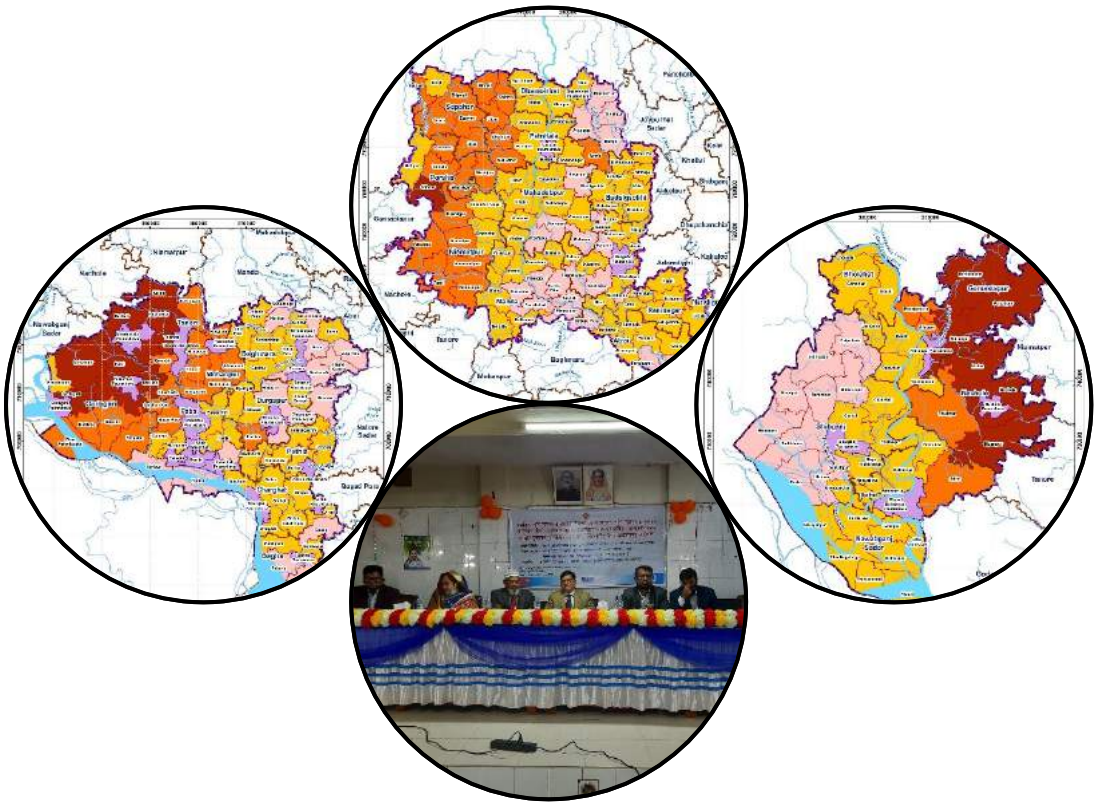
Government of the People's Republic of Bangladesh
Ministry of Water Resources
Water Resources Planning Organization (WARPO)

Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in Rajshahi, Chapai Nawabganj and Naogaon Districts

Under

Operationalizing Integrated Water Resources Management (IWRM) in Compliance with the Bangladesh Water Rules, 2018



Final Report
Volume- I: Main Report
June 2022

BCAS

IWM Water Environment & Climate

Cover Page Images

Top: Water Scarce map of Naogaon District

Bottom: Validation workshop at Mohanpur Upazila

Left: Water Scarce map of Rajshahi District

Right: Water Scarce map of Chapai Nawabganj District

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Memo No 42.07.016.05.05.2399.2022/3807 June 15, 2022

Director General
Water Resources Planning Organization (WARPO)
WARPO Bhaban, 72 Green Road
Dhaka, Bangladesh

Attn: Project Director, Operationalizing IWRM in compliance with the Bangladesh Water Rules, 2018, WARPO

Subject: Submission of Final Report on " Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in the Barind region"

Dear Sir,

In accordance with the provision of Terms of Reference (ToR), we are pleased to submit the Final Report in 25 (Twenty) copies on " Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in the Barind region".

The Final Report has been produced in 05 (five) volumes for the sake of clarity and ease comprehending the issues addressed during the study. **Volume-I** is the Main Report which contains the activities carried out during the study period, districtwise PRA reports, findings and recommendations. Upazilawise detailed PRA Report of Rajshahi district are provided in **Volume-II**. Similarly, upazilawise detailed PRA Report of Chapai Nawabganj and Naogaon districts are given in **Volume-III** and **Volume-IV** respectively. All the relevant appendices covering various field activities are provided in **Volume-V**.

Thanking you in anticipation and assuring you the best of services.

Yours sincerely,

Goutam Chandra Mridha
Director,
Irrigation Management Division
Institute of Water Modelling (IWM)

Enclosure: As stated

CC:

1. Executive Director, IWM
2. Deputy Executive Director (Opn), IWM
3. PL, P-52399

Water Environment & Climate

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Client	Water Resources Planning Organization (WARPO)	Client's contact	Project Director, Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018

Project Title	Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in the Barind region	Project No: P-52399

Division	Irrigation Management Division, IWM	Date	June 15, 2022
Contributors:	Md. Salim Bhuiyan (SMB) Goutam Chandra Mridha (GCM) Dr. Md. Rezaul Hasan (MRH) Md. Atiqur Rahman (ATQ) S.M. Sabahudin (SSN) Md. Saidur Rahman (SDH) Moonmoon Biswas (MBI) Biva Farzana (BVA) S M Shahriar Sifat (SFT) Sumit Kumar Saha (SKS) Md. Faysal Mahmud (FYL) Rafsan Al Amin (RAA) Jakia Sultana (JKS) Dr. Mahiuddin Alamgir, BCAS	Approved by Md. Zahirul Haque Khan Deputy Executive Director (Operations)	
Report type:	Final Report	Edited By MRH Project Leader	Reviewed by GCM Project Supervisor
Key Words:	Participatory Rural Appraisal (PRA), Barind region, Focus Group Discussion (FGD), Validation Workshop, Groundwater Scarcity.	Classification Open Internal √ Restricted within the parties concerned Confidential	

Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in Rajshahi, Chapai Nawabganj and Naogaon Districts

The Final Report consists of the following volumes:

Volume	**Title of the Report**
Volume-I	Main Report
Volume-II	Upazilawise PRA Report of Rajshahi District
Volume-III	Upazilawise PRA Report of Chapai Nawabganj District
Volume-IV	Upazilawise PRA Report of Naogaon District
Volume-V	Appendices

Executive Summary

Water Resources Planning Organization (WARPO) has been implementing a Project named 'Institutionalization of Integrated Water Resources Management (IWRM) process in compliance with the Bangladesh Water Act, 2013' to put the Water Act into practice and to understand local economic and social dynamics related to water management in line with the IWRM concept. The Phase I of the project (November 2014 – June 2018) has been completed, where a set of rules, known as the Bangladesh Water Rules (BWR) 2018 was developed and Water Management Guidelines have also been prepared. In the Phase II "Operationalizing Integrated Water Resources Management (IWRM) In Compliance with The Bangladesh Water Rules, 2018" has been taken up by WARPO, where "Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in the Barind region" is one of the three components of the Project. The study has examined in detail of baseline study to identify the state of surface water and groundwater resources up to mouza level through Participatory Rural Appraisal (PRA) approach in the Barind region, which covers 25 upazilas of three administrative districts namely: Rajshahi, Chapai Nawabganj and Naogaon.

