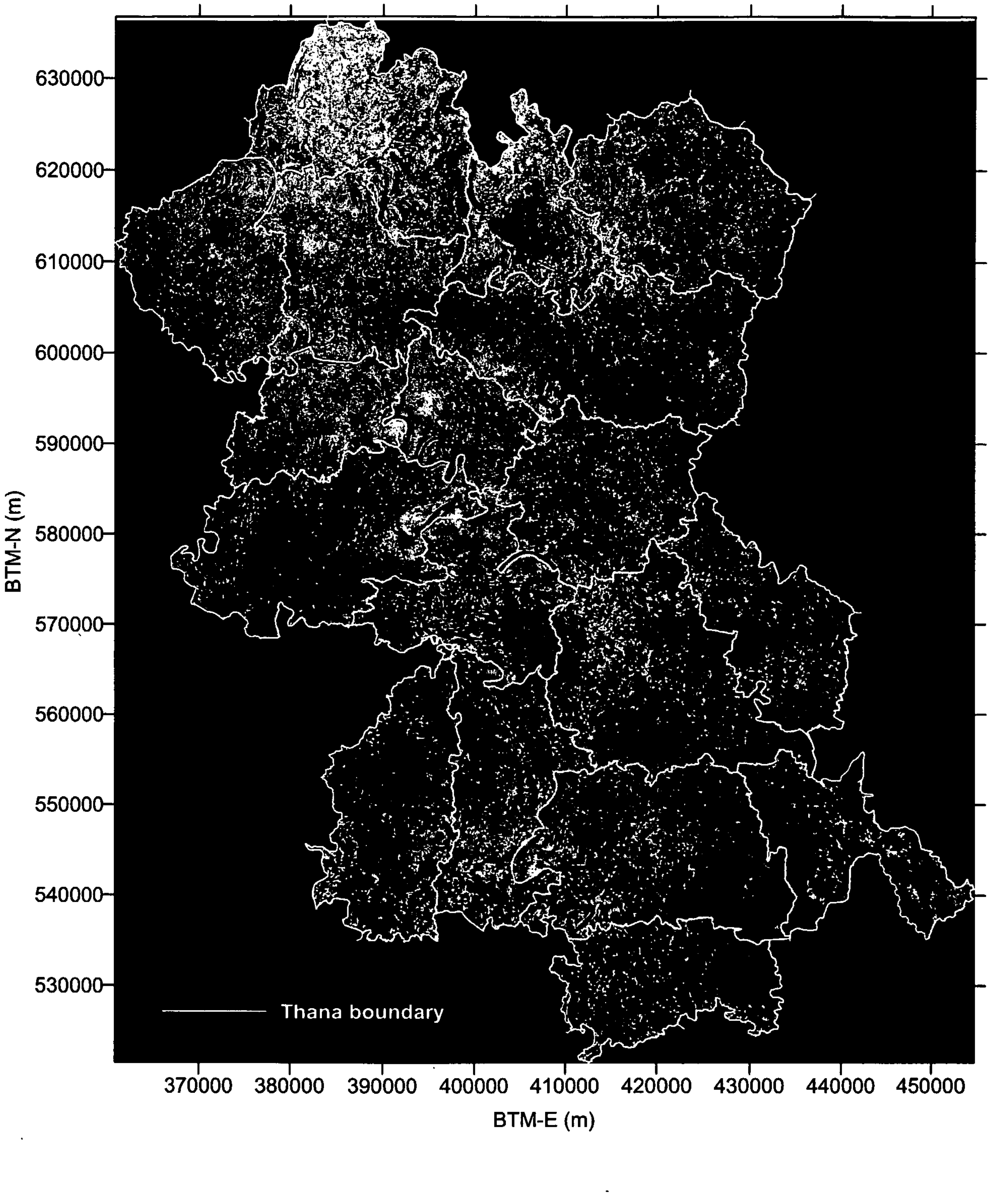
### 2) Subsurface Geology

The subsurface geology is not fully understood in the study area. It is reported by Umitsu (1987) that the alluvial sediments shallower than 30 m in depth in the northwestern part of the Ganges Delta is divided into an upper silty layer and a lower sandy layer. The upper layer has a thickness of 8 to 10 m 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 N value ranging from 15 to 45. Umitsu (1987) also reported that the upper layer occasionally contains peaty silt layers. At Dewlatpur located about 8 km northwest of Khulna city, Umitsu (1987) reported that the alluvial sediments within a 50 m depth 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 46 m 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 to be 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 100 ft from the ground surface throughout the district. The thickness of the clay/silt layer ranges from 20 to 100 ft. 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 goes down toward the southwest. The fine sand layer is underlain by a medium sand layer. The medium sand layer has a thickness ranging from 50 to 200 ft. In some areas, several very fine sand layers are intercalated in the medium sand layer. The medium sand layer is underlain by a coarse sand layer. The boundary between the medium sand layer and coarse sand layer exists at depths of 350 to 450 ft. The coarse sand layer contains gravel in some areas; therefore, it is called a “stone layer”. In Jhenaidah town, the gravel is well rounded and is 3 to 4 cm in diameter.

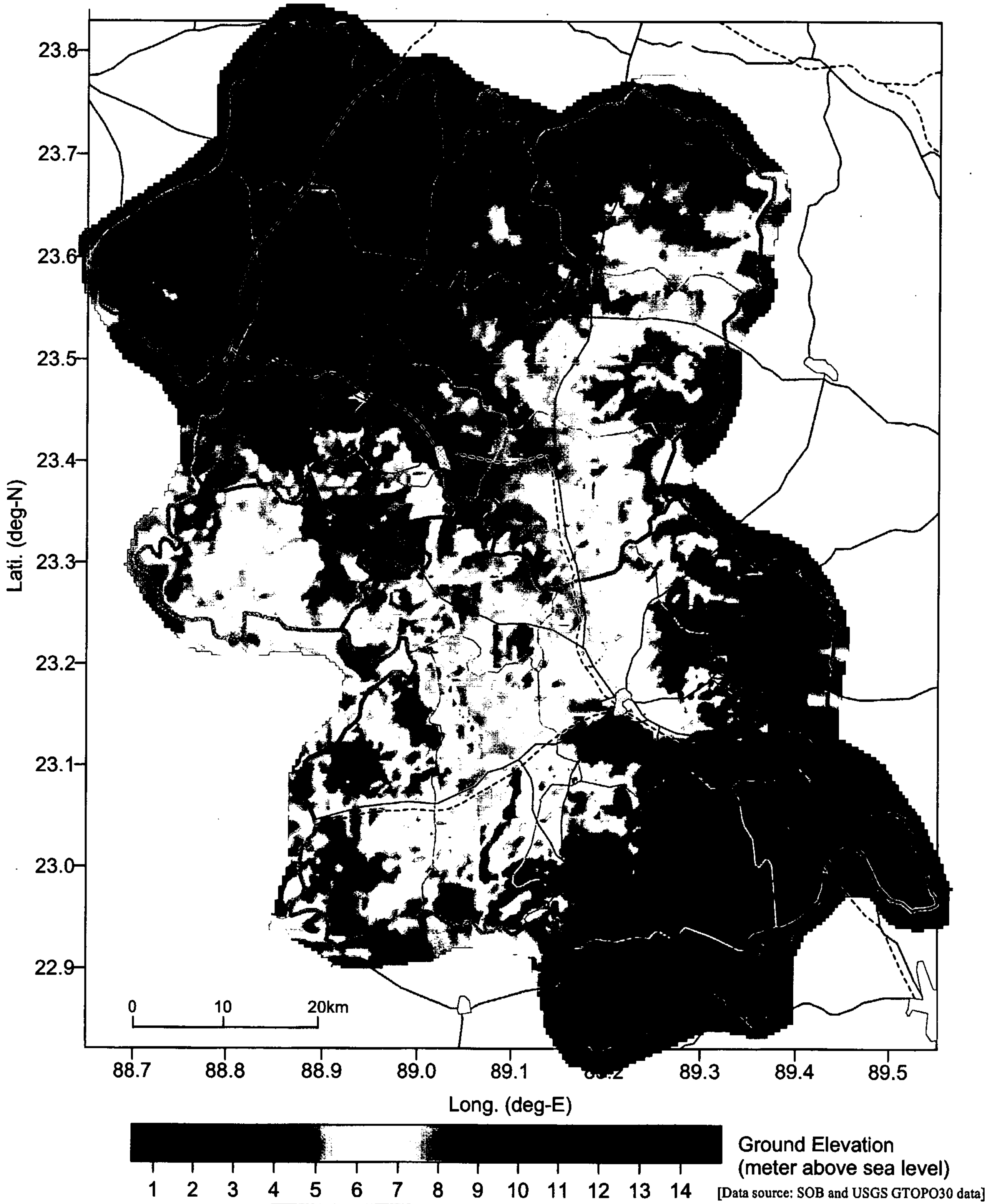
Figure 2.3.5 shows the geological profiles in Jessore District. The shallow clayey layer occurs in the district with a thickness of 10 to 50 ft. The subsurface geology in Jessore District characterized by a thick clayey layer occurs in the southern part. The clayey layer occurs below depths of 200 to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




| 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

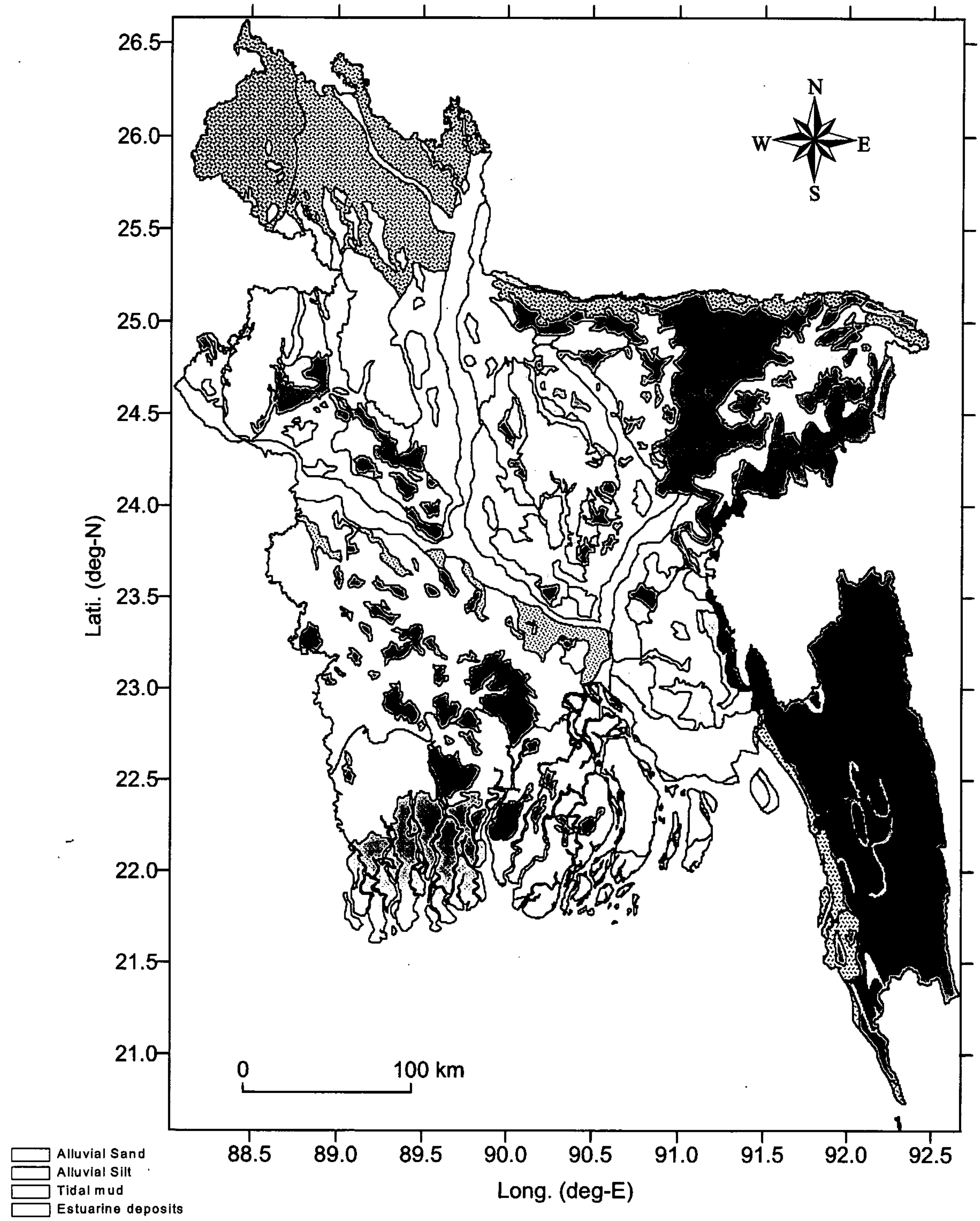
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)




| 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)

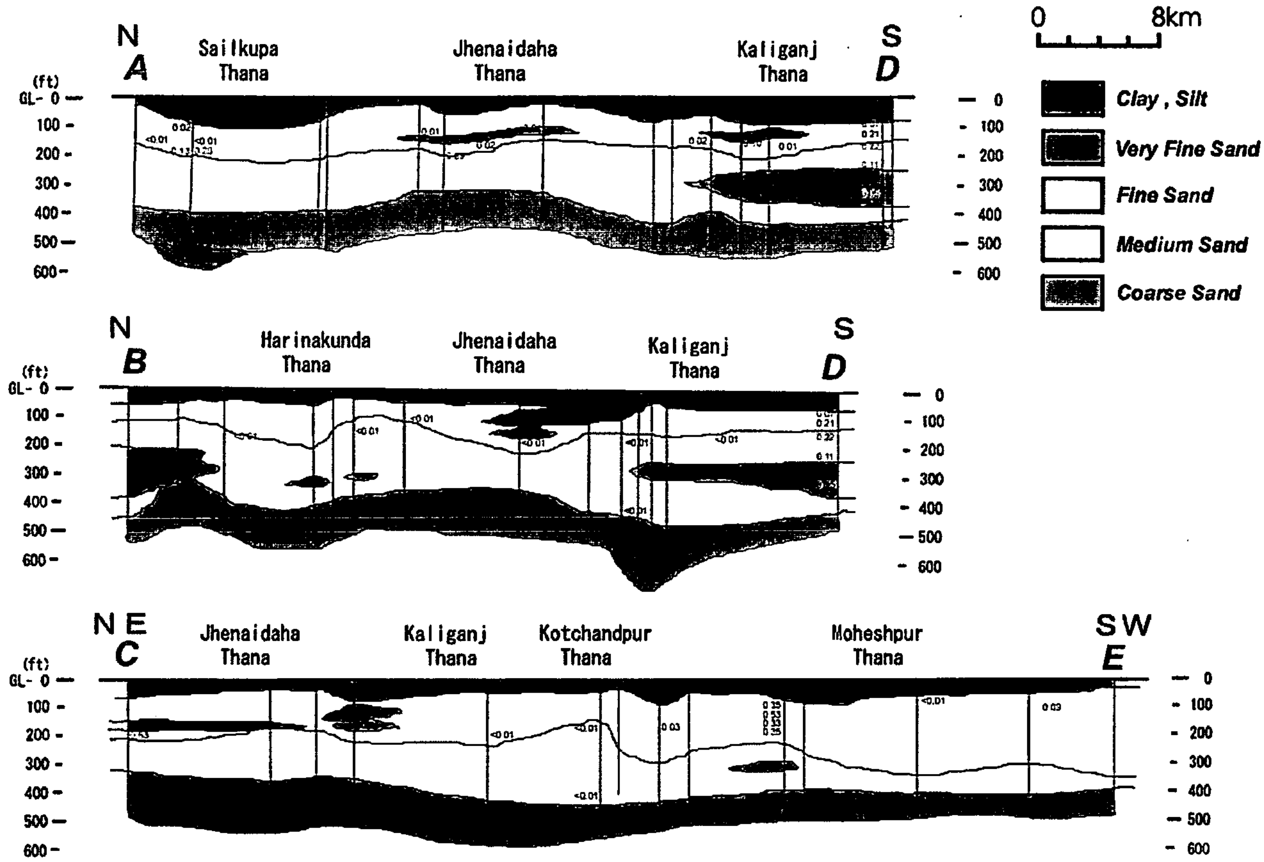



[Data source: GSB(1990)]

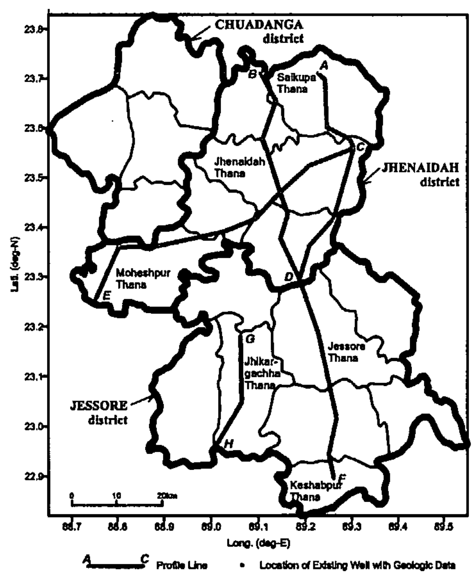
| Figure 2.3.3 | Simplified Geological Map of Bangladesh |
|---|---|

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)