Methodologically, it is based on consultation with the community through PRA and various other relevant actors from the validation workshop and secondary information from different sources for supporting pilot operationalization of the Bangladesh Water Rules, 2018. The local people i.e., the participants at mouza level have shared a comprehensive overview on state of water resources which reveals valuable information/data on the resources existing in the respective villages. IWM has divided the study area comprising 5070 mouzas into 126 clusters having +/- 40 (forty) mouzas in each of the clusters, where one representative from each mouza participated in the FGD. For each cluster, FGD were organized in two sessions, where maximum 20 representatives participated among which one-third participants are women.

A total 25 numbers of PRA validation workshops have been conducted from 26/12/2021 to 20/01/2022. The workshops were presided over by the respective UNO of each Upazila. The participants of each upazila PRA validation workshop were respective Upazila Chairman and Vice Chairmen, AC Land, PIO, Officer in-charge of Thana, UP Chairman/Secretary, relevant govt. officials at upazila level, WARPO and BWDB

officials, WMG/WMA, expert team of the consultants, etc. The findings from the FGD and validation workshops are presented below:

- ✓ The amount of surface water in the study areas has decreased significantly, because of increasing population, improper management of water bodies, unplanned urban sprawl, agricultural land conversion to non-agriculture land and so on.

- ✓ The beels located in the central part of Rajshahi district should be re-excavated to deeper extents for surface water retention and preservation for round the year irrigation, fish culture and household purposes. Beels those needs to be re-excavated in Rajshahi district are Kantar beel at Puthia; beels at Darshan Para union of Paba; beels located at two unions namely Dhurail and Royghati under Mohanpur; and beels of Baghmara and Durgapur. For Naogaon district, the beels are at four unions of Atrai namely Bisha, Kalikapur, Maniari and Panchupur; Masho and Chuary Beels of Raninagar; beels at two unions of Manda namely Bharso and Tentulia; beels at three unions of Naogaon Sadar namely Sekherpur, Dubalhati and Hashaighari. There are several beels in Sapahar among which Damudahar Beel, Dak Beel at Aihai union, Kayamar Beel at Pathari union and Baksha Beel, Puroil Beel, Mahil Beel, Jaba Beel at Goala union; beels at Nithpur union of Porsha; and Chhatra Beel of Niamatpur – all these are located in Naogaon district. Similarly, beels to be re-excavated in Chapai Nawabganj district are Bhatia Beel, Sonajal Beel and Amgachi Beel under Bholahat; beels at Radhanagar union of Gomastapur; and Tali Beel and Anil Beel of Nachol.

- ✓ Total number of ponds in the study area is 52,629 among which 18,808 in Rajshahi, 28,877 in Naogaon and 4944 in Chapai Nawabganj. The ponds of large sizes greater than 100 decimals in Rajshahi, Naogaon and Chapai Nawabganj are 2835, 3800 and 663 respectively.

- ✓ The groundwater level (GWL) has dropped remarkably, due to excessive abstraction for the purpose of increasing agricultural productivity, especially during the Boro rice cultivation (crop planted from December to early February and harvested between April and June). There are 3,656 deep tubewells (mainly for irrigation) and 180,508 active shallow tubewells in Rajshahi district.

The study revealed that 4,533 deep tubewells and 340,944 active shallow tubewells in Naogaon; and 1,644 deep tubewells and 96,418 active shallow tubewells in Chapai Nawabganj. Tubewell density map and groundwater scarce map for each district has also been developed and incorporated in the report. These types of maps for each upazila are given in Volume- II to Volume-IV.

- ✓ Other factors contributing in depleting GWL are: increased crop water demand during dry season; less monthly average rainfall (mm) compared to other parts of the country; increase monthly average evapotranspiration (mm); increased utilization of STWs and DTWs in both domestic and non-domestic purposes. Moreover, submersible pump operated tubewells are being used for household purposes.

From the investigations, it is found that there is no upazila where the GWT remains within the suction limit round the year. Almost all the upazilas under the study area are facing water scarcity during the dry season. Considering the critical depth and suggestions received from PRA validation workshops at upazila level, eight upazilas of the study area falls in severe groundwater scarce zone. The GWT of three upazilas of Rajshahi (i.e., Tanore, Godagari and Mohanpur), three upazilas of Naogaon (i.e., Niamatpur, Porsha and Sapahar), and two upazilas of Chapai Nawabganj (i.e., Nachol and Gomastapur) go below the critical depth during most of the months in a year.

Feedback from the public and stakeholders consultation through the validation workshops, some comments have been raised including (i) the groundwater level dropping and rainfall decreasing alarmingly over the years in Tanore Upazila of Rajshahi district, the residents of the areas have to give extra effort in bringing water from deep tube wells far away from their residence; (ii) The idea of many farmers are “Reality that DTWs may have silence crop diversification as they attempt to uphold water security to increase production in areas, where groundwater levels may decline”; (iii) Many farmers of DTWs user’s areas gain better crop yields, saving time and money as well, whereas, villagers relying on STWs are already facing problems regarding water availability. So, based on the geographical location farmers are using DTWs or STWs, which makes a difference in the developmental trajectory of the community; (iv) It was strongly demanded that rivers/canals/kharies should be embanked and re-excavated to allow

channelized flow and retain water even up-to the dry season; (v) Emphasis is recommended on the use of surface water to reduce dependence on groundwater; (vi) The respective departments of Upazila need to be made aware to improve the efficiency of agricultural water use, diversify cropping patterns, and produce low water consuming crops; and (vii) Iron is present almost everywhere and arsenic has been noticed somewhere in the shallow depth aquifer.

Similarly, the present study has been incorporated subjects related to the state of water resources such as, socioeconomic, gender, land use pattern, biodiversity, environment, forest, agriculture, fisheries, livestock, and poultry sectors. Also, upazila based information obtained from the FGD is given in volume-II to Volume-IV and validation workshop is included in Volume-V.

Moreover, based on the present study and secondary data analysis, it can be concluded that availability of both surface water and groundwater has been reducing over time. Regardless, future research should continue to explore surface water and groundwater sources. Therefore, apart from research for sustainable water resources planning and management in the high Barind region, there is a need for this research in other areas of Bangladesh as well. The salient recommendations of the study are given below:

1. Water resources are limited, so its equitable use should be encouraged. Therefore, emphasis is recommended on the use of surface water to reduce dependency on groundwater.
2. All rivers/canals/kharies should be embanked and re-excavated to enlarge the water retention capacity for irrigation, fish culture and household purposes for the most part of the year, which will reduce dependency on groundwater. However, these should be taken up by the relevant implementing organization following a detailed feasibility study.
3. The ponds of large sizes (>1 acre) should be re-excavated to a deeper extent for wider use in fish culture and household purposes.
4. The respective departments need to be made aware to improve the efficiency of agricultural water use, diversify cropping patterns, and produce low water consuming crops.