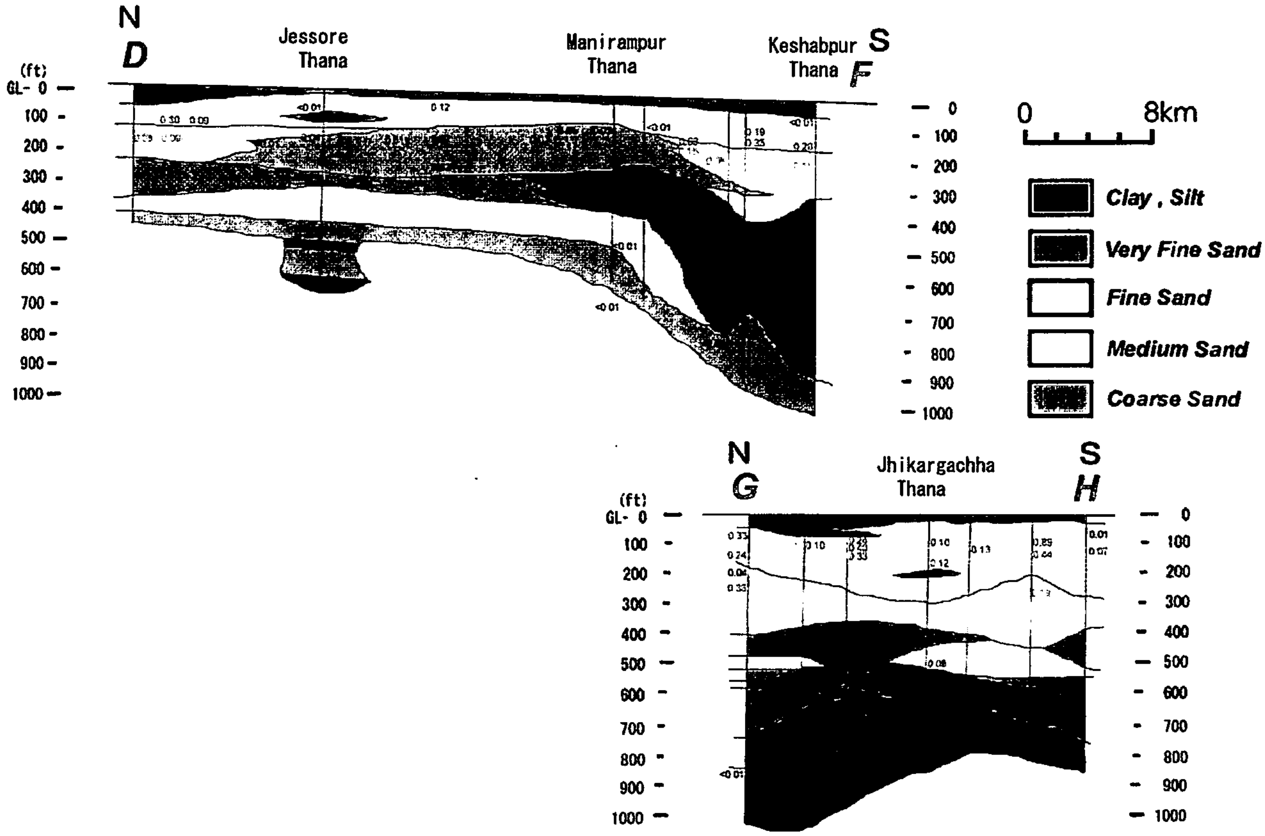



(after JICA Expert Team, 2000)

| 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

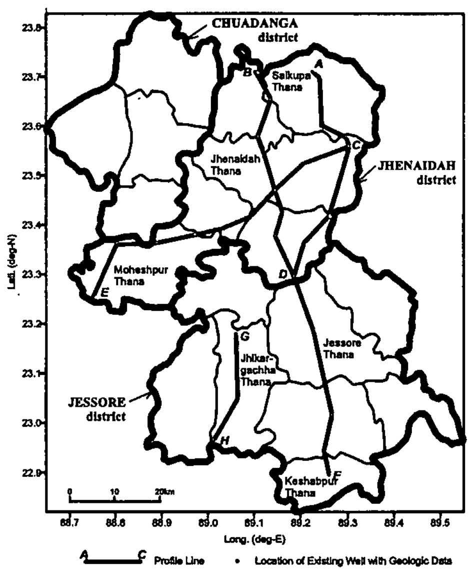
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)




## 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 by place to place. It is said that the shallow aquifer and deep aquifer are bounded by an aquitard at a depth of about 150 m in central Bangladesh, but the boundary is located at a deeper portion in the southern coastal districts.

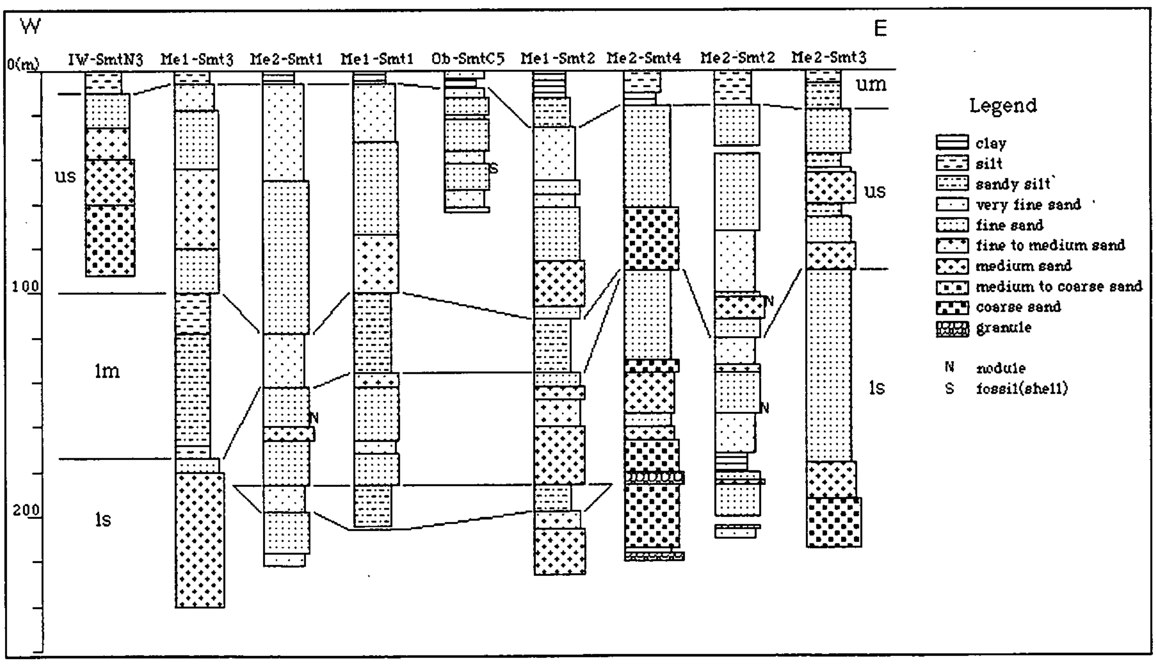
The aquifers of the study area are also made up of Quaternary sediments. According to the geological profiles mentioned in the previous section, the boundary between the shallow aquifer and deep aquifer is not clear in Jhenaidah District. They may be separated by fine sandy or clayey layers occurring at depths of 200 to 350 ft, 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 900 ft. 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 an unconfined aquifer, first aquitard, first confined aquifer, second aquitard, and second confined aquifer within a depth of 200 m based on the 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*

# CHAPTER 3 SOCIO-ECONOMY AND WATER SUPPLY

## 3.1 Socio-Economy

### 3.1.1 Population

1) National Level

The major population and demographic indicators at the national level are given in Table 3.1.1.

**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 Census 1991. 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.

### 3.1.2 Socio-Economy

1) GDP

The 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 during1992/1993 to 1996/1997 is about 4.8%. The per capita GDP in 1996/1997 is approximately 11,284 Taka (US$277).

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.

### 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. The district GDP is approximately 31 billion Taka at a constant price. The district GDP per capita is about 11,511 Taka in FY 1997/1998, which is slightly higher than the national level of FY 1996/1997. 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 service industries is much lower.

### 3) Regional Characteristics of Economic Activities in the Study Area

The major economic activity in the Study Area is 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, such as sugar and soap factories located in Chuadanga, sugar and pharmaceutical factories in Jhenaidah, and textile, jute, and leather factories in Jessore.

### 4) Education

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 was similarly found in the Study Area as shown in Table 3.1.3.

**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.

Table 3.1.4 compares the adult literacy rate of the entire nation to that of the three districts in the Study Area. The difference in primary school enrollment between male and female reflects the gap in literacy level between them.

**Table 3.1.4 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 3.1.5 compares the levels of medical facilities and available human resources of the entire nation to those of the three districts in the Study Area.

**Table 3.1.5 Comparison on the Levels of Medical Facilities and Human Resources**

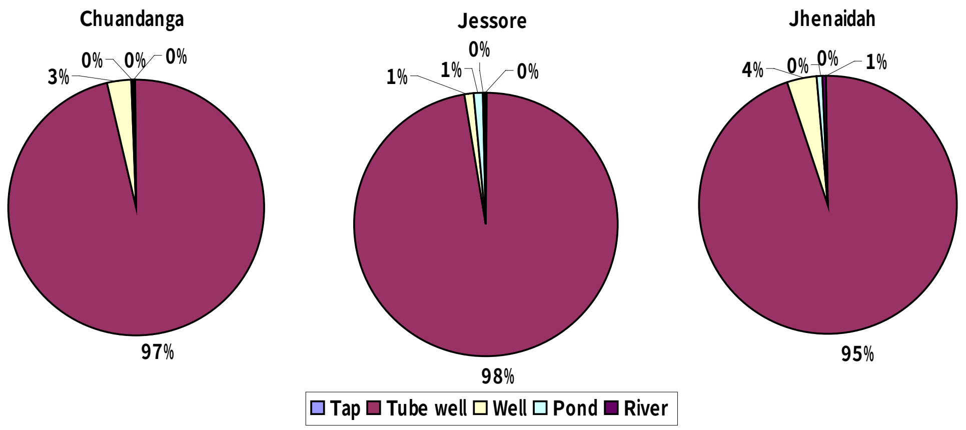
| Indicators | Bangladesh | Jessore | Jhenaidah | Chuadanga |
|---|---|---|---|---|
| Persons per hospital bed | 3,348 | 5,241 | 3,845 | 4,862 |
| Persons per doctor | 4,684 | 14,734 | 14,959 | 16,472 |
| Persons per nurse | 8,124 | 5,820 | 7,520 | 7,473 |

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

6) Hygiene and Sanitation

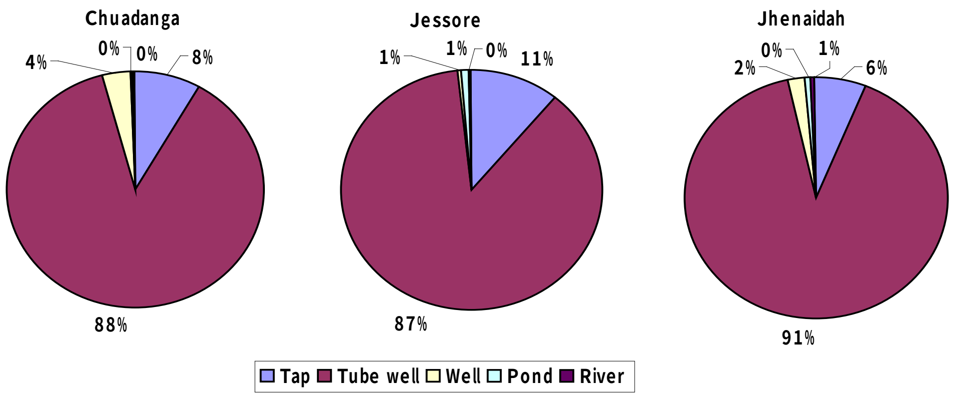
a. Source of drinking water

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 life of the people with a big magnitude. Figures 3.1.1 and 3.1.2 below shows the sources of drinking water in rural and urban areas of the three districts in the Study Area.




Source: Census 1991, Bangladesh

**Figure 3.1.1 Sources of Drinking Water in Rural Areas of the Three Districts**




Source: Census 1991, Bangladesh

**Figure 3.1.2 Sources of Drinking Water in Urban Areas of the Three Districts**

b. Toilet facilities

Toilet facilities are also not in good sanitary condition. Table 3.1.6 compares the conditions of latrines of the entire nation to those of the three districts in the Study Area.

**Table 3.1.6 Current Conditions of Household Latrine**

Unit: % of total household

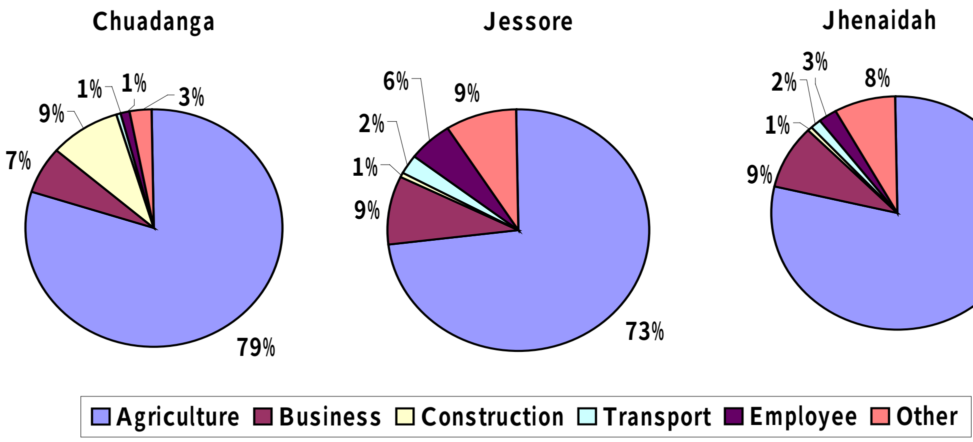
| Type of Latrine | Bangladesh | Jessore | Jhenaidah | Chuadanga |
|---|---|---|---|---|
| Water seal | 12.1% | 5.6% | 12.9% | 6.7% |
| Pit | 28.2% | 50.6% | 42.6% | 52.8% |
| Hanging | 39.8% | 4.6% | 12.0% | 4.7% |
| Open Defecation | 24.5% | 42.4% | 50.5% | 38.8% |

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

7) Other Living Conditions

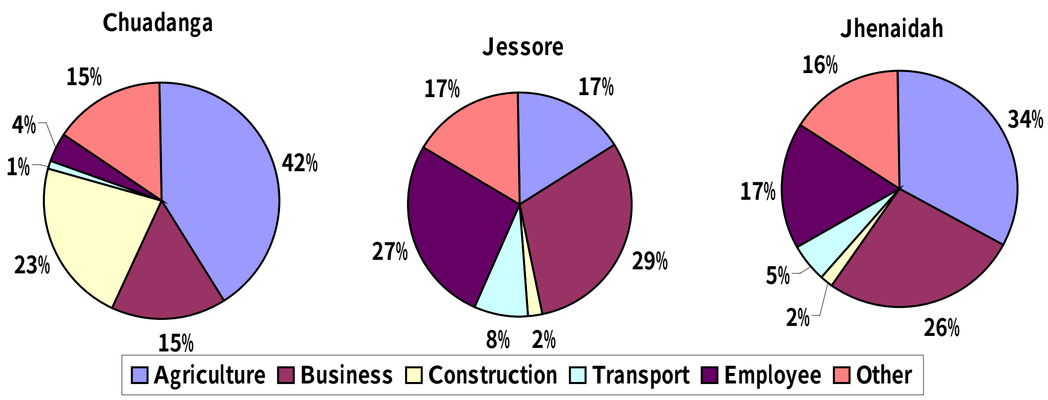
a. Sources of income

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 3.1.3 and 3.1.4 shows the percentage distribution of income sources of the rural and urban households in the three districts




Source: Census 1991, Bangladesh.

**Figure 3.1.3 Sources of Income by Rural Households in The Three Districts**




Source: Census 1991, Bangladesh.

**Figure 3.1.4 Sources of Income by Urban Households in the Three Districts**

c. Electricity supply

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 3.1.7 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 statement of the annual budget by the Ministry of Finance, the state budget for FY 2000/2001 is 385,240 million Taka, which is about a 12% increase from FY 1999/2000. Estimated resources and allocation of the budget is briefly shown in Table 3.1.8 below.

**Table 3.1.8 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.

2) Annual Development Programme (ADP)

a. Resources for ADP

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 3.1.9 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 the 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.

### 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 Growth Rate (1997 to 2002): | 1.32 % for 1997-2002 |
| Piped water supply ratio: | 65% in Dhaka |
| | 50% in Chittagong |
| | 51% in other district towns |
| | 5% in thanas and pourshavas |
| | 1 tube-well per 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 per 80 persons by the final 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 of groundwater in 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 tax concessions 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 placed on the 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. Programmes 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.

Table 3.1.10 and 3.1.11 below show the major achievements from 1990 to 1997 and projected development from 1997 to 2002 in water supply and sanitation sector in Bangladesh.

**Table 3.1.10 Major Achievements of Water Supply and Sanitation Sector in Selected Years (1990 to 97)**

| 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 3.1.11 Projections of Development in Water Supply and Sanitation Sector for Fifth Plan (1997-2002)

| 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-well

## 3.2 Water Supply Conditions

### 3.2.1 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 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 3.2.1. 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 | 90-130 m |
| Drilling Diameter | 450 mm |
| Casing Pipe (Upper) | Mild Steel Pipe, 350 mm dia. |
| Casing Pipe (Lower) | Galvanized Steel Pipe, 150 mm dia |
| Screen Pipe | Stainless Steel, 150 mm dia |
| Screen Position | -70-120 m |
| Screen Length | 20-30 m |

b. Water Pump

| Pump | |
|---|---|
| Type | Turbine/Submersible |
| Capacity | 1.0-2.0 $m^3$/min, (20-40HP) |
| Delivery Head | 55m |
| Riser Pipe | 150 mm dia |
| Pump Position | -20 m |
| 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 | 350-1,000 $m^3$ |

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") |
| | 100 mm(4") |
| | 150 mm(6") |
| | 200 mm(8") |
| | 250 mm(10") |

e. 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.

3) Operation & Maintenance

The pourashavas (municipalities) are responsible for system operation and maintenance.

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 3.2.1 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

**Table 3.2.2 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 | △4 | 545 | 108 | 12 | 6 | 0 | 0 | 0 |
| | Abhoynagar | 2,077 | 90 | 44 | △7 | 17 | 0 | 0 | 0 | 77 | 57 | 0 |
| | Bagarpara | 1,742 | 94 | 36 | 1 | 46 | △4 | 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 | △15 | 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 | △2 | 0 | 0 | 0 |
| | Hornakunda | 1,719 | 187 | 30 | △15 | 223 | △7 | 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 | △4 | 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 | △4 | 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 (△= decreased)

[Data Source: DPHE P&C Division (1997, 1998)]

### 3.2.2 Rural Water Supply

1) Water Source

Groundwater from hand tube wells is mostly used for domestic purposes. 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.

A total of 45,657 DPHE tube wells exist in the study area as shown in Table 3.2.2. In addition to DPHE wells, a number of private tube wells were constructed and utilized.

2) Water supply system

The village water supply system consists of a tube well with hand pumps, a platform and a drain.

a. Tube Well

Shallow wells that are about 50 m in depth are drilled using the manual “Sludger Method”, while the “Donkey Method” (mud rotation and manual drilling) is used for 100 to 200 m 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. In recent year, the DPHE-UNICEF started using the lifting pump Tara. Tara pump is more capable of extracting water from deep levels than No.6.

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 3.2.3). 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, Activate Alumina Adsorption.

## Table 3.2.3 Existing Arsenic Mitigation Technologies for Rural Water Supply

<table>
<tr><th rowspan="2">Water Source</th><th rowspan="2">Intake Facility</th><th colspan="2">Treatment Technology</th></tr>
<tr><th>For Arsenic</th><th>For Fecal Coliform (Bacteria)</th></tr>
<tr><td>Rainwater</td><td>Rain Water Harvester (RWH)*</td><td>Unnecessary</td><td>Unnecessary</td></tr>
<tr><td>Ponds</td><td>None</td><td>Unnecessary</td><td>Pond Sand Filter (PSF)*</td></tr>
<tr><td>Rivers and lakes</td><td>None</td><td>Unnecessary</td><td>(Boiling)</td></tr>
<tr><td>Groundwater in ultra shallow aquifer</td><td>Dug well*</td><td>Unnecessary</td><td>(Boiling)</td></tr>
<tr><td rowspan="8">Groundwater in shallow aquifer</td><td rowspan="8">Hand pump tube well</td><td>Safi Filter*</td><td rowspan="8">Unnecessary</td></tr>
<tr><td>Three Kolshi Filter*</td></tr>
<tr><td>Home-based Surface Water Filter*</td></tr>
<tr><td>Iron Oxyhydroxide Filter*</td></tr>
<tr><td>Double Bucket Unit*</td></tr>
<tr><td>Aeration and Passive Sedimentation Filter*</td></tr>
<tr><td>Activate Alumina Adsorption*</td></tr>
<tr><td>Etc.*</td></tr>
<tr><td>Groundwater in deep aquifer</td><td>Hand pump tube well*</td><td>Unnecessary</td><td>Unnecessary</td></tr>
</table>

*: 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 carries out regular maintenance, inspection, and repair. The assistance of the mechanics (4) in the Thana offices (Assistant Engineer's Office) of DPHE is requested for work beyond the capability of the caretaker. When spare parts run out, the caretaker collects 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.

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.

## 3.3 Village Conditions in the Study Area

A questionnaire survey on the village conditions was conducted for the selected 260 villages in the study area (Chuadanga: 53, Jehnaidah 89, Jessore: 118). These villages were selected considering the size of the mouza and DPHE well location. Finally, the villages were distributed as equally as possible in the study area.

### 3.3.1 General Features of the Villages

1) 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). 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). Most of the villages have a population within the range from 1,000 to 5,000. Since the population size varies by village, mitigation measures and education programs should be prepared taking the population size of a village into account when 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 |

2) Cultural Background

Islam is the major religion in most of the 260 villages but not the only religion in the villages. Muslims and Hindus live together in most of the target villages, especially in Jhenaidah. Other religions such as Buddhism and Christianity are believed in some villages but are not major in the area. Therefore, considerations to the cultural diversity of the villages should be kept in mind in developing the master plan and educational program.

3) Roof Materials

Roofs can be used for collecting rainwater; metal sheet such as (corrugated) tin plate is most appropriate for that purpose. It can be assumed that the main roof material varies by location. In Chuadanga, in 44% of the 53 villages, straw is the main roof material. In Jessore, tile is the main material in 53% of the 118 villages, followed by tin. In Jhenaidah, tin is the main material in 70% of the 89 villages, followed by straw.

4) 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. Most of the villagers eat rice, green leafy vegetables, and other vegetables every day, but not a protein source such as beans, meat, fish, and eggs. Although villagers eat vegetables every day, the villagers might not ingest enough due to traditional cooking methods. Knowledge dissemination on proper cooking methods could be one of the elements in education programs to be developed.

### 5) 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 organization in the villages is the Village Mosjid (mosque) Committee. More than 90% of the villages in Chuadanga and Jhenaidah have such a community organization. In addition, School Committees are also common. Experience in managing the community organizations would be helpful in organizing villagers to take actions to overcome arsenic problems. Several local and national NGOs are active in disseminating knowledge about nutrition and sanitation and assisting the poor and the handicapped. 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

### 6) 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 percentages of the villages where more than half of the households have a radio are 68% in Chuadanga, 77% in Jessore, and 78% in Jhenaidah. TV sets and newspapers are not as common as radios. Therefore, the radio is considered as an effective communication tool to disseminate information across villages at one time. Since the adult literacy rate in the study area is less than 40%, oral communication is considered as more effective.

## 3.3.2 Domestic Water Use

### 1) Water Consumption

According to the survey, daily water consumption for drinking and cooking purposes is in the range from 70 to 80 liters (see Table 3.3.3).

**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 |

### 2) 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 a 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 the purposes other than drinking and cooking.

### 3) Water Fetching

In almost all the 260 villages, the wife is mainly in charge of water fetching in each household. Villagers use several kinds of water containers such as earthen pots, aluminum pots, plastic buckets, and jugs.

## 4) 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 2000 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 there is only one well for almost 40 households in others (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, six in Jessore, and one 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 the 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 tests and monitoring of water withdrawal. Almost all the caretakers in Chuadanga and Jhenaidah are not paid for their service, but some of them are paid in Jessore.

## 5) Wells for Agricultural Use

It is not so common for a village to have communal wells for agricultural use. The percentage 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.

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 at communal wells for agricultural use. This experience would be useful for the same kind of activity for managing communal wells for domestic water use.

### 3.3.3 Arsenic Problems

1) Arsenic Patients Reported from Village Leaders

Among the 260 villages, 19 village leaders reported that there are arsenic patients. The largest number of arsenic patients in one village is reported from Samta (Bagachra Union, Sharsha Thana, Jessore), which has 363 patients 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).

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

2) 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.

3) 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:

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

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 vast room for improvement in the villagers’ understanding of arsenic problems. Therefore, information dissemination on the cause of arsenic poisoning should be emphasized in order to reduce the psychological stress of arsenic patients.

4) 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. 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.

The average transportation costs to go to the nearest medial facility are about 16 Taka in Chuadanga, 44 Taka in Jessore, and 32 Taka in Jhenaidah. The average daily wage of an agricultural laborer (male) was 50 Taka in December 1998, and the daily income of a rickshaw driver is said to be less than 100 Taka. 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 made 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.

### 5) 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. 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 the hardening of skin as one of the symptoms. Priority on dissemination of information about arsenic problems should be given to the area with high arsenic levels in groundwater and low awareness of arsenic problems.

### 6) 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. Most of the villages with a large number of arsenic patients, such as Samta, Achintyanagar and Majdia, held the village meetings. 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 3.3.6).

**Table 3.3.6 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. Actions taken by the villages are the followings:

- establish a committee to deal with the arsenic problems
- invite a knowledgeable person to provide information about the causes of and ways to prevent arsenic poisoning
- ask government organizations or politicians to dig a new well for arsenic safe water
- ask government organizations or NGOs to conduct an arsenic test on well water.

### 7) Actions to Obtain Arsenic Safe Water at Household Level

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

In Chuadanga, using arsenic safe wells is the only action taken in the villages. Other methods such as letting water sit in a pot or bucket over night, using arsenic removal pots, adding chemicals to deposit arsenic, harvesting rain water, 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 for 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.

### 8) NGOs Activity related to Arsenic Problems

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

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

The NGOs currently working in the villages but not in the field of arsenic problems have potential to expand their activities to assisting the villagers to cope with arsenic problems.

# *CHAPTER 4*

# *ACTUAL CONDITION OF ARSENIC CONTAMINATION IN GROUNDWATER*

# CHAPTER 4 ACTUAL CONDITION OF ARSENIC CONTAMINATION IN GROUNDWATER

## 4.1 Present Conditions of 300 Existing Wells

To determine the arsenic contamination and physical condition of existing wells, the well structure and arsenic level of well water were surveyed for 300 existing wells in the study area. Also conducted was a water quality analysis other than for the arsenic level of 30 existing wells out of the 300.

### 4.1.1 Selection of the 300 Existing Wells

1) Target Well Selection and Allocation

Production wells in Pourashava areas and DPHE tube wells are targeted for this survey because they cover a larger number of users than private tube wells. Therefore, all the production wells (40 in total: Jessore (17)[1], Jhenaidah (17), Chuadanga (6)) were selected as the target for the survey. The rest of the existing wells, a total of 260, were selected from DPHE tube wells for drinking water supply in rural and urban areas. The number of target wells was allocated to each Union according to the following steps:

1) Allocate the number of target wells to each District based on the size of its jurisdiction area
2) Allocate at least one target well to each Union
3) The remaining target wells were allocated according to the number of Mouzas in the Union.

As a result of the above steps, 118 target wells (45.34% of the 260 target wells) were allocated to Jessore, 89 to Jhenaidah and 53 to Chuadanga (see Table 4.1.1).

To specify the location of the target wells, Mouzas were firstly selected considering their location in the Union and the number of DPHE wells.

Then one DPHE well was selected on site when surveyors visited the selected Mouzas with the assistance of DPHE staff based on the following conditions:

1) The hand pump is No. 6 type
2) The well has a shallow aquifer
3) The well has the largest number of users in the Mouza

[1] Out of the 17 production wells, 3 were not in use at the time of the survey, but available information was collected.

**Table 4.1.1 Allocation of Target Wells to the 3 Districts**

| | 3 District Total | Jessore | Jhenaidah | Chuadanga |
|---|---|---|---|---|
| Jurisdiction Area ($km^2$) | 5,686 | 2,578 (45.34%) | 1,950 (34.29%) | 1,158 (20.37%) |
| Number of Target Wells | 260 | 118 | 89 | 53 |
| Total Number of Unions | 197 | 92 | 72 | 33 |
| Number of Unions with 2 Target Wells | 63 | 26 | 17 | 20 |
| Number of Unions with 1 Target Well | 134 | 66 | 55 | 13 |

2) Selection of 30 Existing Wells for General Water Quality Analysis

Out of the 300 existing wells, 30 wells were selected for general water quality analysis. In the study area there are 7 Pourashavas that have production wells; therefore, the production well with the largest water withdrawal in each of the 7 Pourashavas was selected. The remaining 23 wells were allocated to Thanas according to the following steps:

(1) Allocate one target well to each Thana (total 18 target wells)

(2) Allocate one more target well to each of the selected 5 Thanas according to its jurisdiction area.

Then one or two Mouzas per Thana were selected from the 260 Mouzas as follows:

(1) The Mouza is located along the main road

(2) The Mouza is located at the center of the Thana (when two Mouzas are selected, the Mouza is located at the center of half the area of the Thana)

Figure 4.1.1 shows the locations of the 300 existing wells (40 production wells and 260 DPHE tube wells) for the well structure investigation and arsenic level analysis and the locations of the 30 wells for the general water quality analysis. The locations of the 260 DPHE tube wells represent approximate locations of the Villages where the socio-economic study was carried out (see Chapter 3.3).

### 4.1.2 Well Structure

1) Well depth of DPHE shallow wells

It is very important to know the actual well depths of the DPHE existing wells, because arsenic in groundwater is said to occur in shallow aquifers. In the field, the groundwater level and well depth were measured after collecting water samples.

Figure 4.1.2 shows the distribution of the well depth of the 260 existing DPHE shallow wells by district. In the Study Area, wells that are 40 to 45 m in depth are most dominant. Well depths of 35 to 40 m and 45 to 50 m come next. The well depths tend to increase toward the south. It is affected by hydrogeologic conditions such as depth and thickness of aquifer, facies of aquifer, and occurrence of aquitard.

2) Characteristics of production wells

The list of the production wells with the results of the field measurements in Jessore Pourashava, Jhenaidah district, and Chuadanga Pourashava are shown in Tables 4.1.2, 4.1.3, and 4.1.4 respectively.

In Jessore Pourashava, the well depth ranges from 85.32 to 132.54m. Most of the wells have a single screen structure, however, one (1) well has two (2) screens and another well has three (3) screens. The screen length ranges from 13.4 to 47.54 m.

In Jhenaidah districts, 5 Pourashavas have production wells for supplying municipal water. There are 7 production wells in Jhenaidah Pourashava, 3 production wells each in Kaliganj, Sailkupa, and Kotchandpur Pourashavas, and 2 production wells in Moheshpur Pourashava. The well depth of the production wells ranges from 92.2 to 132.08 m. The screen length ranges from 4.35 to 30.07m.

In Chuadanga Pourashava, there are 6 production wells. The well depth of the 4 wells ranges from 102.1 to 133.0 m. All the wells have a single screen. The screen length ranges from 24 to 30 m.

3) Specific capacity

The specific capacity (*Sc*) is one of the geohydrologic parameter to evaluate aquifer characteristics as well as the well performance.

Figure 4.1.3 shows the distribution of *Sc* values obtained from the production wells by district and all. The logarithmic average of *Sc* values for all the production wells in the Study Area is 1,086.0 $m^2$/day. The average values of Chuadanga and Jhenaidah Districts are 1,225.3 $m^2$/day and 1,224.4 $m^2$/day, respectively. These are greater than the average value of Jessore (= 876.5 $m^2$/day).

From the existing production well data, it can be said that the aquifer productivity at 60 to 130 m in depth is generally high in the Pourashava areas. However in Jessore Pourashava, the aquifer productivity is less in some places.

### 4.1.3 Groundwater Level

Groundwater levels of the DPHE shallow wells were measured by removing the hand pump. For the production wells, most of the wells have an observation pipe so that the groundwater levels were measured by inserting the water level sensor through the observation pipe.

1) Groundwater Level in Rainy Season

Figure 4.1.4 shows the distribution of the depth to groundwater (DTW) from the ground surface measured from June to July 2000. This period is the beginning of the rainy season. The DTW values range from 1.12 to 9.78 m in the Study Area. Deep groundwater levels more than 5 m from the ground surface are found in the northern part of Jessore District, in the central and the western part of Jhenaidah District, and in the western part of Chuadanga District. On the other hand, the DTW in the southern part of Jessore District is shallower than 3 m from the ground surface.

### 2) Groundwater Level in Dry Season

Figure 4.1.5 shows the distribution of the DTW from December 2000 to January 2001. This period is the beginning of the dry season. The DTW values range from 0.65 to 12.99 m in the Study Area. Deep groundwater levels more than 5m from the ground surface are scattered in the northeastern part and southwestern part of Jhenaidah District, the western part of Chuadanga District, and the central to western part of Jessore District. On the other hand, the shallow DTWs less than 3 m are distributed from central Chuadanga to central Jhenaidah Districts and the southern part of Jessore District. The DTWs of southern to western Keshabpur thana in Jessore District show less than 2 m from the ground surface.

### 3) Changes in GWL between Rainy Season and Dry Season

Figure 4.1.6 shows the changes in groundwater level between the rainy season (June to July 2000) and dry season (December 2000 to January 2001) in the study area. In the rural areas from central Chuadanga District to northern Jessore District, groundwater levels in the dry season are 1 to 3 times higher than those in the rainy season. On the other hand, the groundwater levels in northeastern Jhenaidah and southwestern to southeastern Jessore Districts declined 1 to 2m.

## Table 4.1.2 Results of Well Structure Survey for Production Wells in Jessore Pourashava

| No. | Well No. and Location | Existing Data | | | | | | | | | | | | | | New Data Measured in June 2000 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Well and Facilities | | | | | | | | Production Test | | | | | | Field Measurement by the Study | | | | |
| | | Construction Date | Well Depth (m) | Screen Depth (m) | Screen Length (m) | Well Diameter (mm) | Well Log | OHT | IRP | Collection Date | Discharge (Q) ($m^3$/h) | ① S.W.L (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Specific Capacity ($m^3$/day) | ① S.W.L (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Discharge (Q) ($m^3$/h) | Specific Capacity ($m^3$/day) |
| 1 | W-2 GHOSHPARA | 20-9-89 | 115.41 | 98.96~112.36 | 13.4 | 150 | ◎ | | | 07-10-89 | 71.99 | 3.93 | 5.42 | 1.49 | 1159.57 | 6.600 | 26.710 | 20.110 | 66.00 | 78.77 |
| 2 | W-1 PALBARI | 19-11-89 | 125.15 | 108.7~122.1 | 13.4 | 150 | ◎ | ◎ | ◎ | 29-12-89 | 71.99 | 4.86 | 6.27 | 1.41 | 1225.36 | 6.665 | 19.350 | 12.685 | 174.00 | 329.21 |
| 3 | OW-2 AIRPORT ROAD | 1965-66 | 132.54 | 85.32~129.90 | 44.58 | 200 | ◎ | | | 1965-66 | 90.90 | 3.123 | 4.799 | 1.676 | 1301.67 | 6.190 | 6.960 | 0.770 | 26.00 | 810.39 |
| 4 | OW-1 SMITH ROAD | 1962-63 | 98.85 | 60.94~91.41 | 30.47 | 100 | ◎ | | | 1962-63 | 45.45 | 3.123 | 6.779 | 3.656 | 298.36 | 6.485 | 16.160 | 9.665 | 110.00 | 273.15 |
| 5 | W-3 NEAR at STADIUM ROAD | 03-4-89 | 117.53 | 67.75~72.93<br>95.93~98.6<br>106.93~112.48 | 13.42 | 150 | ◎ | ◎ | | 19-10-89 | 71.99 | 2.67 | 4.2 | 1.53 | 1129.25 | 6.190 | 14.810 | 8.620 | 58.00 | 161.48 |
| 6 | OW-7 M.M.ALI ROAD | 1981-82 | 125.84 | 98.42~122.79 | 24.37 | 150 | × | | | 1981-82 | 68.18 | 5.078 | 7.617 | 2.539 | 644.43 | 9.800 | 23.900 | 14.100 | — | — |
| 7 | W-17 West BARANDI PARA | 26-11-99 | 114.77 | 79.16~111.13 | 31.97 | 150 | ◎ | | | 15-12-99 | 116.10 | 4.74 | 6.57 | 1.83 | 1522.62 | 6.710 | 8.590 | 1.880 | 144.00 | 1838.30 |
| 8 | OW-3 Khal dhara Road near,PHE,staff Quartar | 1965-66 | 131.94 | 81.96~129.50 | 47.54 | 200 | ◎ | | | 1965-66 | 90.90 | 2.742 | 4.25 | 1.508 | 1446.68 | N.M. | N.M. | — | — | — |
| 9 | W-6 NEAR at CITY COLLEGE | 08-3-89 | 118.46 | 102.01~115.41 | 13.4 | 150 | ◎ | ◎ | ◎ | 21-8-89 | 73.08 | 3.76 | 5.02 | 1.26 | 1392.00 | 5.930 | 9.630 | 3.700 | 91.00 | 590.27 |
| 10 | W-7 HOLLAH PARA | 06-9-89 | 124.1 | 111.06~124.46 | 13.4 | 150 | ◎ | | | 20-8-89 | 71.99 | 4.45 | 5.83 | 1.38 | 1252.00 | 6.520 | 8.400 | 1.880 | 100.00 | 1276.60 |
| 11 | OW-8 PEARY MOHON ROAD | 1982-83 | 89.31 | 61.88~86.26 | 24.38 | 150 | × | | | 1982-83 | 68.175 | 4.113 | 6.779 | 2.666 | 613.73 | 5.680 | 9.680 | 4.000 | 128.00 | 768.00 |
| 12 | W-5 Bejpara, South Side of Answar Camp | 02-5-89 | 120.16 | 103.36~116.76 | 13.4 | 150 | ◎ | ◎ | ◎ | 19-6-89 | 71.99 | 4.08 | 5.49 | 1.41 | 1225.36 | 5.170 | 20.320 | 15.160 | 107.00 | 169.50 |
| 13 | OW-4 ASRAM ROAD (Ram Krishna Mission road) | 1972-73 | 91.41 | 65.21~89.58 | 24.37 | 150 | × | | | 1972-73 | 68.18 | 2.59 | 10.207 | 7.617 | 214.81 | N.M. | N.M. | — | — | — |
| 14 | WO-6 CHANGHARA | 1978-79 | 103.6 | 70.08~100.55 | 30.47 | 150 | | | ◎ | 1978-79 | 68.18 | 2.361 | 7.236 | 4.875 | 335.63 | 5.295 | 10.410 | 5.115 | 98.00 | 459.82 |
| 15 | W-4 Benapole Road | 08-3-89 | 118.46 | 102.01~115.41 | 13.4 | 150 | ◎ | ◎ | ◎ | 09-8-89 | 71.99 | 2.61 | 3.83 | 1.22 | 1416.20 | N.M. | N.M. | — | 92.00 | — |
| 16 | W-8 GHOPH | 06-9-89 | 124.1 | 100.65~108.76<br>115.67~120.96 | 13.4 | 150 | ◎ | | | 16-9-89 | 71.99 | 5.03 | 5.84 | 0.81 | 2133.04 | 6.780 | N.M. | — | — | — |
| 17 | OW-5 JAIL ROAD | 1973-74 | 85.32 | 59.11~83.49 | 24.38 | 100 | ◎ | ◎ | | 1973-74 | 45.45 | 3.352 | 5.941 | 2.589 | 421.32 | 6.580 | 9.970 | 3.390 | 120.00 | 849.56 |