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Acronyms and Abbreviation

BBS	Bangladesh Bureau of statistics
BCAS	Bangladesh Centre for Advance Studies
BDP	Bangladesh Delta Plan
BGS	British Geological Survey
BMDA	Barind Multipurpose Development Authority
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
BWP	Bangladesh Water Policy
BWR	Bangladesh Water Rules
CHT	Chittagong Hill Tracts
CNG	Compressed Natural Gas
DASCOH	Development Association for Self Reliance Communication and Health
DFR	Draft Final Report
DPHE	Department of Public Health Engineering
DTW	Deep Tubewell
EH	Eastern Hill
ECNWRC	Executive Committee of National Water Resources Council
FAP	Flood Action Plan
FGD	Focus-Group Discussion
FYP	Five Year Plan
GIS	Geographic Information System
GWL	Groundwater Level
GWT	Groundwater Table
GW	Groundwater
HBT	High Barind Tract
HBR	High Barind Region
HIES	Household Income and Expenditure Survey
HL	High Land
HTW	Hand Tubewell
HYV	High Yielding Variety
IWM	Institute of Water Modelling
IWRM	Integrated Water Resources Management
LIV	Local Improved Variety
MCM	Million Cubic Meter
MHL	Medium High Land
ML	Medium Land
MLL	Medium Low Land

MTR	Midterm Report
NGO	Non-Governmental Organization
NWMP	National Water Management Plan
NW	North West
NWP	National Water Policy
PIO	Project Implementation Officer
PD	Project Director
PRA	Participatory Rural Appraisal
RS	Remote Sensing
RW	Rain Water
RE	Rivers and Estuaries
SPI	Standard Precipitation Index
STW	Shallow Tubewell
SW	Surface Water
ToR	Term of Reference
TL	Team Leader
UNO	Upazila Nirbahi Officer
VLL	Very Low Land
WARPO	Water Resources Planning Organization

1 Introduction

1.1 Background

The water sector worldwide is increasingly passing through a crisis of governance and its sustainable solutions require a holistic water governance that would encapsulate in the Integrated Water Resources Management (IWRM) concept. To face the growing challenges regarding water rights, protection of resources, water use, and water services management, Bangladesh has enacted a comprehensive legal framework called the Bangladesh Water Act 2013.

To put the Bangladesh Water Act 2013 into practice and to understand local economic and social dynamics related to water management, as Phase-I a Project named 'Institutionalization of Integrated Water Resources Management (IWRM) process in compliance with the Bangladesh Water Act, 2013' has been implemented through Water Resources Planning Organization (WARPO). The Phase I of the project (November 2014 – June 2018), in consultation with stakeholders, developed a set of rules, known as the Bangladesh Water Rules (BWR) 2018. In addition, Water Management Guidelines have also been prepared in that Phase, and various activities have been undertaken to organize local IWRM Committees to pilot IWRM in water scarce area in Barind region.

The Bangladesh Water Rules (2018) clearly demonstrates that Bangladesh has been advancing towards the goal of sustainable development for water resources. At a local scale, the problems of water scarcity in the Barind region continue unchecked. Even though installation of new public irrigation wells has been stopped and existing irrigation and drinking water wells are being abandoned or operate at reduced capacity, the water table continues to fall. Awareness of the problems inside and outside the region, is increased but initiatives to reverse the lowering trends of groundwater are piecemeal, inadequate, and not coordinated. Though, the first IWRM project has taken important corrective measures against the problems, still much more is needed to coordinate, implement, and facilitate water-saving actions and to address the water scarce situations. Current activities in the Barind region offer opportunity for WARPO to bring about a solution to water scarce problem in short or medium term only. Although the problems of the groundwater dependent Barind region are relative and not so complex and are quite

amendable to solution, building on the success of the first phase, a next phase of the project has been felt necessary to implement the Bangladesh Water Rules 2018 and to advance IWRM goal of achieving sustainable abstraction from the Barind aquifer which leads to formulate the present "Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018" where, "Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in the Barind region" is one of its component. The Project will promote and facilitate the operationalizing of the Bangladesh Water Rules, 2018; however, most of the activities will be targeted at piloting the implementation of the Rules, Guidelines, IWRM interventions and assessment of state of water resources in the administrative limits of Rajshahi, Chapai Nawabganj and Naogaon districts in the Barind region.

IWM has been awarded to conduct this PRA study component of the project. Accordingly, a contract agreement was signed on February 23, 2021 between WARPO and the JV of Institute of Water Modelling (IWM) and Bangladesh Centre for Advance Studies (BCAS).

The Inception Report, the Mid Term Report, and Draft Final Report (DFR)was submitted in due time. Incorporating the suggestions on DFR made by the Technical Committee members, the Final Report has been prepared. Minutes of the meeting is given in Annex-B and accordingly a compliance report has also been incorporated in the Annex -C of this report.

1.2 Objectives of the Study

The main objective of this study component is to perform baseline study to identify the state of surface and groundwater resources (water availability, demand, and use) in the Barind region up to Mouza level through Participatory Rural Appraisal (PRA) approach for supporting pilot operationalization of the Bangladesh Water Rules, 2018.

The specific objectives of this study are

- ✓ to identify the water sources, present water use scenario and sectoral water demand up to union/mouza level of the project area,

- ✓ to prepare detail assessment report of the baseline condition incorporating local people's needs, views and preferences on water resources management required for operationalizing the Bangladesh Water Rules, 2018, and
- ✓ to facilitate monitoring with a view to create improved environment for sustainable water resources planning and management in the Barind region.

1.3 Scope of Works

The major activities that will be performed to fulfill the study objectives through PRA will include (a) an inventory of all local water resources and the way they are presently used; (b) the perceptions of local interest groups on water related constraints in relation to domestic, agricultural, fisheries, navigational, environmental and other usage; and (c) the perception of the various local interest groups on solutions to resolve the constraints identified and their positive and negative impact on the various local interest groups.

Activities to Perform:

1. Perform the baseline study, identify the water sources, present water use scenario and sectoral water demand up to union/mouza level of the Barind region through Participatory Rural Appraisal (PRA) process.
2. Conduct Focus-Group Discussion (FGD) meetings through PRA at Mouza level; each meeting will cover 40 Mouzas. At least one-third of the participants will be women.
3. Identify the current location and status of observation/monitoring wells and irrigation borehole logs for each mouza of the Barind region.
4. Establish baseline condition concerning population, natural resources, land use and farming systems, agricultural practices and their constraints and opportunities.
5. Ensure equitable account of views of different socio-economic group; identify special needs and aspirations of specific group like women, marginal farmers, land less group, fishermen and minority groups.
6. Incorporate people's needs, views and preferences in regarding water availability, water demand and water use in the study area through people's participation and associated consultation process at local level with PRA approach.

7. Prepare all physical features of land use inventory using GIS application and satellite image processing; develop GIS, RS and Time Series database collected from different primary and secondary sources.
8. Prepare a detail PRA report with comprehensive maps for water availability, water use, water demand, water scarce areas, water zoning, aquifer formation and location and status of monitoring wells in the Barind region.
9. Validate the PRA report at Upazila level for each Upazila in the Barind region.

1.4 Expected Outputs

The major outputs of the study are as follows:

(i) Comprehensive maps for water availability, water use, water demand, water scarce areas, water zoning, aquifer formation and recharge potentials in the study area.

(ii) Base map of the study area using information from PRA showing observation/ monitoring wells, rivers and canals and wetlands.

(iii) Maps showing population, natural resources, all physical features of land use inventory and agricultural practices in the study area.

1.5 Checklist on Compliance of Activities

The Table 1-1 presents indications of the respective activities as given in Section 1.3, where salient activities of the study are addressed in this Final Report of PRA study.

Table 1-1: Major Activities and its relevant sections

Sl. No.	Activities to perform	Addressed in Chapter/Section
01	Perform the baseline study.	Chapter 4
02	Conduct Focus-Group Discussion (FGD) meetings through PRA at Mouza level; each meeting will cover 40 Mouzas. At least one-third of the participants will be women.	Section 4.3.9
03	Identify the current location and status of observation/monitoring wells and irrigation borehole logs for each mouza of the Barind region.	The status of tubewells is given in the "Water Resources" section of each Upazila as presented in the Volume-II to Volume-IV.