S.W.L=Startic Water Level, D.W.L=Dynamic Water Level, G.W.L=Groundwater level, OHT=Over Head Tank, IRP: Iron Removal Plant, ◎=exist, ×=not exist, N.M.=not measured

## Table 4.1.3 Results of Well Structure Survey for Production Wells in Jhenaidah District

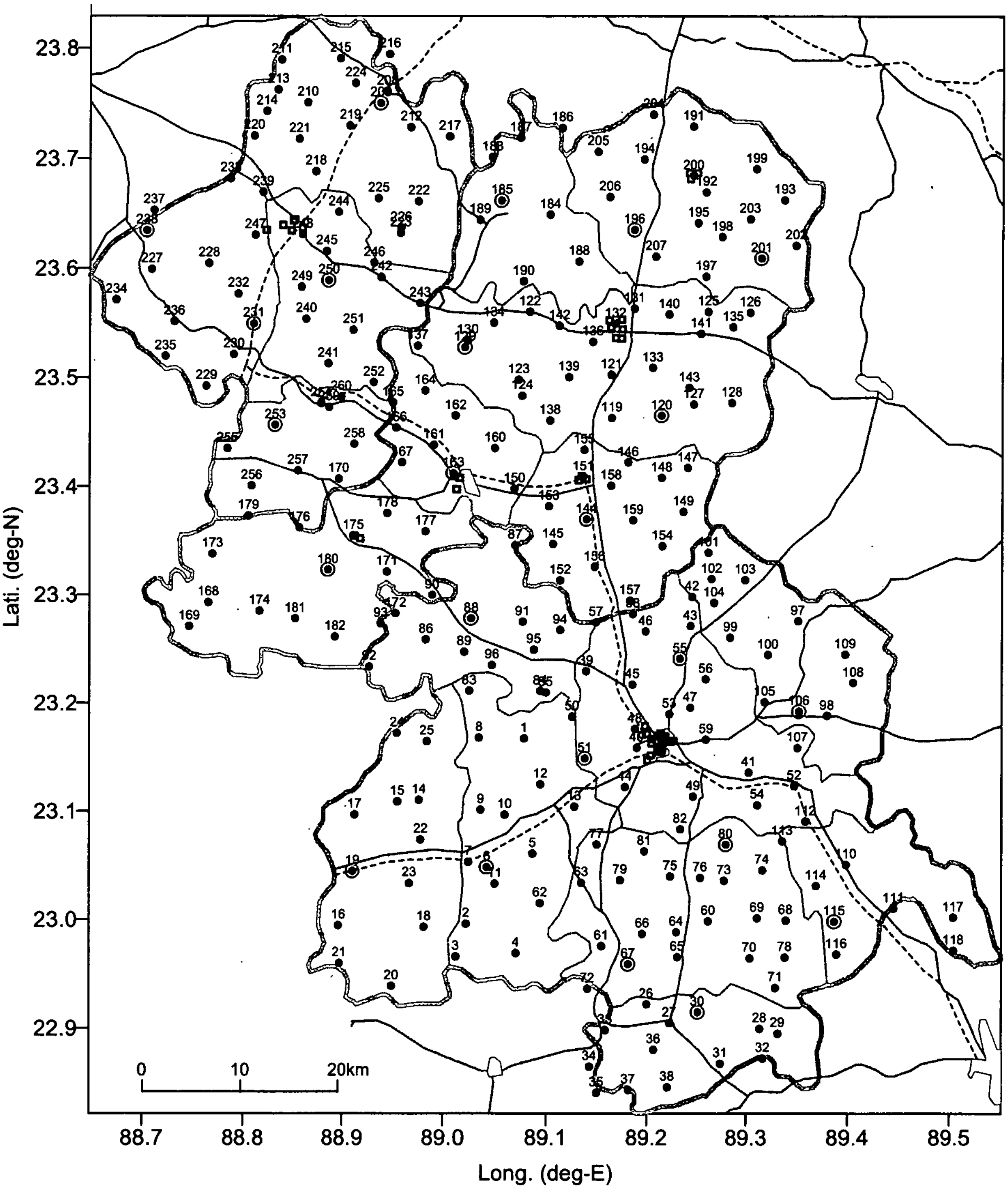
| No. | Pourashava Name, Well No. and Location | Existing Data | | | | | | | | Existing Data | | | | | | New Data Measured in June 2000 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Well and Facilities | | | | | | | | Production Test | | | | | | Field Measurement by the Study | | | | |
| | | Construction Date | Well Depth (m) | Screen Depth (m) | Screen Length (m) | Well Diameter (mm) | Well Log | OHT | IRP | Collection Date | Discharge (Q) ($m^3$/h) | ① S.W.L (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Specific Capacity ($m^2$/day) | ① S.W.L. (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Discharge (Q) ($m^3$/h) | Specific Capacity ($m^2$/day) |
| 1 | Jhenaidah W-1 Kanchanrapur | 04-Jun-00 | 132.08 | 99.01~129.08 | 30.07 | 150 | ◎ | ◎ | | 17-Jun-00 | 154.26 | 5.640 | 11.120 | 5.480 | 675.59 | 5.980 | N.M. | — | — | — |
| 2 | Jhenaidah W-2 Hamdah | | no data | ~ | | 150 | no data | ◎ | | | | | | | | 5.910 | N.M. | — | — | — |
| 3 | Jhenaidah W-3 P.H.E.Cowpus (SAE office) | 04-Jun-00 | no data | ~ | | 200 | no data | | | | | | | | | 3.975 | 7.295 | 3.320 | 68.18 | 492.87 |
| 4 | Jhenaidah W-4 Ponro Park | | no data | ~ | | 150 | no data | ◎ | | | | | | | | 5.700 | 10.630 | 4.930 | 68.18 | 331.91 |
| 5 | Jhenaidah W-5 Chaklapara | 10-Jun-95 | 92.2 | 71.85~96.20 | 24.35 | 150 | ◎ | | | 10-Jun-95 | 145.98 | 6.730 | 9.050 | 2.320 | 1510.14 | 6.800 | 9.160 | 2.360 | 68.18 | 693.36 |
| 6 | Jhenaidah W-6 Arappur Bus Stand | 03-Jun-95 | 123.34 | 91.12~120.34 | 29.22 | 150 | ◎ | | | 10-Jun-95 | 173.62 | 5.290 | 7.920 | 2.630 | 1584.37 | 6.830 | N.M. | — | — | — |
| 7 | Jhenaidah W-7 Track TerminalL | 14-Jul-96 | 95.32 | 68.0~92.35 | 24.35 | 150 | ◎ | | | 14-Jul-96 | 168.17 | 2.620 | 6.250 | 3.630 | 1111.87 | 6.720 | 14.110 | 7.390 | 68.18 | 221.42 |
| 8 | Kaliganj W-1 Ap Barn | 18-Aug-95 | 123.65 | 96.30~120.65 | 24.3 | 150 | ◎ | | | 22-Sep-95 | 167 | 2.790 | 6.320 | 3.53 | 1135.41 | 5.500 | N.M. | — | — | — |
| 9 | Kaliganj W-2 Nischintapur (Old Hospital) | 14-Oct-95 | 129.25 | 96.31~120.6 | 24.29 | 150 | ◎ | | | 25-Oct-95 | 168 | 3.290 | 6.735 | 3.445 | 1170.39 | 3.545 | 5.640 | 2.095 | 90.90 | 1041.34 |
| 10 | Kaliganj W-3 Bus Stand | 28-Aug-96 | 128.07 | 100.72~125.07 | 24.35 | 150 | ◎ | | | 12-Sep-96 | 163.17 | 3.060 | 6.015 | 2.955 | 1325.20 | 3.855 | 8.135 | 4.280 | 113.62 | 637.12 |
| 11 | Sailkupa W-1 Garowarpara | 09-Jun-95 | 96.54 | 69.19~73.54 | 4.35 | 150 | ◎ | | | 16-Jun-95 | 175.89 | 5.630 | 8.455 | 2.825 | 1494.30 | 5.220 | N.M. | — | — | — |
| 12 | Sailkupa W-2 Kabirpur | 12-Jun-95 | 93.49 | 66.14~90.47 | 24.33 | 150 | ◎ | | | 18-Jun-95 | 175.89 | 6.640 | 9.265 | 2.625 | 1608.15 | 6.090 | N.M. | — | — | — |
| 13 | Sailkupa W-3 Shahi mosque pra | 11-Jun-96 | 97.76 | 55.56~70.17<br>85.07~94.81 | 24.35 | 150 | ◎ | | | | | | | | | 5.620 | N.M. | — | — | — |
| 14 | Kotchandpur W-1 Purusova Compus | 11-Jun-96 | 116.79 | 89.44~113.79 | 24.35 | 150 | ◎ | | | 01-Jun-95 | 168.48 | 4.590 | 9.230 | 4.640 | 871.45 | 3.170 | 4.440 | 1.270 | 102.26 | 1932.47 |
| 15 | Kotchandpur W-2 Model School | 23-Jun-95 | 111.16 | 78.94~108.16 | 29.22 | 150 | ◎ | | | 01-Jun-95 | 175.00 | 5.270 | 9.180 | 3.910 | 1074.17 | 4.040 | 7.170 | 3.130 | 102.26 | 784.10 |
| 16 | Kotchandpur W-3 Solamanpur | 22-Nov-96 | 118.93 | 91.62~115.97 | 24.35 | 150 | ◎ | | | | | | | | | 5.680 | 7.710 | 2.030 | 68.18 | 806.07 |
| 17 | Moheshpur W-1 Zamider para | 17-Jun-95 | 99.6 | 72.25~96.60 | 24.35 | 150 | ◎ | | | 01-Jun-95 | 172.73 | 5.450 | 8.260 | 2.810 | 1475.27 | 5.900 | N.M. | — | — | — |
| 18 | Moheshpur W-2 Baraipara | 16-Jul-96 | 113.47 | 88.79~110.14 | 21.35 | 150 | ◎ | | | 05-Sep-96 | 164.53 | 4.280 | 7.265 | 2.985 | 1322.85 | 6.570 | N.M. | — | — | — |

S.W.L=Startic Water Level, D.W.L=Dynamic Water Level, G.W.L=Groundwater level, OHT=Over Head Tank, IRP: Iron Removal Plant, ◎=exist, ×=not exist, N.M.=not measured

## Table 4.1.4 Results of Well Structure Survey for Production Wells in Chuadanga Pourashava

| No. | Pourashava Name, Well No. and Location | Existing Data: Well and Facilities: Construction Date | Well Depth (m) | Screen Depth (m) | Screen Length (m) | Well Diameter (mm) | Well Log | OHT | IRP | Production Test: Collection Date | Discharge (Q) (m³/h) | ① S.W.L (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Specific Capacity (m³/day) | New Data Measured in June 2000: Field Measurement by the Study: ① S.W.L (GL-m) | ② D.W.L. (GL-m) | ③=②-① Drawdon (m) | Discharge (Q) (m³/h) | Specific Capacity (m³/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chuadanga TW-1 Kedargonj | 23-10-1988 | 106.50 | 80.6~105.0 | 24.4 | 150 | | ◎ | | 23-10-1988 | 145.00 | 5.75 | 10.25 | 4.50 | 773.33 | 6.590 | 10.450 | 3.860 | — | — |
| 2 | Chuadanga TW-2A Mohalla Sheak Para (Pourashav Compound) | 10-11-1991 | 102.10 | 69.10~99.10 | 30 | 150 | | | | 10-11-1991 | 290.49 | 3.45 | 9.30 | 5.85 | 1191.75 | 5.360 | 11.625 | 6.265 | — | — |
| 3 | Chuadanga TW-2B Majer para (Football Ground) | 07-11-1991 | 133.00 | 100~124 | 24 | 200 | | ◎ | | 07-11-1991 | 288.37 | 3.30 | 8.60 | 5.30 | 1305.83 | 5.280 | 9.380 | 4.100 | — | — |
| 4 | Chuadanga TW-3 PHE Office Compound (near Hospital) | 10-11-1991 | 133.00 | 86.0~110 | 24 | 200 | | ◎ | | 10-11-1991 | 271.54 | 5.00 | 8.48 | 3.48 | 1872.69 | 5.820 | 7.350 | 1.530 | — | — |
| 5 | Chuadanga TW-4 Zila Parishad Compound Area | | | | | | | | | | | | | | | 6.650 | 9.530 | 2.880 | — | — |
| 6 | Chuadanga TW-5 Bus Terminal | | | | | | | | | | | | | | | 5.680 | 8.720 | 3.040 | — | — |

S.W.L=Startic Water Level, D.W.L=Dynamic Water Level, G.W.L=Groundwater level, OHT=Over Head Tank, IRP: Iron Removal Plant, ◎=exist, ×=not exist, N.M.=not measured




28 • Existing Shallow Tubewell with Serial No.

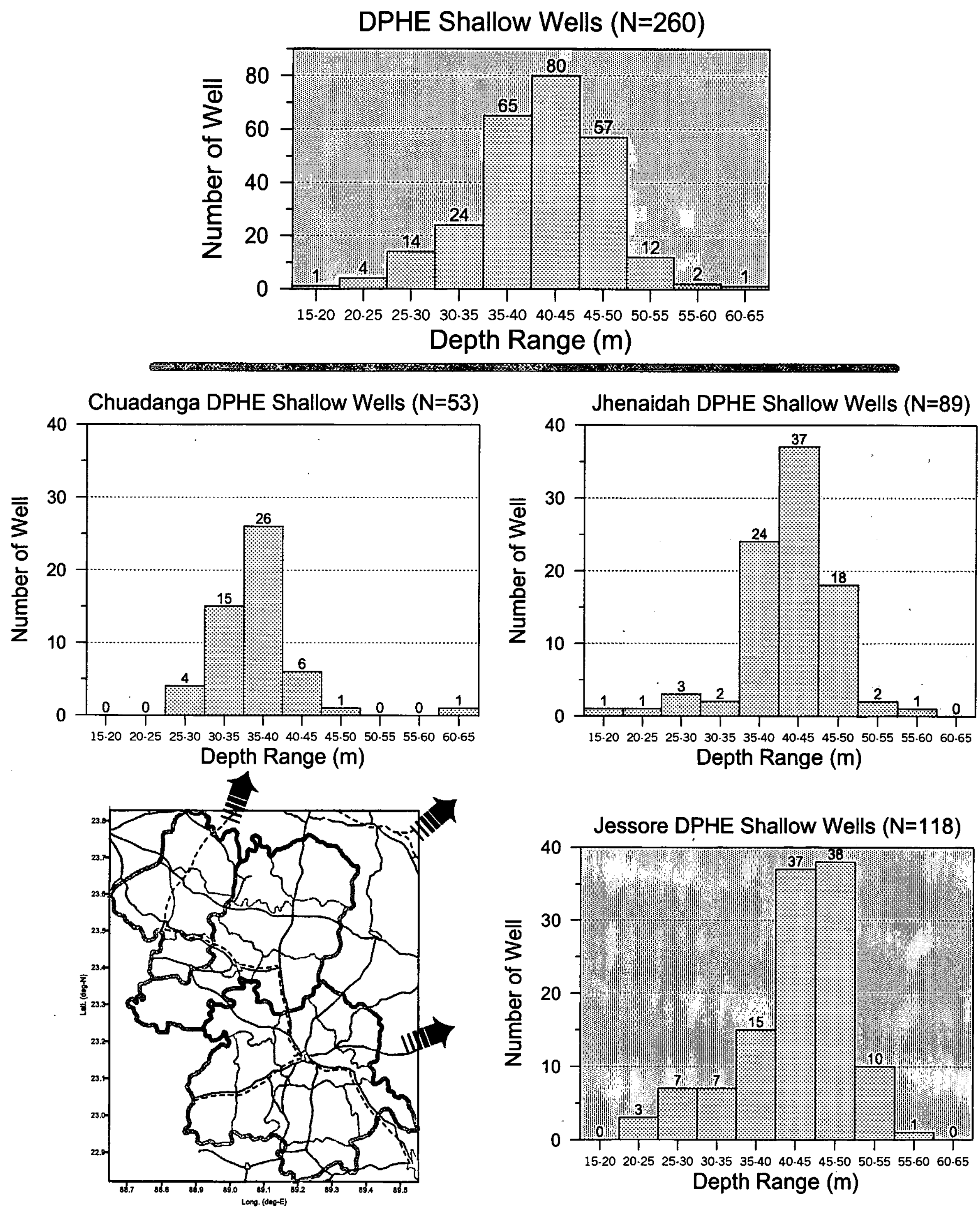
◽ Pourashava Production Wells

◉ Sample Taken for General Water Quality Analysis

| Figure 4.1.1 | Location of 300 Existing Wells |
|---|---|

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

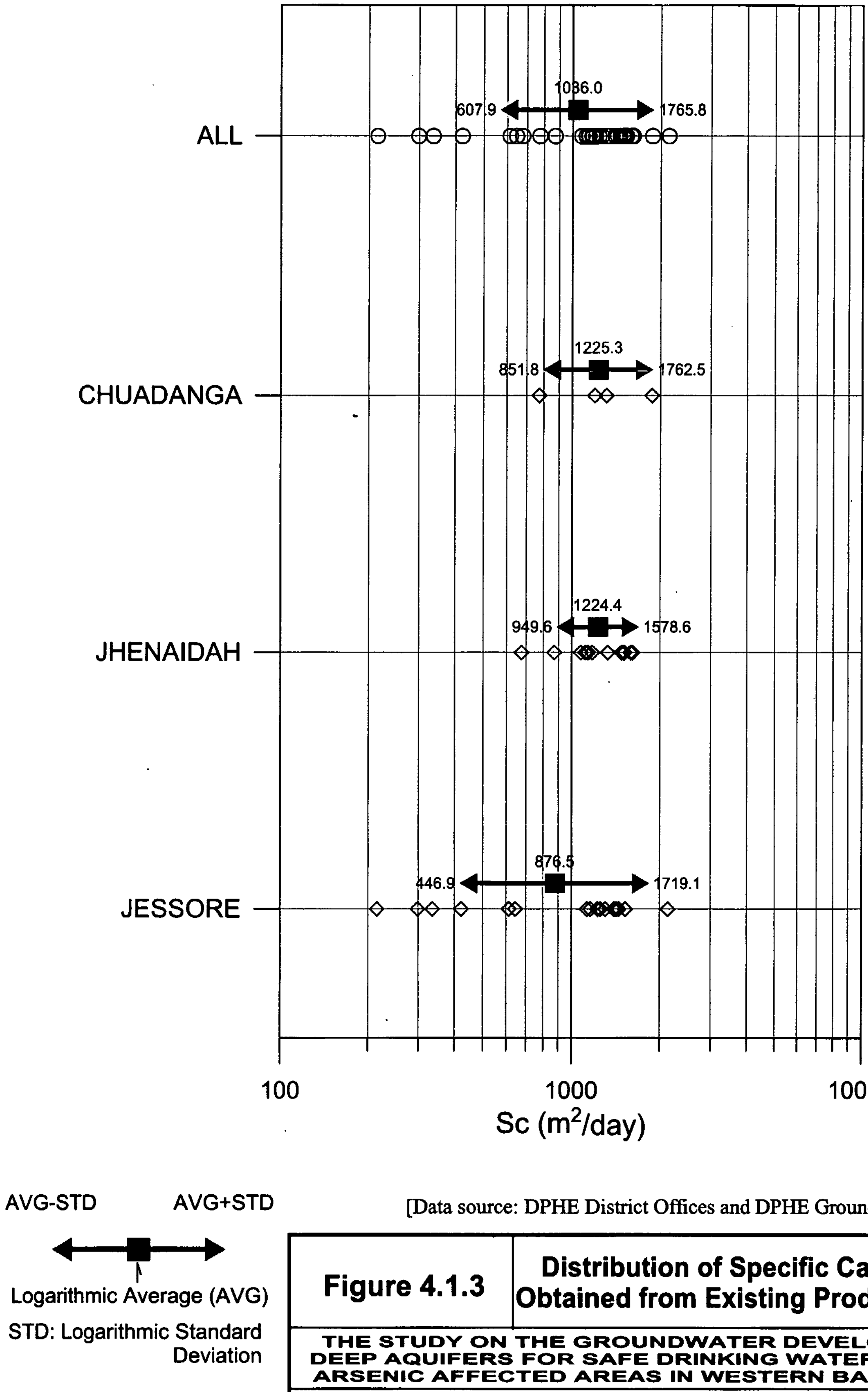
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)




| Figure 4.1.2 | Well Depth of 260 Existing DPHE Shallow Wells by District |
|---|---|

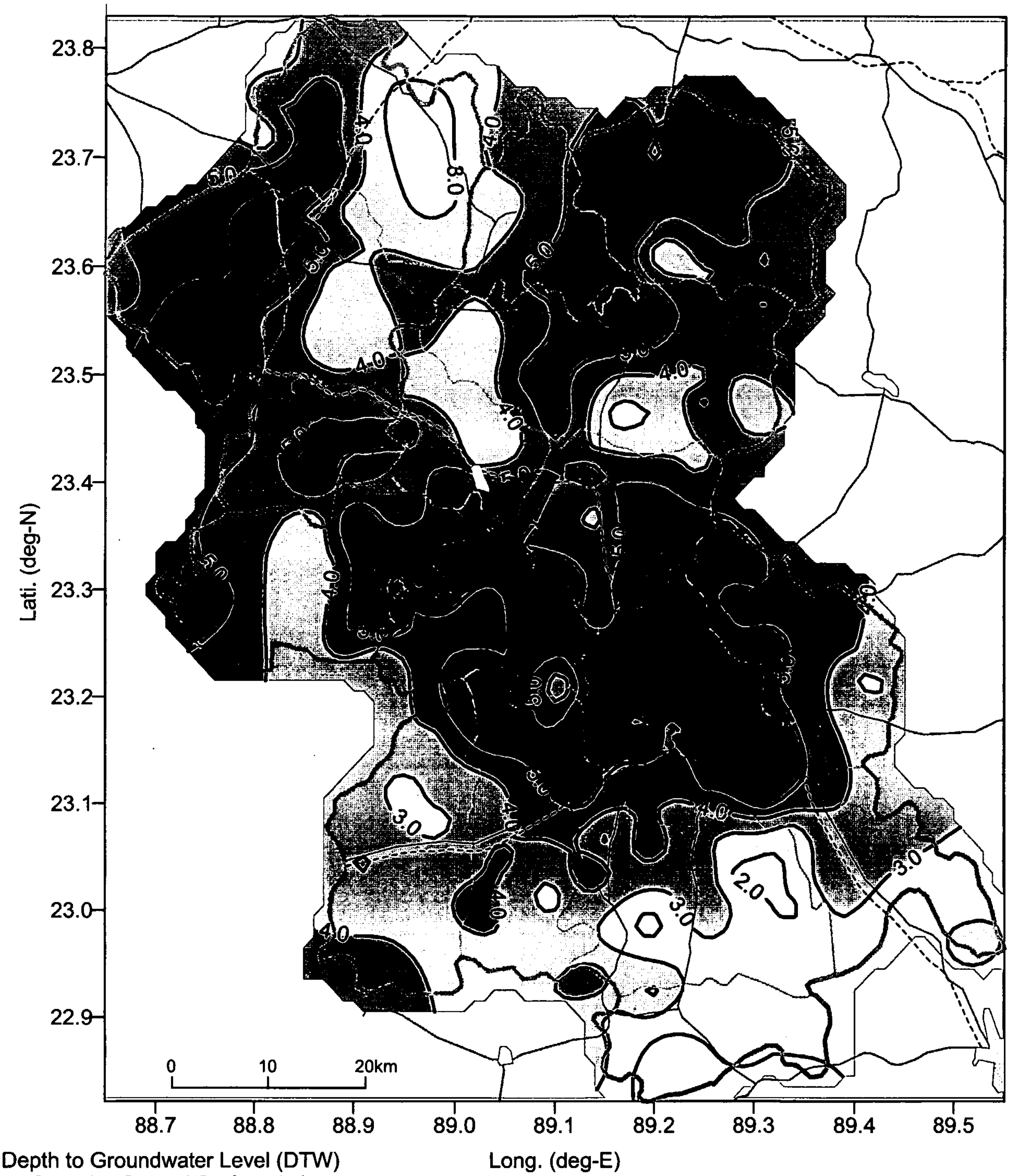
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

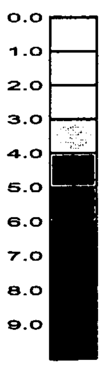



[Data source: DPHE District Offices and DPHE Ground Water Division]

| Figure 4.1.3 | Distribution of Specific Capacity (Sc) Obtained from Existing Production Wells |
|---|---|
| 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) | |

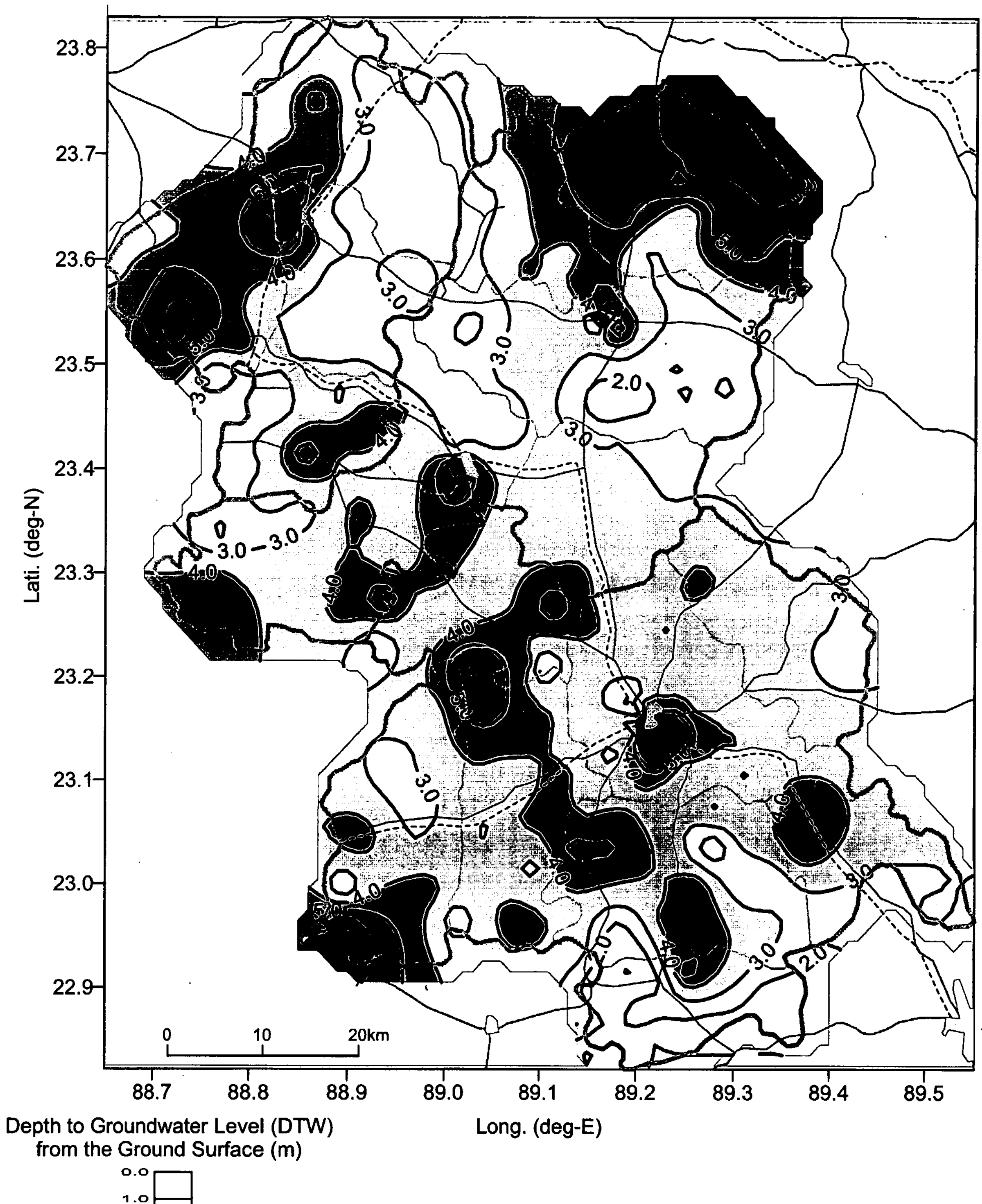



Depth to Groundwater Level (DTW)
from the Ground Surface (m)



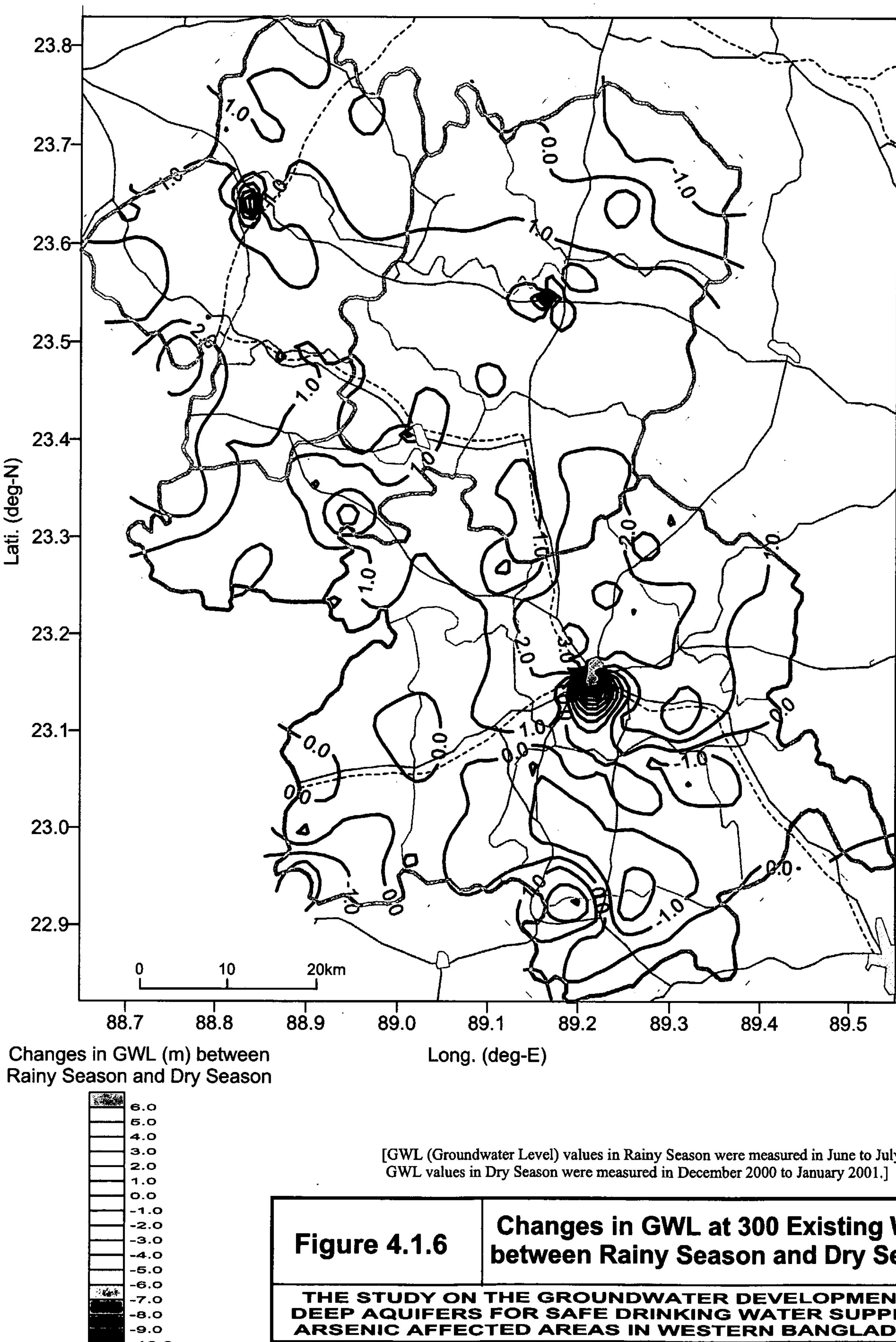

[DTW (Depth to Groundwater Level from the ground surface) values at 300 existing wells were measured by the JICA Study Team in June to July 2000 using potable water level meter.]

| | |
|---|---|
| **Figure 4.1.4** | **DTW Measured at 300 Existing Wells in Rainy Season** |
| 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) | |




[DTW (Depth to Groundwater Level from the ground surface) values at 300 existing wells were measured by the JICA Study Team in December 2000 to January 2001 using potable water level meter.]

| Figure 4.1.5 | DTW Measured at 300 Existing Wells in Dry Season |
|---|---|
| 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) | |




[GWL (Groundwater Level) values in Rainy Season were measured in June to July 2000. GWL values in Dry Season were measured in December 2000 to January 2001.]

| Figure 4.1.6 | Changes in GWL at 300 Existing Wells between Rainy Season and Dry Season |
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## 4.2 Arsenic Contamination in the 300 Existing Wells

Groundwater samples from the 300 existing wells were collected in the rainy season (June to July 2000) and the dry season (December 2000 to January 2001) for the arsenic analysis in the rainy season. The samples were brought to Jhenaidah Laboratory established by the study team and analyzed by AAS.

At the time of the groundwater sampling, groundwater quality including arsenic was tested in the field. The tested parameters in the field and their methods are shown below:

(1) Arsenic (AAN Field Kit)
(2) Dissolved iron, $Fe^{2+}$ ($Fe^{2+}$ pack test kit)
(3) pH (potable pH meter)
(4) Oxidation-reduction potential, ORP (potable ORP meter)
(5) Electric conductivity, EC (potable EC meter)

### 4.2.1 Arsenic Analysis by AAS

1) Arsenic Concentration by District

Figure 4.2.1 shows bar charts of arsenic concentrations of the existing wells by district in the rainy season. In the study area, 99 wells (33.3%) have arsenic concentrations less than 0.01 mg/l. There are 94 wells (31.7%) having As concentrations between 0.01 to 0.05 mg/l. Therefore, 65.0% of the wells in the study area show As concentrations below the Bangladeshi permissible limit for drinking water (= 0.05 mg/l). Above the standard, there are 49 wells (16.5%) having As concentrations between 0.05 and 0.1 mg/l and 51 wells (17.2%) having As concentrations between 0.1 and 0.5 mg/l. The number of wells showing more than 1.0 mg/l of As concentration is 2 (0.7%). There is no significant change in As contaminated wells between the rainy season and the dry season.

Among Pourashava water supply systems in the study area, those in Jhenaidah Sadar, Mohespur Thana and Chuadanga Sadar exceeded the Bangladesh standard both in the rainy and dry seasons.

2) Arsenic Concentration Map

Figure 4.2.2 shows the distribution of As concentrations in the study area in the rainy season measured by AAS. The figure clearly shows that the contaminated areas having more than 0.05 mg/l of As are located mostly in the western part of the study area. On the other hand, less contaminated areas within 0.01 mg/l of As are found in the eastern part of the study area, which is bounded from the contaminated area to the west by a line with NNW-SSE orientation.

To know the changes of As concentration in detail, the change ratios of As concentration from the rainy season to the dry season were computed. Figure 4.2.3 shows the distribution of the change ratio of As concentration. As concentrations clearly decreased in the dry season from western Jessore District to central Jhenaidah District.

### 4.2.2 Groundwater Quality

1) Dissolved Iron ($Fe^{2+}$)

Figure 4.2.4 shows the distribution of $Fe^{2+}$ in groundwater measured with an Iron Pack Test Kit in the rainy season. Although the accuracy of the $Fe^{2+}$ measurement is limited, the distribution pattern of $Fe^{2+}$ concentrations is quite similar to that of As concentrations.
It seems that the $Fe^{2+}$ concentration tends to increase in the western half of the study area in the dry season. On the other hand, the concentration in the eastern part tends to decrease.