Sl. No.	Activities to perform	Addressed in Chapter/Section
		Observation/monitoring wells and irrigation borehole logs will be addressed in the 2nd component of the Project.
04	Establish baseline condition concerning population, natural resources, land use and farming systems, agricultural practices and their constraints and opportunities.	Volume-II to Volume-IV.
05	Ensure equitable account of views of different socio-economic group; identify special needs and aspirations of specific group like women, marginal farmers, land less group, fishermen and minority groups.	Volume-II to Volume-IV.
06	Incorporate people's needs, views and preferences in regarding water availability, water demand and water use in the study area through people's participation and associated consultation process at local level with PRA approach.	Reflected and presented in Volume-II to Volume-IV.
07	Prepare all physical features of land use inventory using GIS application and satellite image processing; develop GIS, RS and Time Series database collected from different primary and secondary sources.	All relevant physical features are shown in the figures of each Upazila PRA given in Volume II to Volume-IV. The time series database will be given in the 2nd component of the Project.
08	Prepare a detailed PRA report.	Volume-II to Volume-IV.
09	Validate the PRA report at Upazila level for each Upazila	Each Upazila in Volume II to Volume-IV.

1.6 Structure of the Report

This report is the Final Report of "Participatory Rural Appraisal (PRA) / Baseline Study of the State of Water Resources in Rajshahi, Chapai Nawabganj and Naogaon Districts".

This report contains the activities carried out during the study period, findings and recommendations. The report is presented in five volumes for sake of clarity and ease of comprehending the issues addressed during the study. The volumes are as follows:

Volume	Title of the Report
Volume-I	Main Report
Volume-II	Upazilawise PRA Report of Rajshahi District
Volume-III	Upazilawise PRA Report of Chapai Nawabganj District
Volume-IV	Upazilawise PRA Report of Naogaon District
Volume-V	Appendices

This is Volume-I: Main Report that contains the summary of the three volumes as mentioned above. It comprises seven chapters including a list of references mentioned in the report. A list of acronyms and abbreviations used in the report has been presented following the table of contents.

Chapter 1 focuses on the project background, study objectives and scope of works.

Chapter 2 provides the physical setting of the study area that includes the location of the study area, its climate and river system, hydrogeological setting, environmental conditions, state of water resources and socio-economic profile.

Chapter 3 briefs collection and review of key acts, policies, and guidelines.

Chapter 4 focuses on the major data collection issues. It deals with the data collection program through PRA from field.

Chapter 5 represents the district wise PRA reports which includes Socioeconomic and Gender Dynamics, Agricultural System, Biodiversity, Water Resources and finally a PRA map of respective upazila.

Chapter 6 provided the recommendations of the study.

Chapter 7 cited the References of the reports and manuals consulted for the preparation of the report.

Annexes:

Annex-A: Terms of Reference (ToR)

Annex-B: Minutes of Technical Committee Meeting

Annex-C: Compliance on Draft Final Report

2 Study Area Profile

2.1 General

This project is designed for developing the solid ground-based information incorporating social and economic dynamics related to integrated water resources management in Rajshahi, Chapai Nawabganj and Naogaon districts of Barind region.

2.2 Location of the Study Area

The study area is located in Charghat, Paba, Bagmara, Puthia, Durgapur, Tanore, Mohonpur, Godagari, Bagha Upazilas of Rajshahi district, Patnitala, Raninagar, Dhamoirhat, Mohadevpur, Niamatpur, Manda, Porsha, Badalgachi, Atrai, Naogaon and Sapahar Upazilas of Naogaon district and Nachol, Bholahat, Shibganj, Chapai Nawabganj Sadar and Gomastapur Upzilas of Chapai Nawabganj District as shown in Figure 2-1. The area lies approximately between $24^0 23^/$ to $25^0 15^/$ N latitudes and $88^0 02^/$ to $88^0 57^/$ E longitudes. The area is bounded by Indian territory on the west and North, Ganges River on the South, and Iswardi-Joypurhat Railway line and part of the L Nagor River on the east.

2.3 Topography

Topographic data for the study area has been extracted from the topographic database developed by FAP-19. Based on topography, the area can be divided into three categories: High Barind, Medium Barind and Low Barind. In high Barind area, topography varies from 20.0 m PWD to 47.0 m PWD, whereas in Medium Barind area it varies from 15.0 m PWD to 30.0 m PWD and in Low Barind area, it is from 9.50 m PWD to 15.0 m PWD. Most of the area in High and Medium Barind is flood free and Low Barind is subject to flood and drainage congestion. Figure 2-2 provides classification of Barind area based on topography.

2.4 Climate

The study area experiences a tropical humid monsoon climate. In summer, the mean maximum temperature is well above 35^0C, whereas in winter the mean minimum temperature is below 10^0C. The cool weather begins in October and continues up to the end of March. The early summer is dry, with scorching winds, but the rainy season is

quite wet with a range of 1400 mm to 2000 mm rainfall. Almost 80% of the rainfall occurs during June to October. The relative humidity in the study area varies from 46% to 83%.

Figure 2-1: Map of the Study Area

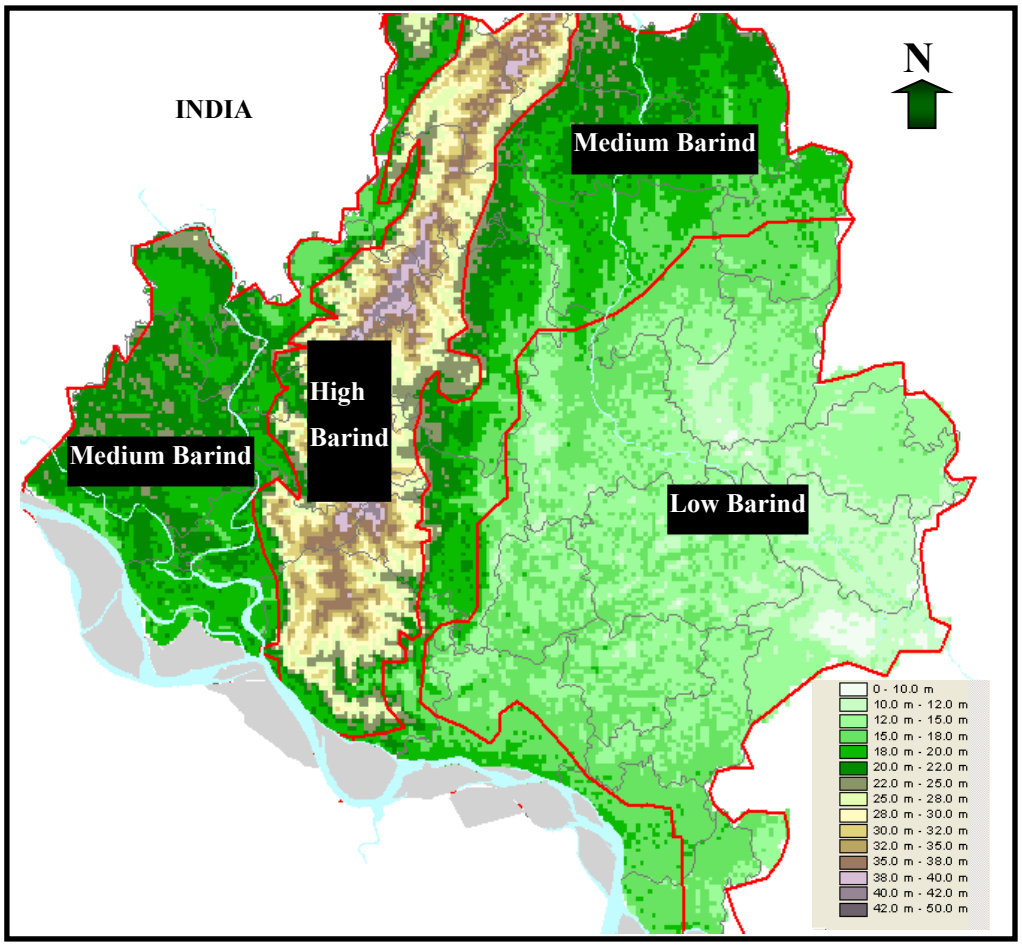


Figure 2-2: Classification of Barind Area Based on Topography

2.5 River System

The Atrai, little Jamuna and Shib-Barnai are the major rivers, which carry most of the drainage water in the eastern part. In the western part most of the drainage water flows through the river Padma and Mohananda. The depressions in the Mahananda and Atrai floodplains remain watery almost throughout the year due to steady water flow from upland river systems of the rivers Karatoa, Teesta and the Jamuna. The study area appears to be well drained because of these rivers and a number of small rivers, which criss-cross the study area. However, there are some low-lying areas and small beels in the study area. These low-lying areas and beels get dried up during dry season. Overall, the study area is not subject to flooding during normal year of rainfall although the annual rainfall is around 2000 mm and 80% of which occurs between June and October.