2) pH

It is known that the pH and ORP values control the occurrence of iron hydroxides and arsenic in groundwater. Figure 4.2.5 shows the distribution of pH values measured at the existing wells in the rainy season. In the study area, acidic groundwater is distributed in the central part of Jhenaidah District and Jessore District. Particularly in the northwestern part of Jessore District, acidic groundwater is distributed in a relatively wider area. On the other hand, there is no acidic groundwater in Chuadanga District. It is noted that the alkaline groundwater occurs along a NW-SE line across the study area from southern Chuadanga to eastern Jessore District. However, there is no clear correlation between the pH distribution and As distribution.
The pH values decreased in the western part of Chuadanga District and the southwestern part of Jessore District in the dry season. Increased pH values are seen in the eastern part of the study area.

3) Oxidation-Reduction Potential (Eh)

Figure 4.2.6 shows the distribution of Eh values in the study area in the rainy season. The lower Eh values less than 200 mV are widely distributed in the western part of the Study area. Particularly, the Eh values below 100 mV are found in the central to southern part of Jessore District, the western part of Jhenaidah District, and the southern part of Chuadanga District where the As concentration is high. On the other hand, higher Eh values more than 200 mV are mainly found from the eastern part of the Study area. The boundary between the high Eh area and low Eh area separated by 200 mV is located across the Study area with orientation of NNW-SSE. The distribution pattern of the lower values of Eh is similar to that of As concentrations.
Figure 4.2.7 shows the changes in Eh between the rainy season and the dry season. It is clearly shown that the Eh values in most parts of Jessore District increased 50 to 150 mV. On the other hand, the Eh values in central Chuadanga District, northern to central and western Jhenaidah District, and the southeastern part of Jessore District decreased 100 to 200 mV from the rainy season.

4) Electric Conductivity (EC)

Figure 4.2.8 shows the distribution of EC values measured at the existing wells in rainy season. Higher EC values more than 100 mS/m are found from southeastern part of Jessore District. The area is known to be affected by saline water from Khulna area. The high EC area is also correspond to the low ground elevation area. There is no correlation between the EC distribution and As distribution.

The EC values increased in the higher EC zone from southern Jessore District to Jessore Sadar thana in the dry season. Increased EC values are also seen in the northern part of Jhenaidah District and western parts of Chuadanga District.

5) Eh-pH-$Fe^{2+}$ Relationship

Figure 4.2.9 shows the relationship between Eh, pH, and $Fe^{2+}$ concentrations in the existing wells. Although the $Fe^{2+}$ concentration was tested with a field pack test kit, the results show that most of the samples having $Fe^{2+}$ concentrations of more than 1.0 mg/l have pH values ranging from 6.6 to 7.4 and Eh values ranging from 50 to 150 mV. The high concentration zone of $Fe^{2+}$ and the high concentration zone of As are located in almost the same domain, but the area of the high $Fe^{2+}$ zone is larger than that of the high As zone in the graph.

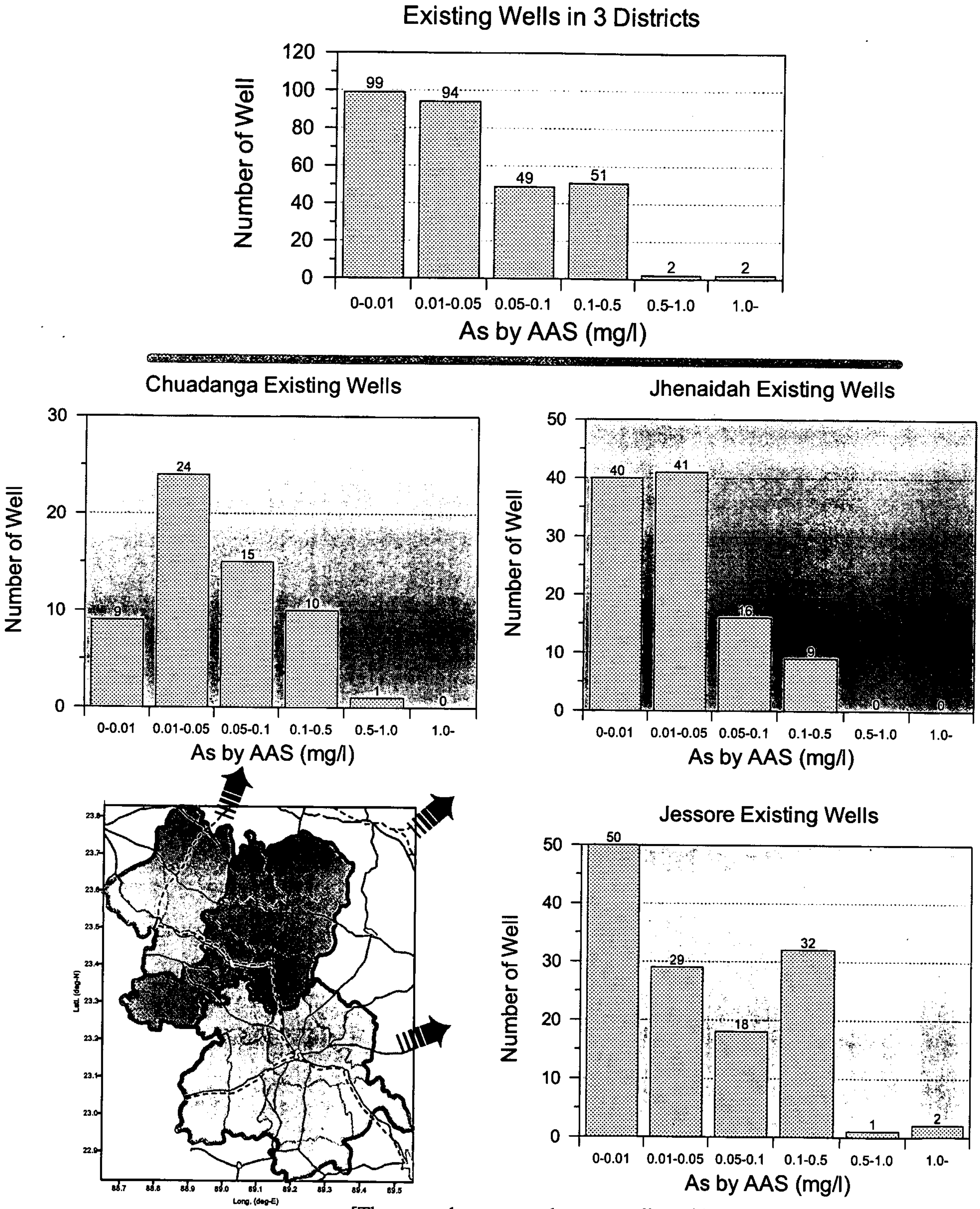
The relationships of Eh-pH-As and Eh-pH-$Fe^{2+}$ suggest that the occurrence of arsenic in groundwater is strongly correlated with the occurrence of iron. And the groundwater that is rich in arsenic and iron shows reducing conditions. This would be basic information to reveal the mechanism of groundwater contamination by arsenic as well as to design appropriate measures to remove arsenic from groundwater.

Compared with the plots in the rainy season, the high $Fe^{2+}$ zone in the dry season takes a narrower range in pH and wider range in Eh.

### 4.2.3 Comparison of FK and AAS

In the study, arsenic concentrations were measured with an AAN Field Kit in the field and with an AAS in a Jhenaidah laboratory. It will be very useful to know the correlation between the results of the field kit and AAS for evaluating the results as well as for planning future screening and monitoring programs.

Figure 4.3.10 shows the comparison of As concentrations measured with the AAN Field Kit and AAS by log-log plot for the rainy season. The results show that the field kit results tend to be lower than AAS results when As concentrations measured with AAS are below 0.044mg/l, and higher when above that value. The samples showing 0.01 mg/l with the FK range from 0.0025 to 0.13mg/l with the AAS. The samples showing 1.0 mg/l with the FK range from 0.13 to 1.6mg/l with the AAS.




[The groundwater samples were collected in June to July 2000.
The arsenic concentrations were analyzed by the AAS in Jhenaidah Laboratory.]

| Figure 4.2.1 | As Concentrations by District in Rainy Season Analyzed by AAS |
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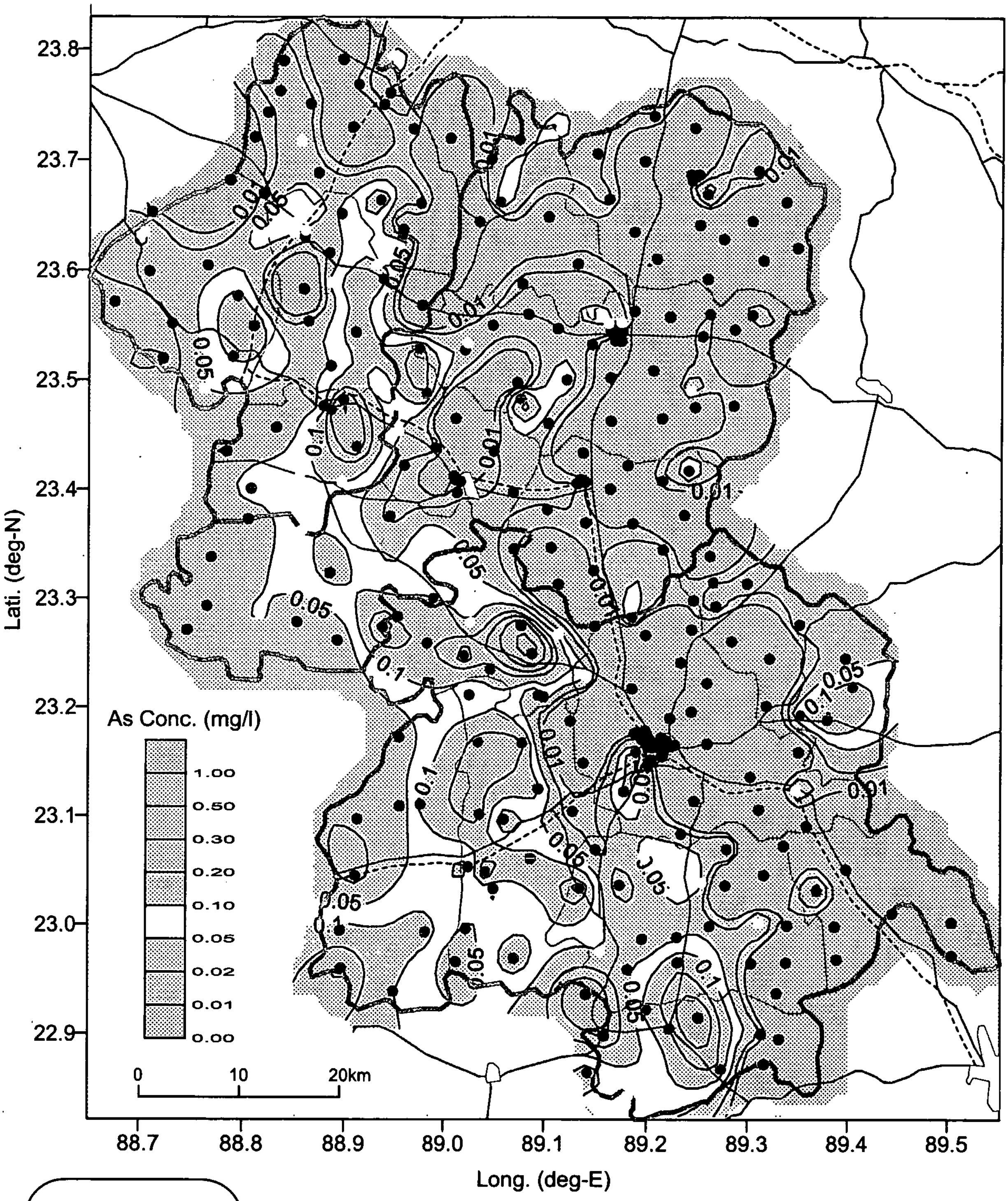


As (mg/l) analyzed by AAS
- 0 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.5
- 0.5 to 1
- 1 to 2

[The groundwater samples of 300 existing wells were collected in June to July 2000.]
[The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory established by the JICA Study Team.]

| Figure 4.2.2 | As Concentration in Rainy Season Analyzed by AAS |
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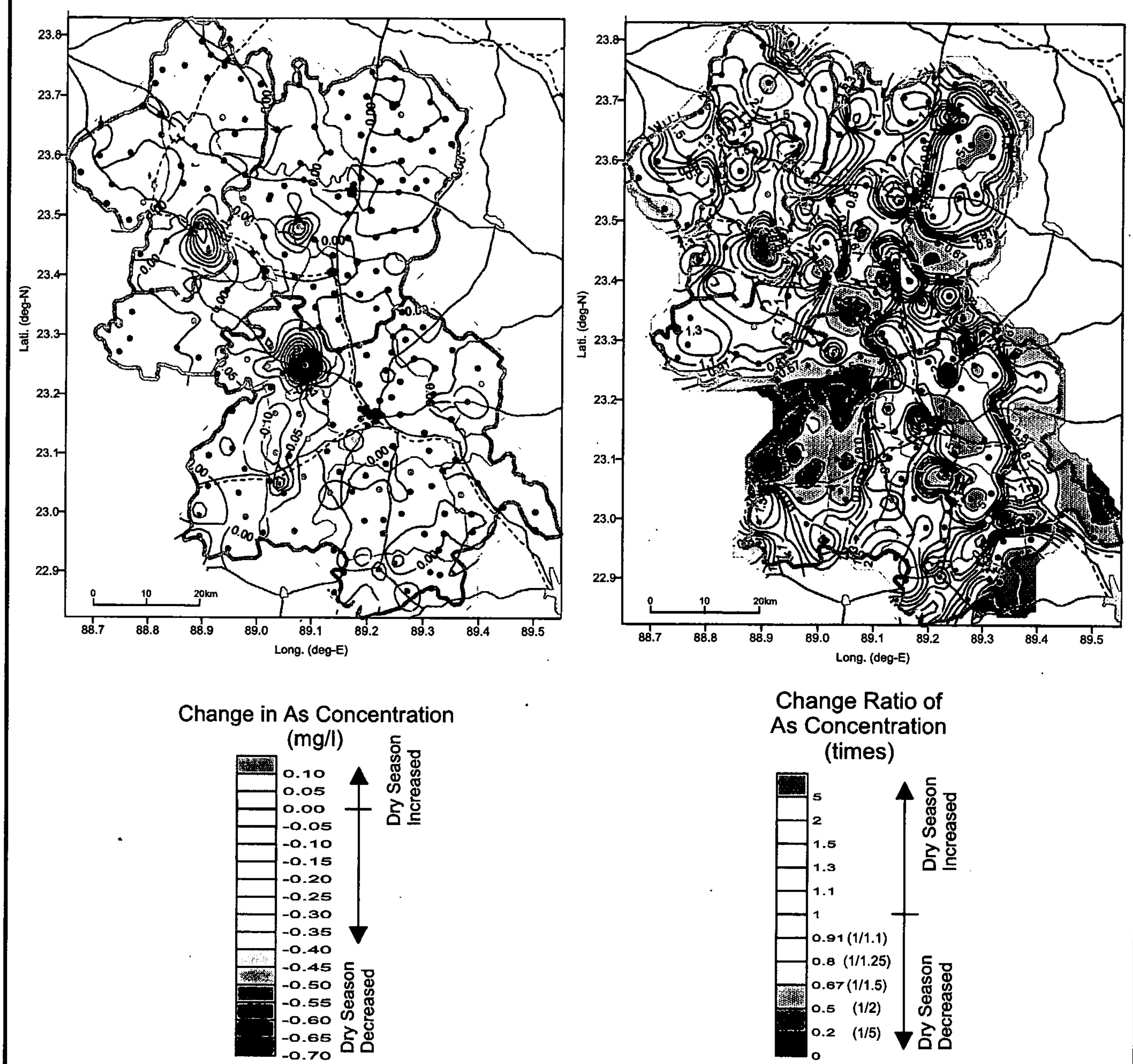


As (mg/l) in Dry Season analyzed by AAS

- 0 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.5
- 0.5 to 1
- 1 to 2

[The groundwater samples of 300 existing wells for rainy season and dry season were collected in June to July 2000 and December 2000 to January 2001, respectively. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory established by the JICA Study Team.]

| Figure 4.2.3 | Changes of As Concentration from Rainy Season and Dry Season |
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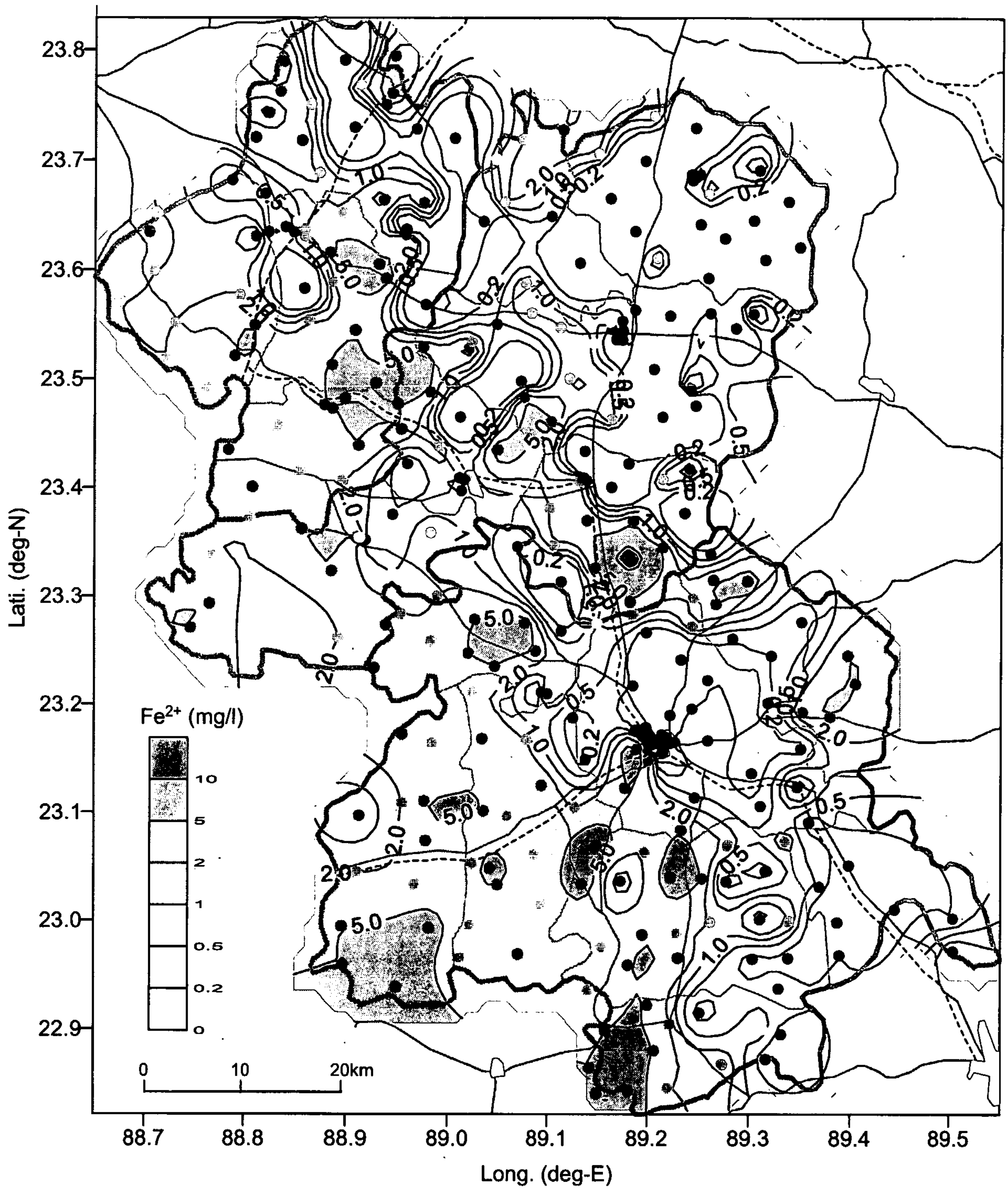


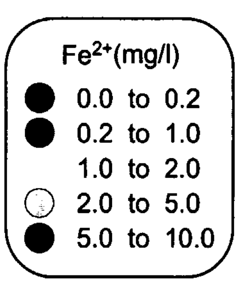


[Iron ($Fe^{2+}$) concentrations in groundwater of 300 existing wells were measured in June to July 2000 using Iron Pack Test Kit.]

| Figure 4.2.4 | Iron ($Fe^{2+}$) Concentrations Measured at 300 Existing Wells in Rainy Season |
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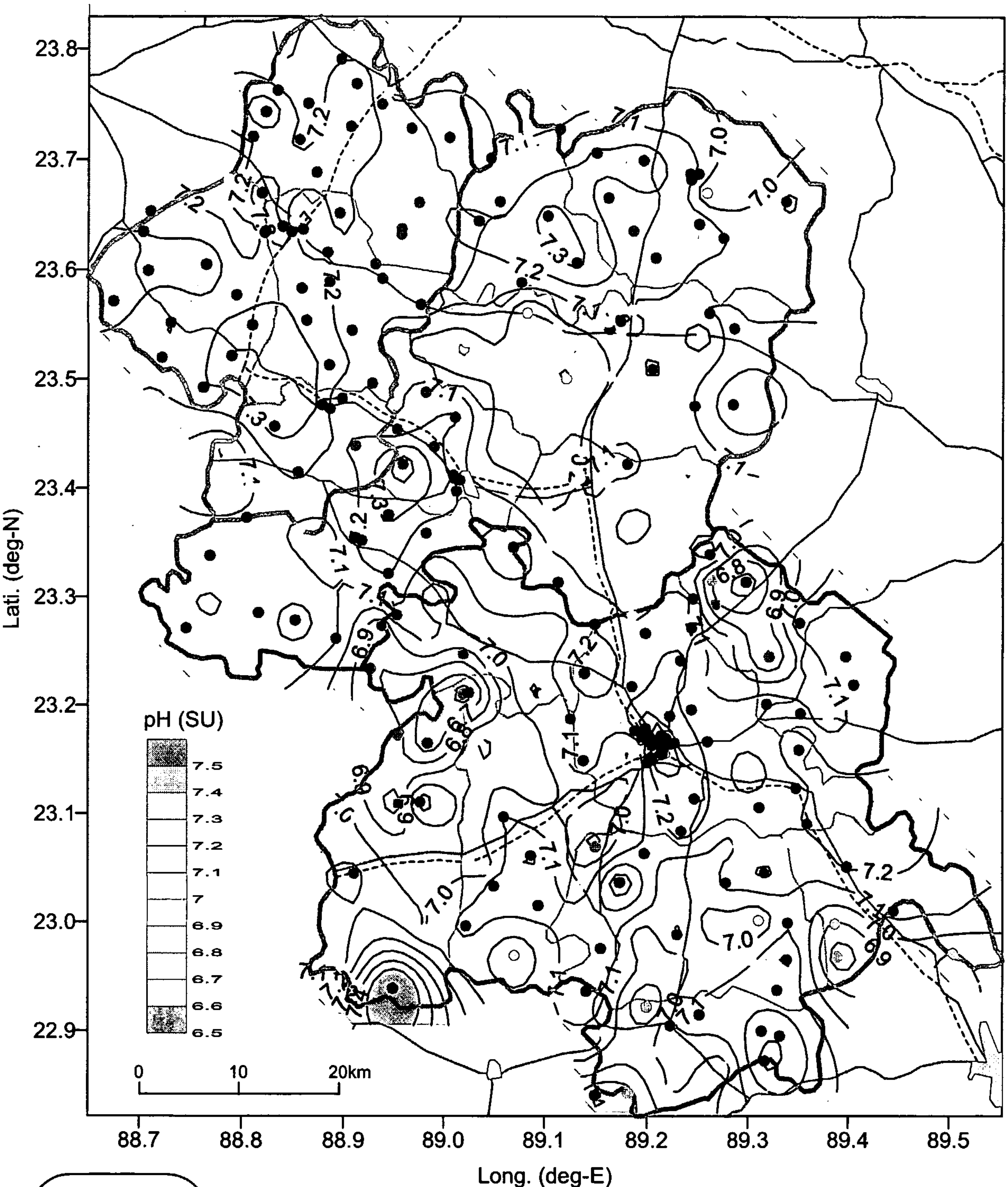


pH (SU)
- 6.5 to 6.7
- 6.7 to 6.9
- 6.9 to 7.1
- 7.1 to 7.3
- 7.3 to 7.5
- 7.5 to 7.8

[SU: Standard Units]

[pH values in groundwater of 300 existing wells were measured in June to July 2000 by potable pH meter.]

| Figure 4.2.5 | pH Values Measured at 300 Existing Wells in Rainy Season |
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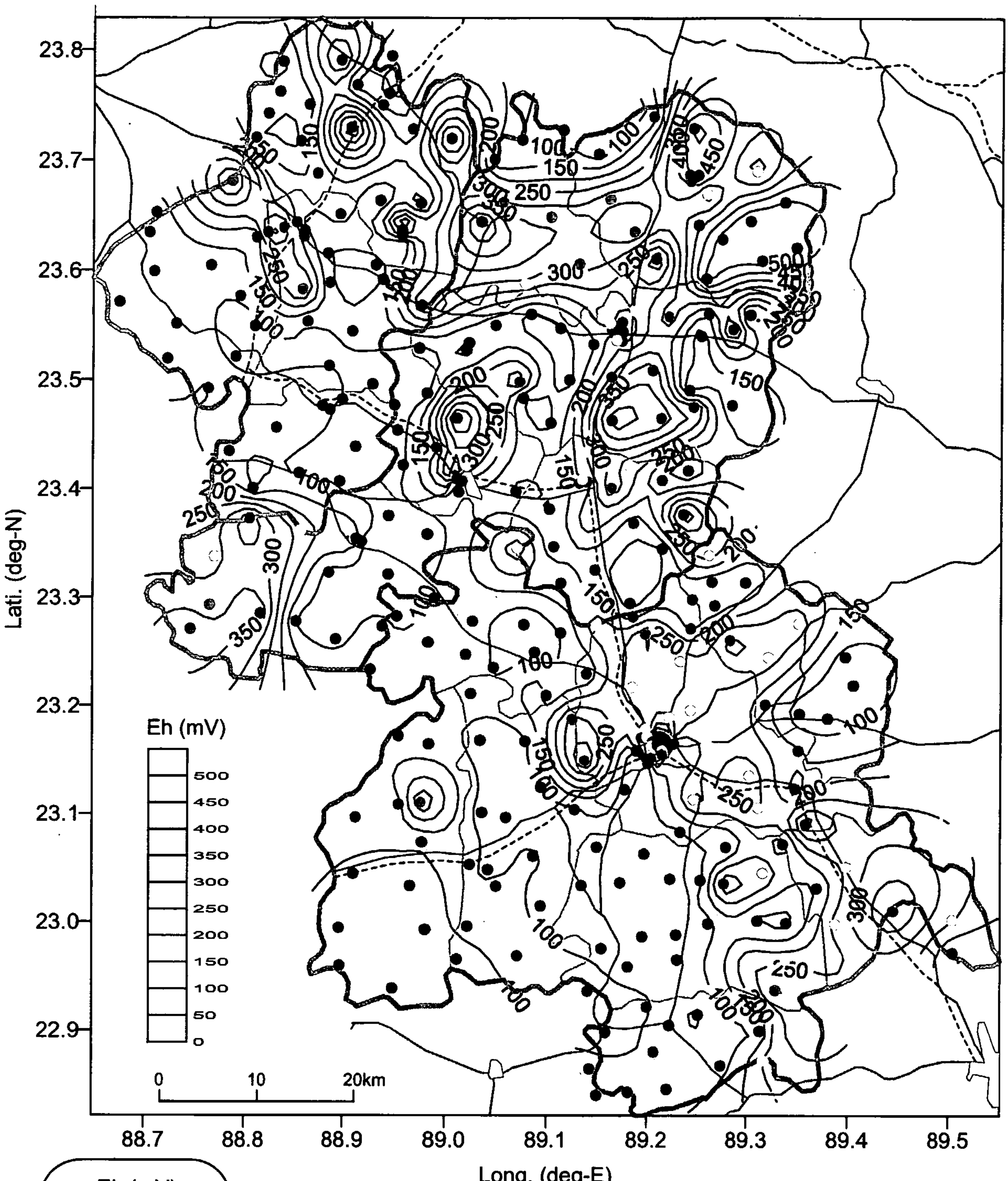


Eh (mV)
- 0 to 50
- 50 to 100
- 100 to 150
- 150 to 200
- 200 to 250
- 250 to 300
- 300 to 350
- 350 to 400
- 400 to 450
- 450 to 600

[ORP (Oxidation-Reduction Potential) values in groundwater of 300 existing wells were measured in June to July 2000 by potable ORP meter.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

| Figure 4.2.6 | Eh Values Measured at 300 Existing Wells in Rainy Season |
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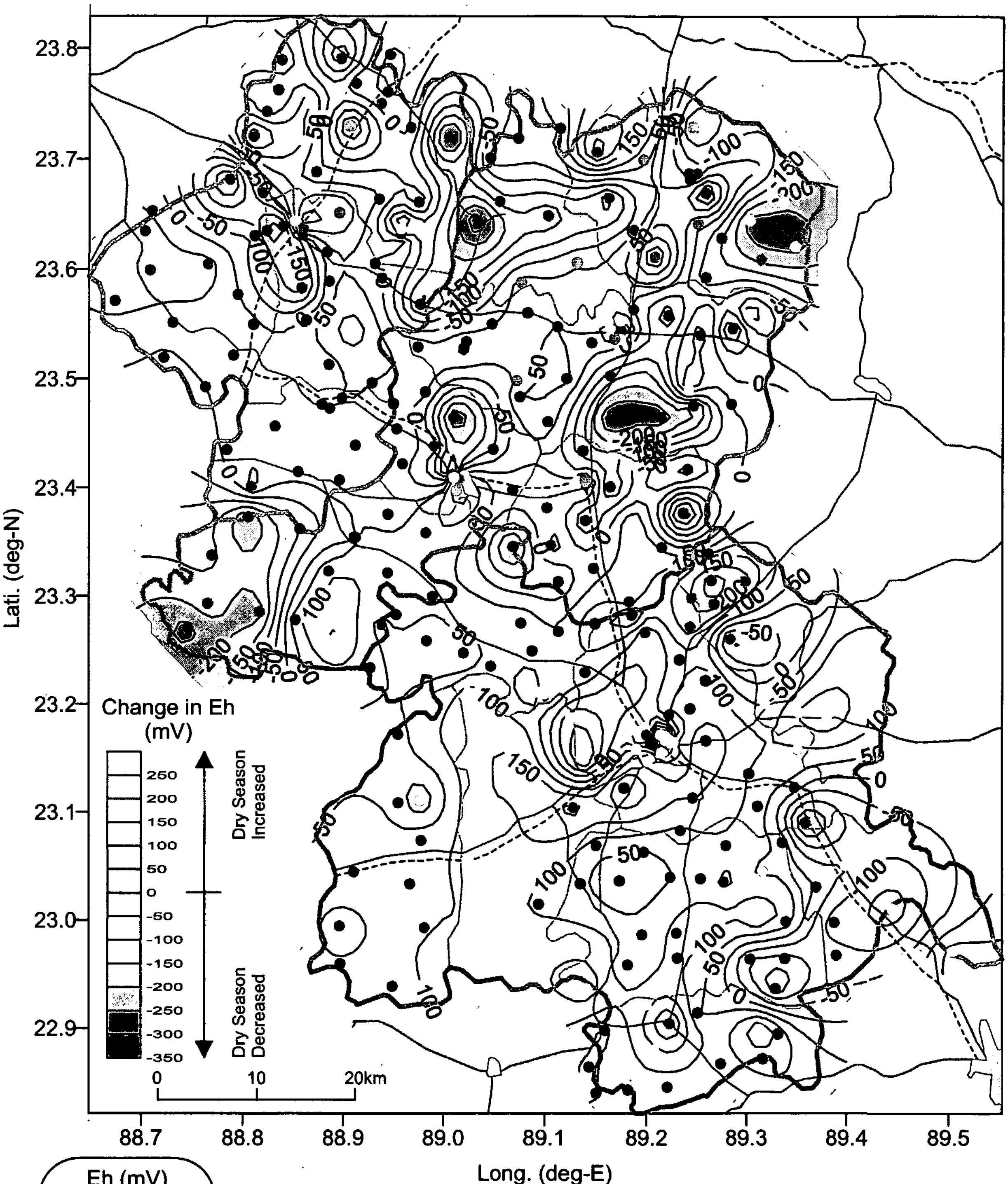


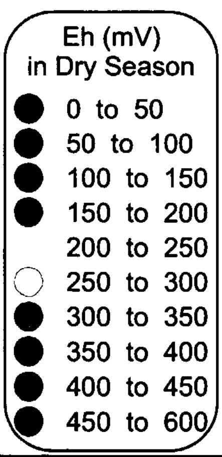


[ORP (Oxidation-Reduction Potential) values in groundwater of 300 existing wells were measured in June to July 2000 for rainy season and in December 2000 to January 2001 for dry season by potable ORP meter.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

| **Figure 4.2.7** | **Changes in Eh Value between Rainy Season and Dry Season** |
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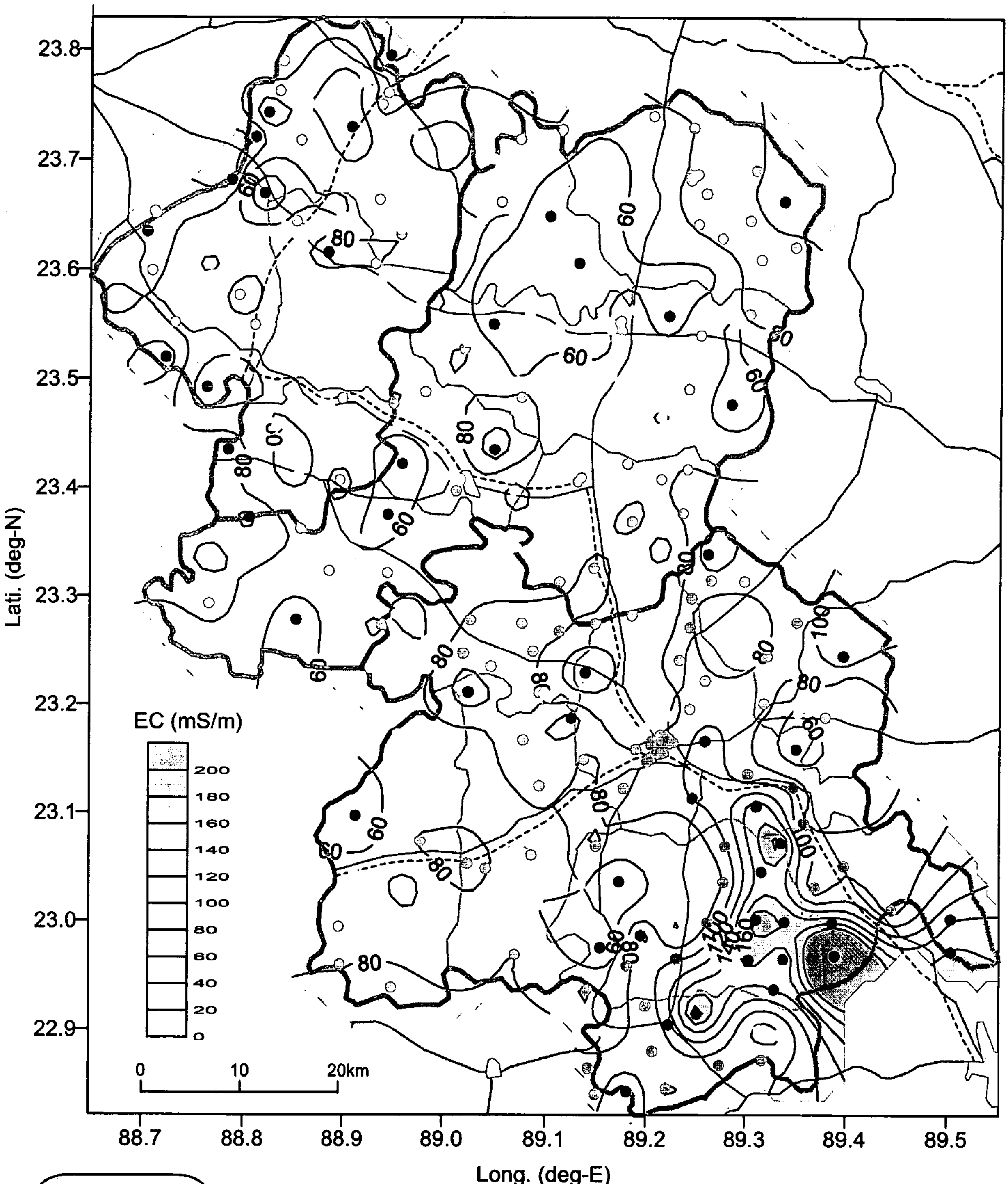


[Electric Conductivity (EC) in groundwater of 300 existing wells were measured in June to July 2000 by potable EC meter.]