2.6 Hydrogeological Setting

Based on so far available hydro-stratigraphic data and reports it appears that within the exploited depth one-aquifer unit exists in the study area. However, there is a clay layer but not continuous within this aquifer. The upper part of this aquifer is composed of grey and light brown colored very fine-to-fine sand with lenses of fine to medium grained sand and occasionally with clay, silt, and trace mica lenses. Average thickness of this upper part is ranges from 10 m to 35m. The lower part of this aquifer is considered as principal source of groundwater production in the study area. The lower part of this aquifer has average thickness ranges from 20 m to 70 m and composed of medium to coarse-grained sand with occasional fine sediment lenses. The geometry and confining properties of both of this aquifer are variable with its location in the study area and controlled by local subsurface geology.

2.7 Agriculture System

The agricultural system in Barind region depends on the climate, type of soil, rainfall, irrigation facilities, agricultural technology, marketing and communication facilities, agro-industry etc. of an area. The main crop cultivation in this region is rice. Rice-based cropping is 50% of total crop cultivation, and the main cropping pattern is Boro-fallow-T. Aman. The main crop of kharif 2 season is Aman and that of rabi season is Boro. In the kharif 1 season, small area is cultivated with jute, aus rice, sesame, mungbean, maize and vegetables and most of the area remains fallow. In the kharif 2 season, Aman, betel leaf, mashkalai and monsoon vegetables are planted. In the rabi season, Boro, pulse mosur, khesari, chickpea, gram, felon, tubers such as potato, sweet potato, spices such as onion, garlic, mustard etc. are cultivated. Cereal crops like wheat, maize, winter vegetables cauliflower, cabbage, raddish, spinach, red amaranth, carrot, turnip, tomato etc. are also crops of rabi season. The High Yielding Variety (HYV) of Boro rice like BRRI Dhan28 and BRRI Dhan29 are the most popular, and 28 is cropped at a larger scale compared to 29 because less time is required. Other common varieties of rice in the HBT are Aman, Swarna, BRRIDhan39, BRRIDhan51. The Local Improved Variety (LIV) Jirashail is cultivated in the Boro season and Swarna is an Indian variety/LIV harvested in the Aman season. Maize is harvested in both Kharif 1 and 2.

Due to the declination of groundwater table in most of the Mouzas, scope of abstraction of groundwater from the shallow aquifer has been reduced to great extent. As a result, agricultural production is hindered, and the problem turns acute in the dry months of Chaitra-Jaishtha (March-May). The water level is further going down due to reckless and impetuous abstraction of groundwater. At present, the depth of DTW installation is extending up to 180-200 feet and even more, which was previously 90-120 feet in case of the depth of STW installation is extending from previous 60 -70 feet to 120-130 feet. During April, when Boro rice ripens, waterlogging due to rainfall causes huge damage to crops in the F2 type of land (medium low land). This results in economic loss on the farmer's part. In case of potato, harvest takes place in December instead of November because of the abstraction problem. As farmers fail to grow the potatoes in due season, yield decreases.

Horticultural crops such as mango, guava, lemon, jujube etc. do not produce high yield due to shortage of irrigation water. In the HBR, most of the canals and water bodies have filled up due to siltation, so rainwater is not stored and irrigation with surface water becomes impossible. Moreover, some Mouzas experience waterlogging even after little rainfall due to filling of canals and damage crops. In winter or rabi season, farmers in most of the Mouzas are unable to grow Boro rice because of water scarcity. However, they grow Boro rice in a small portion of their land and most area of their land is used to grow less water demanding such crop. These crops are usually shallow-rooted, for example gram, mosur, chickpea, khesari, mustard, wheat, maize etc.

In many places Aman rice production is hampered due to the influence of drought. At times sufficient water is not available during Aman cultivation and water crisis occurs at the last stages of cultivation.

Unplanned digging of ponds and canals leads to waterlogging in the crop fields, which hampers production of Aman rice. Especially the high banks of the ponds obstruct the water flow and cause waterlogging.

Shortages of rainwater, depletion of groundwater etc. bring changes in the mind set to convert arable lands into fruit gardens or timber lands in areas like Puthia and Bagha. Again, some arable lands are being used for pisciculture.

2.7.1 Livestock

Based on district level livestock and fisheries information, secondary data are shown in the following table, where data has been collected from Bangladesh Bureau of Statistics is shown in Table 2-1 to Table 2-3.

Table 2-1: Selected Livestock Species as on 2008 (BBS, 2014)

District	Upazila	Cows & buffalo		Goats		Sheep		Swine	
		Holding /farm	Total number	Holding/ farm	Total number	Holding/ farm	Total number	Holding/ farm	Total number
Rajshahi	Bagha	15259	25278	23701	56390	91	414	0	0
	Bagmara	50728	106193	27357	74568	1058	4872	0	0
	Charghat	17337	26782	25173	59565	86	437	0	0
	Durgapur	22576	41029	24374	67524	309	1222	0	0
	Godagari	34996	91426	26637	735742	1417	5075	269	1598
	Mohonpur	21815	44868	19994	53251	1534	5685	20	135
	Paba	29516	56874	31610	77790	856	3060	15	152
	Puthia	17786	30374	22197	56200	230	1028	0	0
	Rajshahi city corporation	4908	9936	9418	23572	65	261	0	0
	Tanore	27132	68652	15866	43892	2146	7265	0	0
	Total	***242053***	***501412***	***226327***	***586294***	***7792***	***29319***	***304***	***1885***
Naogaon	Atrai	19993	50941	14344	40232	1715	6062	0	0
	Badalgachhi	32806	77640	23743	62861	983	3473	0	0
	Dhamoirhat	32166	86672	20044	59215	3335	10310	0	0
	Manda	50738	118113	41613	114515	5058	17952	0	0
	Mahadebpur	42891	120575	22895	65347	3292	11042	0	0
	Naogaon sadar	32113	76491	24281	63614	3784	11180	0	0
	Niamatpur	38288	117931	23396	75781	3220	11694	0	0
	Patnitala	38087	114165	21098	64761	4272	13021	0	0
	Porsha	17553	58017	11696	39729	3055	10655	0	0
	Raninagar	19922	57181	11542	34348	2470	8860	0	0
	Sapahar	23090	70813	15845	54142	4459	14018	0	0
	Total	***347647***	***948539***	***230497***	***674545***	***35643***	***118267***	***0***	***0***
Chapai Nawabganj	Bholahat	8821	20977	7209	19993	388	1643	0	0
	Chapai	31437	65774	38730	104640	601	2885	0	0
	Gomastapur	27786	73150	22389	65551	1672	6371	0	0
	Nachol	17567	46951	10486	31030	507	2225	0	0
	Shibganj	42406	87216	49008	137280	778	4056	0	0
	Total	***128017***	***294068***	***127822***	***358494***	***3946***	***17180***	***0***	***0***

Table 2-2: Selected Poultry/birds as on 2008 (BBS, 2014)

District	Upazila	Hen and cock		Duck		Others	
		Holding reporting	Total number	Holding reporting	Total number	Holding reporting	Total number
Naogaon	Atrai	29461	244140	20222	137705	0	0
	Badalgachhi	33694	275785	20024	104983	1477	16146
	Dhamoirhat	32101	316075	22589	185566	1775	35500
	Manda	61423	515579	42944	266056	4692	49534
	Mahadebpur	38416	312308	27574	169438	630	20261
	Naogaon sadar	44450	309054	26830	142610	10500	29956
	Niamatpur	38732	384131	28466	216445	25	12000
	Patnitala	36492	325361	25342	187834	1698	23171
	Porsha	18634	187095	12139	84032	0	0
	Raninagar	27265	245437	21217	165939	520	10400
	Sapahar	24115	263745	14621	115252	1845	22219
	Total	***384783***	***3378710***	***261968***	***1775860***	***23162***	***219187***
Rajshahi	Bagha	23514	147385	6878	23720	400	600
	Bagmara	66221	638803	48994	315602	5588	51934
	Charghat	25873	165625	9373	31426	0	0
	Durgapur	27209	179843	18789	86183	298	12377
	Godagari	35780	280805	13405	85703	400	10500
	Mohonpur	28560	215875	17900	105258	572	3500
	Paba	36836	227917	19942	92508	1799	28270
	Puthia	29173	180837	16281	62697	2134	10971
	Rajshahi city corporation	9358	45945	3403	15016	390	1950
	Tanore	29947	290745	19808	139726	0	0
	Total	***312471***	***2373780***	***174773***	***957839***	***11581***	***120102***
Chapai Nawabganj	Bholahat	10257	92458	2858	19631	910	10500
	Chapai	38709	313924	8153	46309	4384	48103
	Gomastapur	30019	264962	10710	70708	2295	30446
	Nachol	15896	181648	8318	60050	1387	26620
	Shibganj	45909	321268	13646	85929	7117	71028
	Total	***140790***	***1174260***	***43685***	***282627***	***16093***	***186697***

2.7.2 Fisheries

Table 2-3: Number of Fisherman and Production of Fishes in 2009-2010 and 2010-2011 (BBS, 2014)

(Production in metric ton)

District Name	Upazila Name	2010-11		2009-10	
		Number	Production	Number	Production
Naogaon	Atrai	1900	6293	19020	6150
	Badalgachhi	208	2666	190	2650
	Dhamoirhat	2665	4298	2150	4298
	Manda	6371	8915	6371	8846
	Mahadebpur	1200	5647	1150	5540
	Naogaon sadar	3000	4970	3000	4850
	Niamatpur	900	3948	1055	3769
	Patnitala	500	7667	500	7660
	Porsha	630	2084	600	2255
	Raninagar	2000	7500	2000	7300
	Sapahar	1050	4026	1050	3947
	Total	***20424***	***58014***	***37086***	***57265***
Rajshahi	Bagha	880	2124	810	2010
	Bagmara	1300	9503	1200	8460
	Charghat	150	1630	145	1445
	Durgapur	317	12470	317	13850
	Godagari	2905	1960	2905	1952
	Mohonpur	300	4140	250	3476
	Paba	600	12140	600	11477
	Puthia	165	2967	165	4623
	Rajshahi city corporation	238	34	250	57
	Tanore	500	2130	450	2126
	Total	***7355***	***49098***	***7092***	***49476***
Chapai Nawabganj	Bholahat	1587	713	1577	750
	Chapai	1152	503	1160	566
	Gomastapur	1095	1263	1083	1257
	Nachol	350	12	310	10
	Shibganj	2121	5075	2121	5050
	Total	***6305***	***7566***	***6251***	***7633***

2.8 Environmental Condition

2.8.1 Natural Resources

There are many natural resources in Bangladesh such as renewable natural resources like energy, water, fish, forest; and coal, petroleum, oil, natural gas, limestone, hard rock, sand is considered as non-renewable natural resources. Mainstream rural poor of Bangladesh depend on natural resources for their lives and livelihoods. Land, water, forests, and livestock are the sources of livelihoods, where the rural economy depends on productivity of the natural resources. But there are no significant natural resources

found, except land, water, forestry and white clay in the study area. However, the major limestone mine discovered in Tajpur area of Badalgachi upazila, which contains around 50-100 billion tonnes of limestone (22 April 2016, The Daily Star). There are surface to near surface deposits of white clay (China clay) in Patnitala upazila. There are no significant natural resources in Porsha, Atrai, Raninagar, Sapahar, Mahadebpur, Niamatpur and Manda upazila which reported by many sources. According to the literature there are no natural resources but during the monsoon season, water level of Naogaon upazila increases creating a different natural environment. Besides, the soil of Naogaon upazila is suitable for agriculture. According to the literature, there are no natural resources listed in Mohonpur, Puthia, Boalia, Tanore upazila, but Paba upazila has 1.51 acre of riverine area. In Bagmara, there are no known literature records of any natural resources being unearthed in the area, however there is the common pool resource of land that is used for agriculture as well as the groundwater aquifer that the community is reliant on. There are no records of any significant natural resources found in Durgapur upazila other than the basic kinds such as groundwater and land that helps sustain livelihoods. Bagha's prized natural resources currently are its Mango trees that bear the infamous Fazli mangoes.

As per the literature there are no listed natural resources in Shibganj, Nachol, Gomastapur, and Bholahat upazila. However, those upazilas has its land and groundwater resources significantly. Moreover, the agriculture and fisheries are counted as natural resources.

2.8.2 Biodiversity

Biodiversity benefits people through more than just its contribution to substantial welfare and livelihoods as well as essential for sustainable socio-economic development. It also produces goods and services for the most fundamental needs viz clean air, fresh water and shelter. It also provides people with recreational, psychological, emotional and spiritual enjoyment. On the other hand, food comes directly or indirectly from plants, where plants supply over 90 per cent of the food consumed by humans. Bangladesh is exceptionally rich in biodiversity due to its unique geo-physical location and favorable climate conditions but the country is going through a crisis that is unsuitable for biodiversity and ecosystems (Nishat et al., 2002). Study documents from the British

colonial times, Hamid and Hunt (1987) has found the original botanical history of the Barind region, mentions from East India Company's reports that the region was covered by thick, impenetrable jungle during the nineteenth century. The forest provided shelter for a wide range of mammals, reptiles, and birds. Game reservoir animals included tigers, leopards, spotted deer, mouse deer, hog-deer, rabbits, wild hog, wild buffalo, and nilgai (blue bull; *Boselaphus tragocamelus*). Other mammals included elephants, monkeys, porcupines (or sajaru; *Histrix indica*), pangolins (or bon rui; *Manis crassicaudata*), civets (*Viverricula indica*), and many species of bats (Khalequzzaman 2009). Birds included ducks, geese, waterfowl, partridge, quail, kingfishers, various pigeons, and vultures, among a large range of other big and small birds (Khalequzzaman 2009). Later, the British statistician Hunter (1876) described the High Barind Tract (HBT) as "unbelievable" because it was covered by all types of trees, so it was difficult to penetrate the areas which local people called "Katal ban" (*thorny jungle*). This mixed forest was dominated by Sal trees but other trees, shrubs, herbs, and grasses were found too.

There is no record of the details of the botanical composition of the forests in the Barind region (Ali et al 2018). Further, there is no record of microscopic life forms but can only speculate as to their infinite diversity and abundance. Nevertheless, the qualitative descriptions of the forests and animals available at that time do suggest that the Barind region supported large biomass, with rapid turnover of organic matter in the relatively warm and moist climate.