| Figure 4.2.8 | Electric Conductivity (EC) Measured at 300 Existing Wells in Rainy Season |
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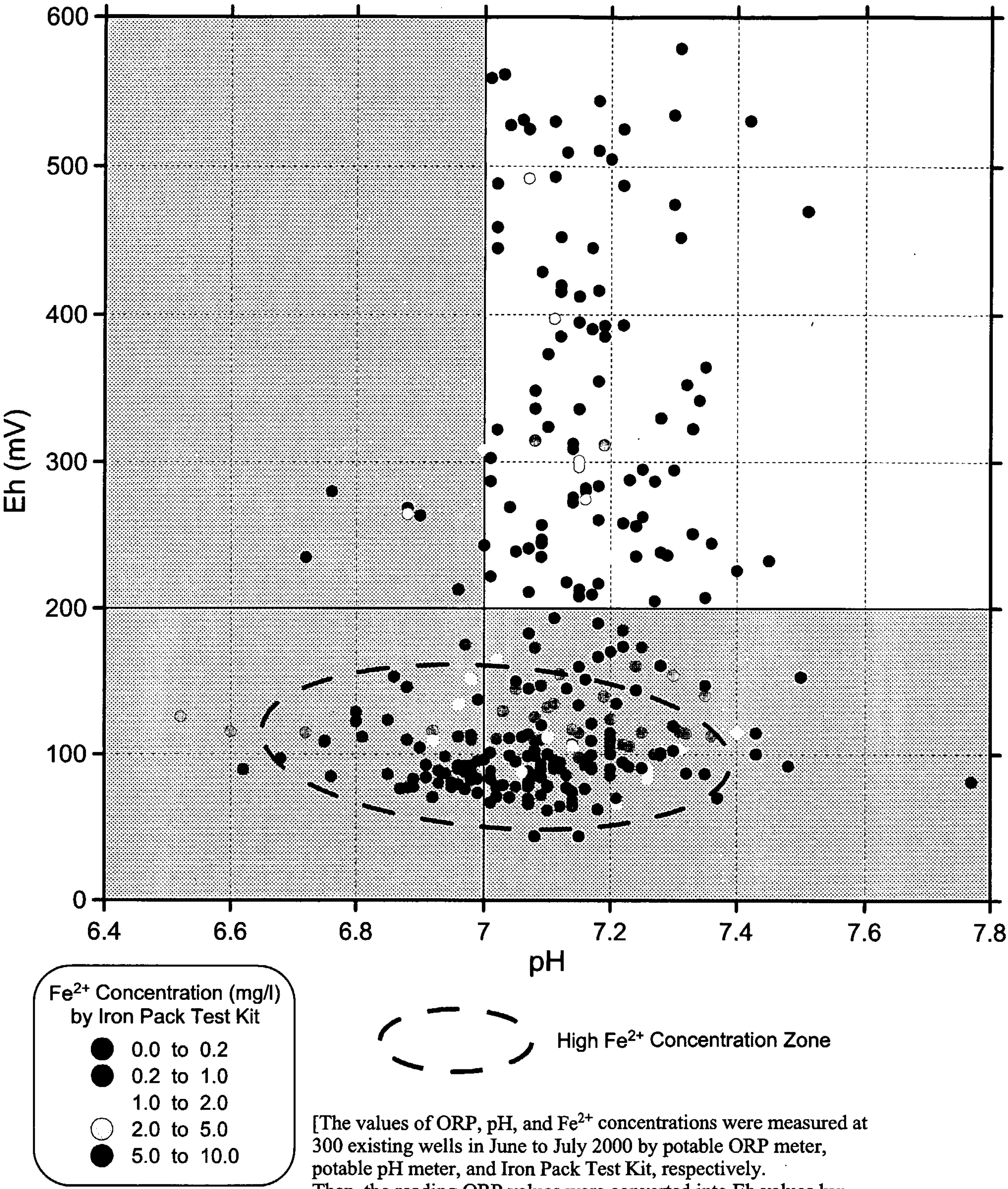


[The values of ORP, pH, and $Fe^{2+}$ concentrations were measured at
300 existing wells in June to July 2000 by potable ORP meter,
potable pH meter, and Iron Pack Test Kit, respectively.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

| Figure 4.2.9 | Eh-pH-$Fe^{2+}$ Relations of 300 Existing Wells Measured in Rainy Season |
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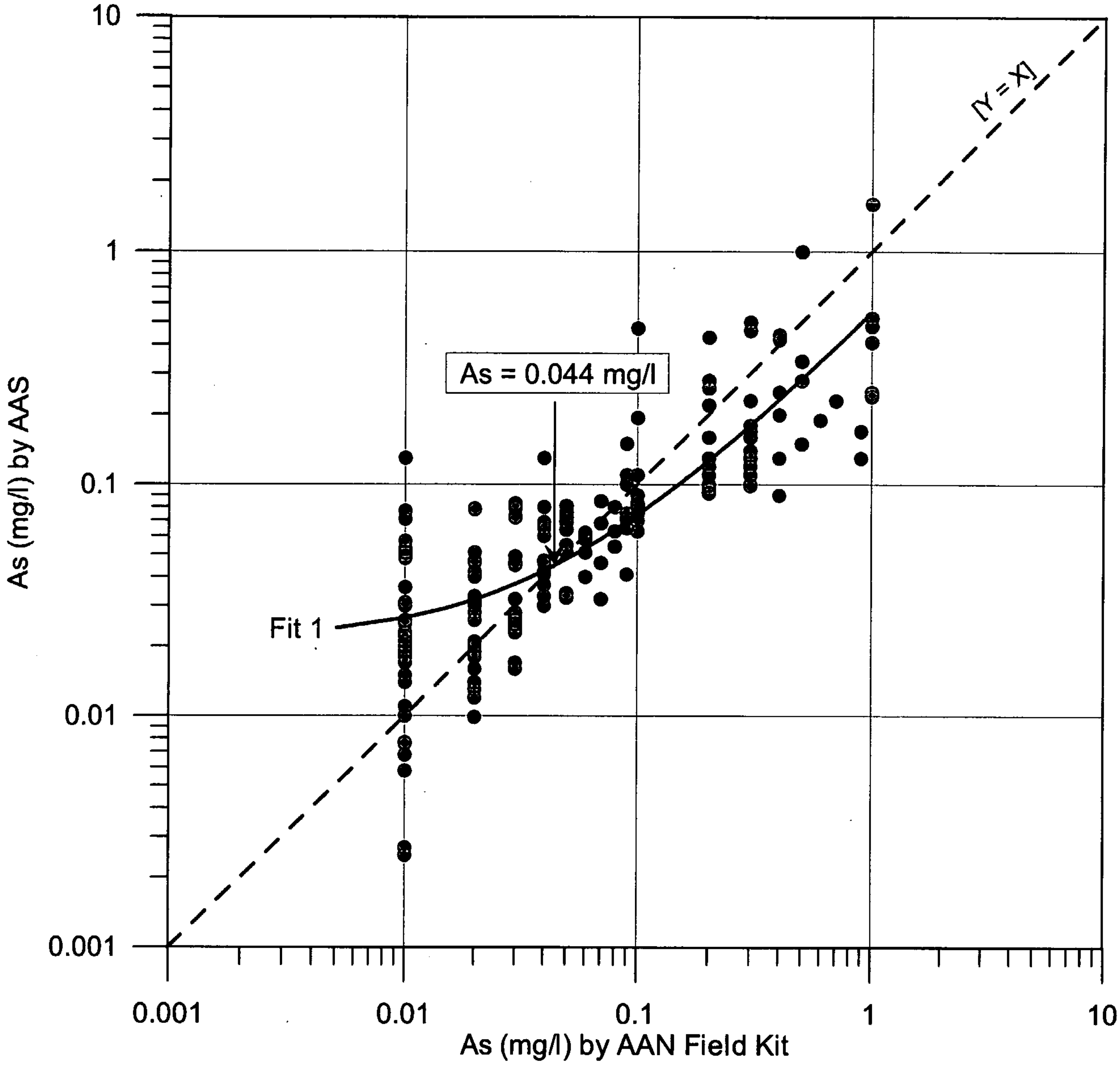


Fit Results

Fit 1: Linear
Equation Y = 0.5272264224 * X + 0.0212958878
Number of data points used = 297
Coef of determination, R-squared = 0.499782

(The arsenic concentrations were measured at 300 existing wells in June to July 2000.)

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| **Figure 4.2.10** | **Comparison of As Concentrations Measured by FK and AAS by Log-Log Plot in Rainy Season** |

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## 4.3 General Water Quality

A total of 30 groundwater samples for general water quality analysis were colleted from 23 existing tube wells and 7 production wells in Pourashava in the rainy season and the dry season.

### 4.3.1 Groundwater from Shallow Tube wells

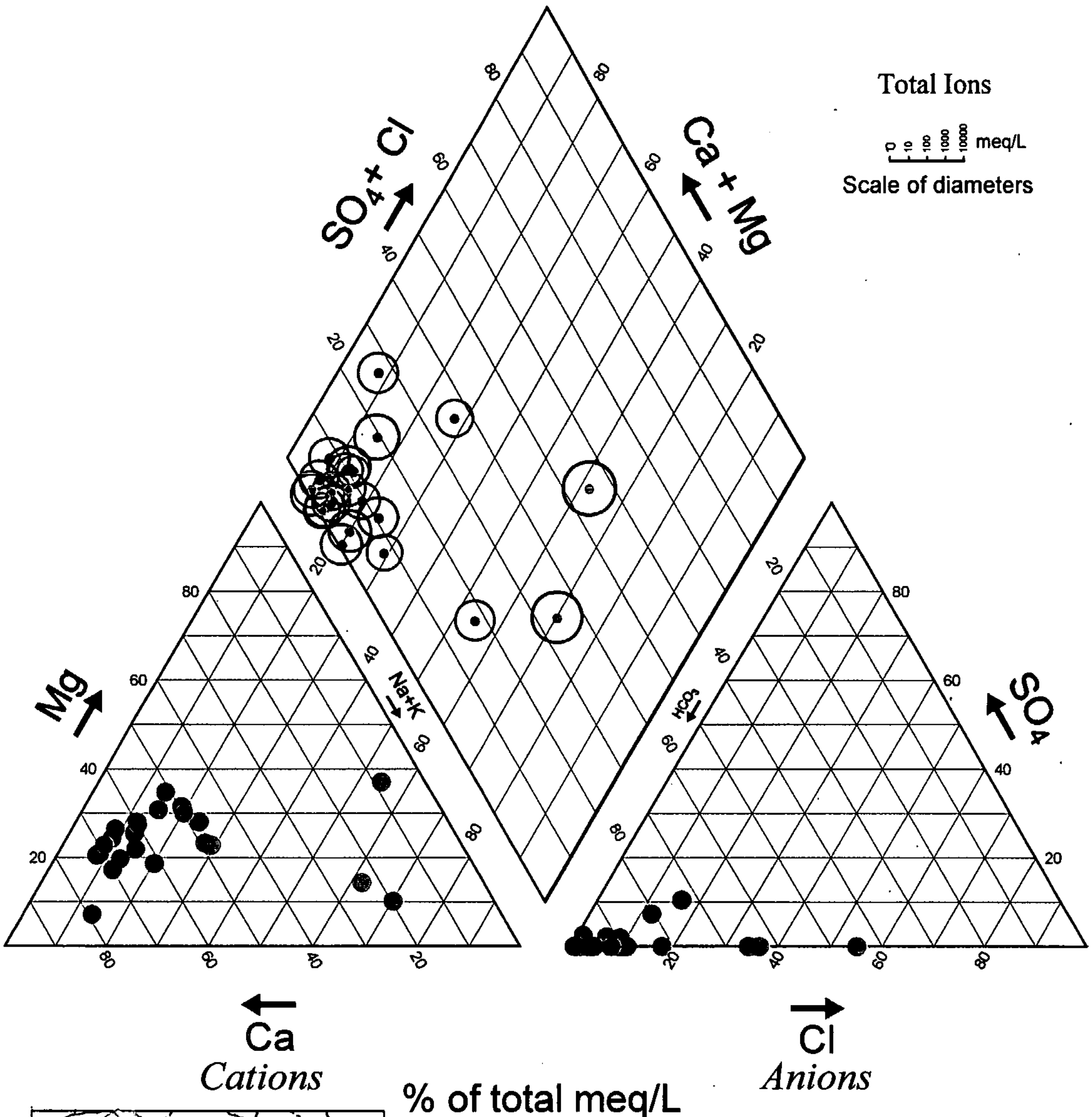
Figure 4.3.1 shows the trilinear diagram of shallow groundwater taken from 23 shallow tube wells in the rainy season. The well depths range from about 30 to 60 m. The results show that the most samples are plotted on the left corner of the diamond-shape diagram. The chemical compositions of these samples are characterized by Ca in cations and $HCO_3$ in anions. The $SO_4$ content is very small in all the samples. However, the samples colleted from the southern part of Jessore District are plotted in the central to lower parts of the diamond-shape diagram. These samples are characterized by higher contents of Na+K and Cl indicating that the groundwater compositions show a stronger influence of saline water. The chemical composition of the samples taken in the dry season is virtually the same as in the rainy season.

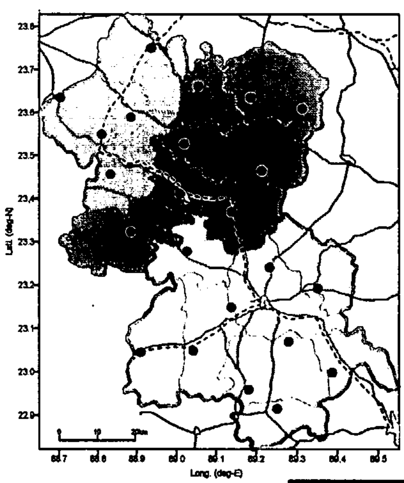
### 4.3.2 Groundwater from Production Wells

Figure 4.3.2 shows the trilinear diagram of groundwater from Pourashava production wells at the end of the rainy season. The depths of the production wells range from 100 to 130 m.

The trilinear diagram shows that the Chuadanga and Jhenaidah production wells show almost the same chemical compositions. In cations, Ca occupies 50 to 70%, and Mg occupies 20 to 35%. In anions, $HCO_3$ is dominant and the $SO_4$ content is very small.

The production well in Jessore is plotted in slightly different positions from the Chuadanga and Jhenaidah wells. In cations, the Na+K element occupies about 30%. In anions, Cl occupies about 30%. The chemical composition of the samples taken in the dry season is virtually the same as in the rainy season.



Shallow Tubewell Groundwater Samples

- Chuadanga District
- Jhenaidah District
- Jessore District

[A total of 23 groundwater samples were collected from shallow existing tubewells in June to July 2000 for the general water quality analysis.]

| **Figure 4.3.1** | **Trilinear Diagram of Shallow Groundwater by District in Rainy Season** |
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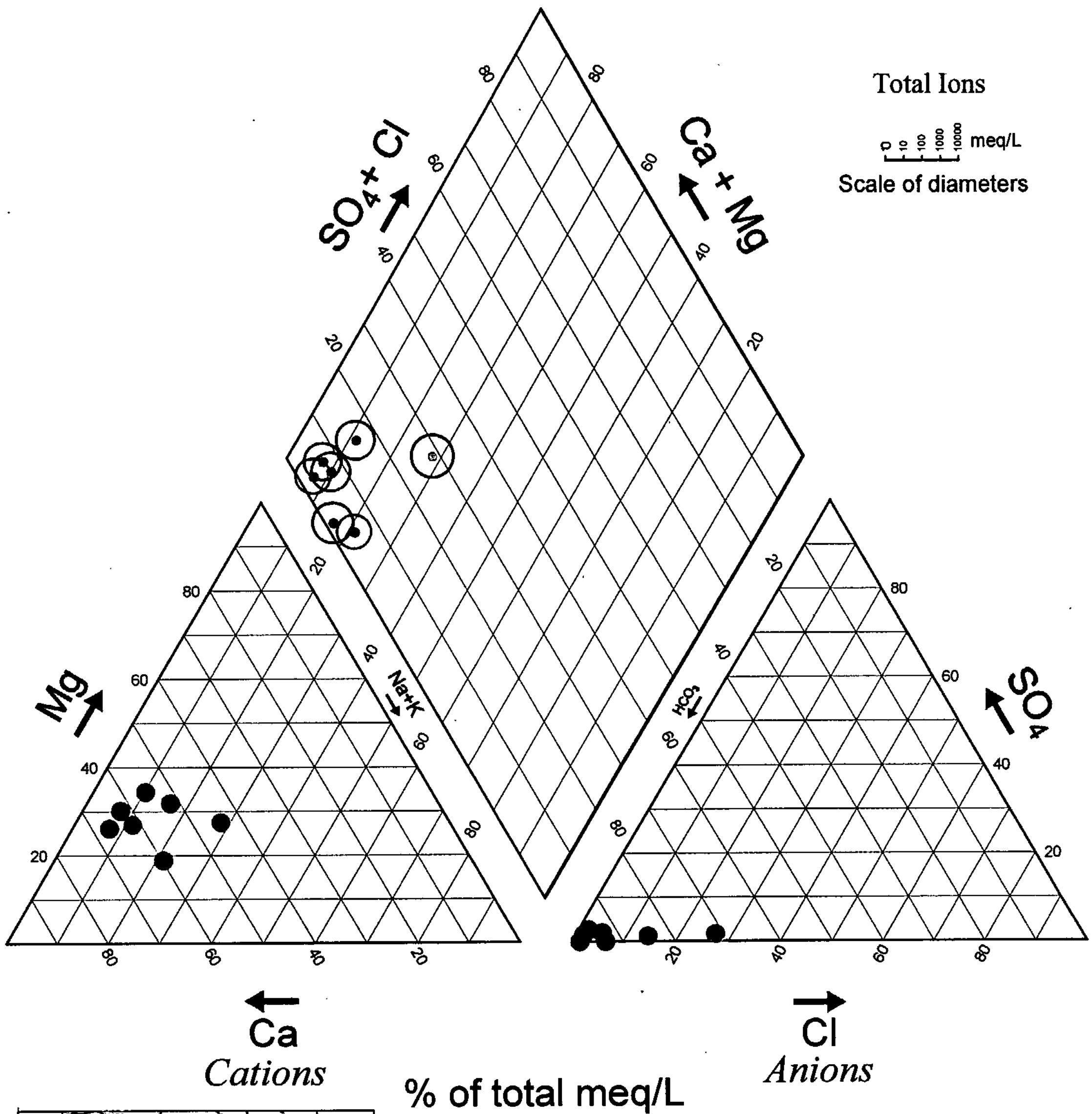


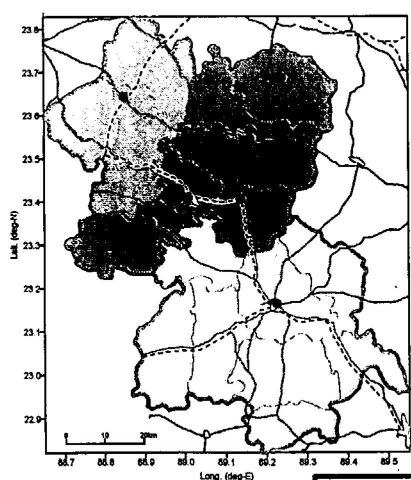


Production Well Groundwater Samples

- Chuadanga District
- Jhenaidah District
- Jessore District

[A total of 7 groundwater samples were collected from production wells in October 2000 for the general water quality analysis.]

| Figure 4.3.2 | Trilinear Diagram of Groundwater from Production Wells in Rainy Season |
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