During the period of British rule, the landscape of the HBT was dramatically changed with almost all the natural forest area indiscriminately destroyed for cultivation without considering its environmental effects. Most of the original flora and fauna had disappeared by the time the British left in 1947.

2.8.3 Drivers of Environmental Change

2.8.3.1 General

The table of environmental statistics collected from the Bangladesh Bureau of statistics is shown in Table 2-4**.** Where the data of soil characteristics, atmosphere, and key natural hazard of the three districts (Rajshahi, Chapai Nawabganj, and Naogaon) was covered.

Table 2-4: General Environmental Statistics of the Study Areas (DoE 2018)

Name of study area		Atmosphere	Soil Characteristics	Key Natural Hazard		
Districts	Upazila (Clusters)	Air Quality Index (AQI)	Total soil (Bele, doash, Etel) in acre	Drought Index (SPI)	Occurrences of flood	Occurrences of storms
Naogaon	Atrai	68	58795	0.32	NA	No
	Badalgachhi	55	50405	0.37	NA	No
	Dhamoirhat	55	69828	0.36	NA	No
	Manda	69	102258	0.33	Yes	No
	Mahadebpur	62	86835	0.35	NA	No
	Naogaon	62	66456	0.36	NA	No
	Niamatpur	68	110804	0.33	NA	No
	Patnitala	14	88394	0.35	NA	No
	Porsha	55	67197	0.34	NA	No
	Raninagar	37	61280	0.36	NA	No
	Sapahar	39	51000	0.35	NA	No
Chapai Nawabganj	Bholahat	58	30020	0.30	NA	NA
	Chapai	160	103618	0.29	NA	NA
	Gomastapur	NA	70892	0.31	NA	No
	Nachol	NA	69981	0.30	NA	No
	Shibganj	41	20366	0.29	NA	No
Rajshahi	Bagha	55	40647	0.22	No	NA
	Bagmara	55	81636	0.31	No	NA
	Charghat	55	35769	0.26	No	NA
	Durgapur	54	41074	0.29	No	NA
	Godagari	NA	80337	0.29	No	NA
	Mohonpur	NA	34870	0.30	Yes	NA
	Paba	68	49561	0.28	No	NA
	Puthia	68	41963	0.27	No	NA
	Tanore	35	59347	0.31	No	NA

The Air Quality indexes of the districts are then listed where four of the Upazila's data are not listed. The highest value is 160 which can be found in Chapai Nawabganj Sadar and the lowest 14 is seen in Patnitola Upazila of Naogaon district. A total of 1585203 acres of land is covered in the soil characteristics column, where Niamatpur Upazila of Naogaon district has the highest area (110804 acres) and Rajshahi Upazila of Rajshahi district has the lowest area (11870 acres) covered.

The last criterion the table has is Key natural hazard, which represents the drought index, occurrences of flood, and occurrences of storms in the districts. Based on drought index the study areas can be seen in different scenarios, where highest SPI value is 0.37 shown in Badalgacchi upazilas, means that the area has the lowest possibilities of affected due

to drought, and similarly in Bagha Upazila has shown SPI value of 0.22, which indicates highest possibility of affected by drought.

2.8.3.2 Arsenic (As) Contamination in Groundwater

Concentration of arsenic in groundwater data has been collected from BGS and DPHE as shown in Table 2-5. The data shows that arsenic concentration exists in five upazilas namely Manda in Naogaon districts, Paba, Mohonpur, Puthia in Rajshahi districts and Shibganj in Chapai Nawabganj districts. In Paba upazila, 30% of samples exceeded drinking water limit.

Table 2-5: Upazila Wise Arsenic (As) Concentration in Groundwater

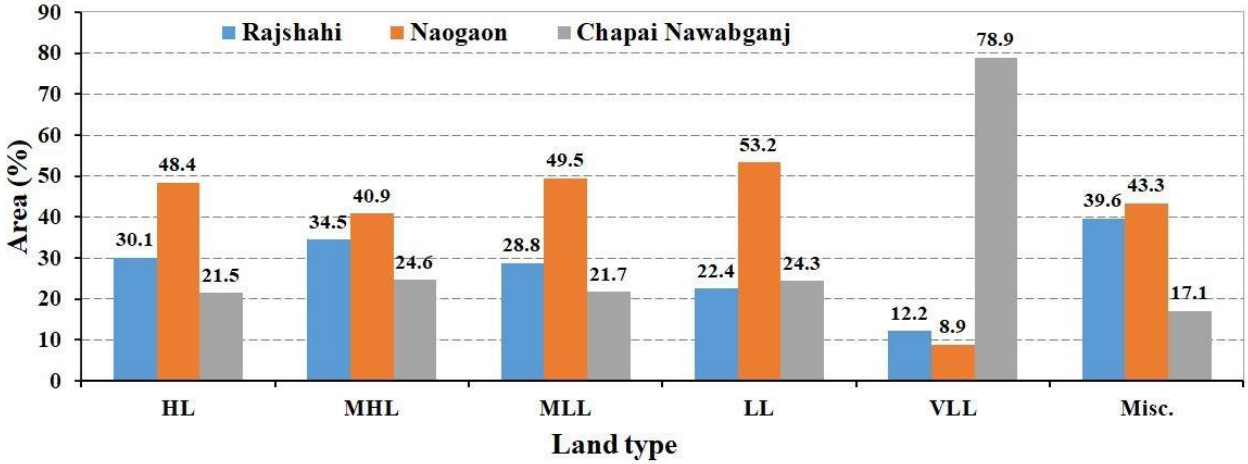
District name	Upazila Name	BD Drinking Water Limit (mg/l)	BD Irrigation Water Limit (mg/l)	Concentration Range (mg/l)			Total Number of Samples	% of Samples Exceeding Drinking Water Limit	% of Samples Exceeding Irrigation Water Limit
				Min[m]	Max[m]	Average			
Naogaon	Atrai	0.05	1	0	0.00	0.00	9	0	0
	Badalgachhi	0.05	1	0	0.02	0.00	9	0	0
	Dhamoirhat	0.05	1	0	0.01	0.00	9	0	0
	Manda	0.05	1	0	0.24	0.05	9	22	0
	Mahadebpur	0.05	1	0	0.01	0.00	9	0	0
	Naogaon sadar	0.05	1	0	0.00	0.00	10	0	0
	Niamatpur	0.05	1	0	0.00	0.00	8	0	0
	Patnitala	0.05	1	0	0.01	0.00	9	0	0
	Porsha	0.05	1	0	0.00	0.00	6	0	0
	Raninagar	0.05	1	0	0.00	0.00	8	0	0
	Sapahar	0.05	1	0	0.00	0.00	6	0	0
Rajshahi	Bagha	0.05	1	0	0.02	0.00	8	0	0
	Bagmara	0.05	1	0	0.01	0.00	6	0	0
	Charghat	0.05	1	0	0.04	0.01	10	0	0
	Durgapur	0.05	1	0	0.04	0.01	8	0	0
	Godagari	0.05	1	0	0.01	0.00	8	0	0
	Mohonpur	0.05	1	0	0.06	0.01	8	13	0
	Paba	0.05	1	0	0.09	0.02	10	30	0
	Puthia	0.05	1	0	0.06	0.01	10	10	0
	Tanore	0.05	1	0	0.01	0.00	10	0	0
Chapai Nawabganj	Bholahat	0.05	1	0	0.01	0.00	6	0	0
	Nawabganj Sadar	0.05	1	0.005	0.04	0.01	10	0	0
	Gomastapur	0.05	1	0	0.01	0.00	10	0	0
	Nachol	0.05	1	0	0.01	0.00	10	0	0
	Shibganj	0.05	1	0	0.06	0.02	9	22	0

Source: GW quality data from BGS and DPHE (2001)

2.8.3.3 Land Types

Land types of Rajshahi district covered in HL-30.1%, MHL-34.5%, MLL-28.8%, LL 22.4%, VLL 12.2%. It means that these areas' land types are almost uniform. Whereas Naogaon district covered in HL-48.4%, MHL-40.9%, MLL-49.5%, LL 53.2%, VLL

8.9%. It indicates that the amount of LL area is high. Chapai Nawabganj district shows in HL-21.5%, MHL-24.6%, MLL-21.7%, LL 24.3%, VLL 78.9%. So, it can be seen that these areas contain a wide variety of different land types in different percentage as shown in Figure 2-3.



HL: High Land; MH: Medium High Land; MLL: Medium Low Land; LL: Low Land; VLL: Very Low Land; Misc.: Miscellaneous

Figure 2-3: Percentage in Land Types of Three Districts

Ecosystem Characteristics

The general ecosystem characteristics of the study area show that the total inland water body is 112675.45 hectares wherein Naogaon (53297.46 ha); Chapai Nawabganj (15650.27 ha); and Rajshahi (43727.72 ha), whereas the total number of sanctuaries in the three districts is only 34 hectares shown in Figure 2-4.

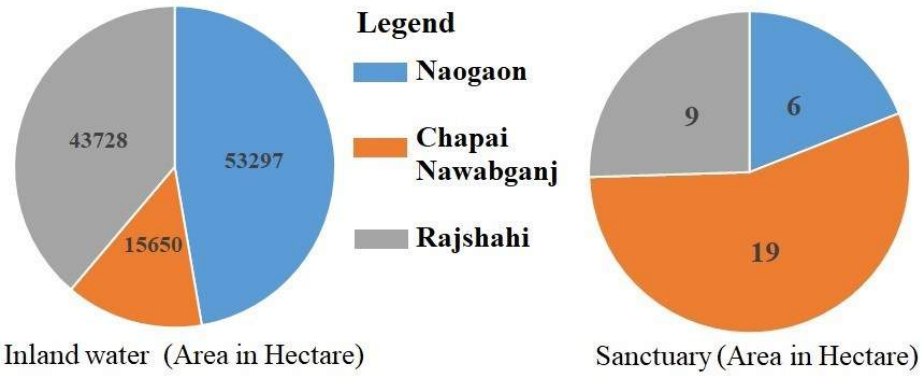


Figure 2-4: General Ecosystem Characteristics of Three Districts (Source: Bangladesh Environment Statistics, 2020)

2.9 Socioeconomic and Gender Dimension

In the districts of Chapai Nawabganj, Naogaon and Rajshahi there are clear differences in the type of water problems in the area and a significant disparity in socioeconomic conditions as well. Elements of socioeconomic and gender drivers range from the literacy rate of the area, accessibility of healthcare (no of clinics, hospitals, planning centres etc.) as well as the job scene varies place to place.

The poverty graph of 2016 used for unit level data of HIES 2016 and the Population and Housing Census, 2011. The survey and census were conducted at intervals of more than 5 years. In Naogaon district, extreme poverty rate in Atrai (5%); Manda (5.4%); and Raninagar (4.9%) upazila which is less than other upazilas like Naogaon sadar (8.3%); Niamatpur (7.4%); Patnitala (8.1%); Porsha (9.4%); and Sapahar (9%) as shown in Figure 2-5 (a). Similarly, In Rajshahi district, seven upazilas fall under 12 to 20% of extreme poverty rate whereas the rest of two upazilas are above 20% as shown in Figure 2-5 (b). Among the three districts, Naogaon district has the lowest extreme poverty rate than the others. Whereas, in Chapai Nawabgonj upazila, both percentage of extreme poor and poor has been found to be highest 36.6% and 51.5% as shown in respectively Figure 2-5(c). Figure 2-5 (a-c) shows that percentage of extreme poor (below poverty line) is reducing than percentage Poor (above poverty line).

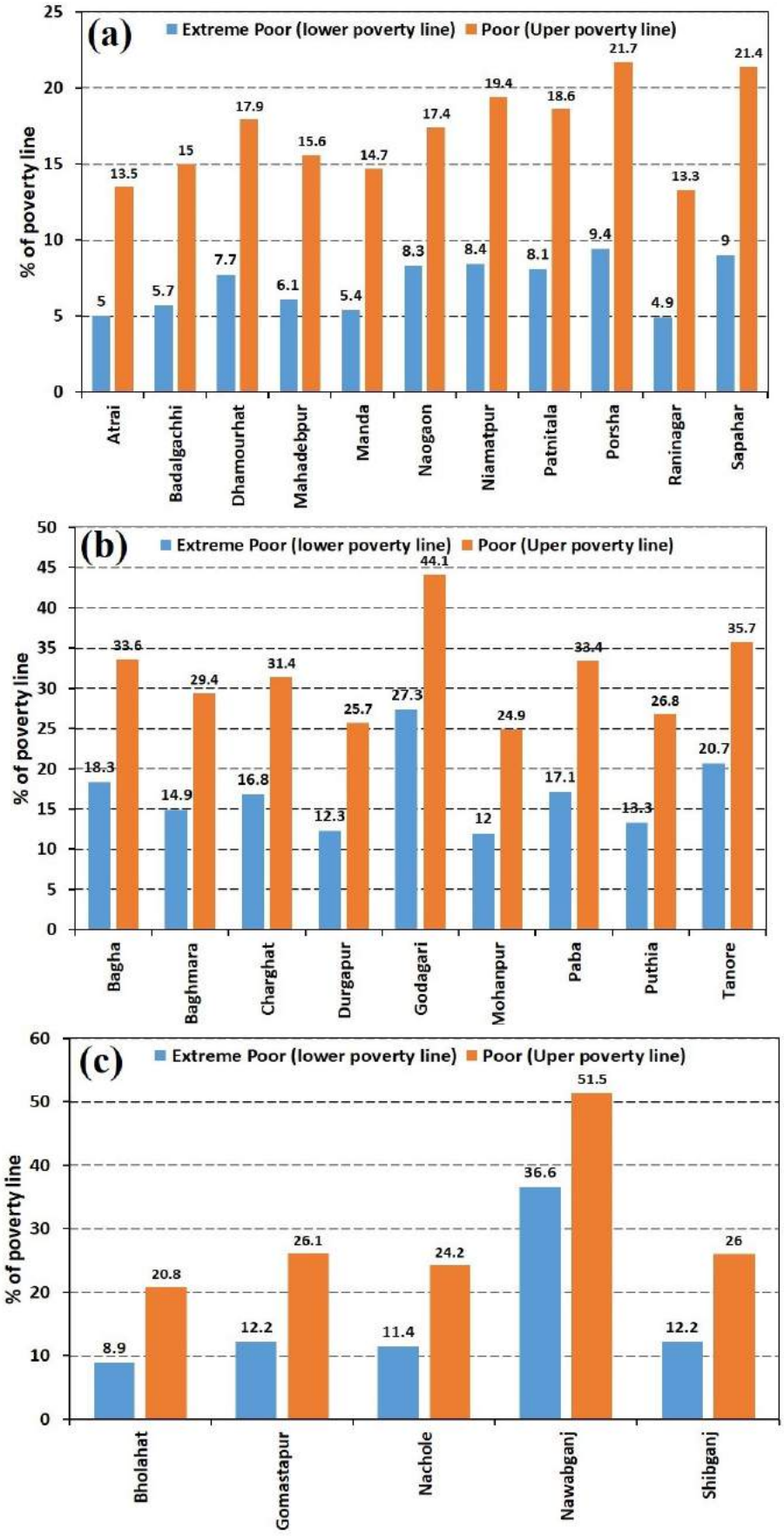


Figure 2-5: Percentage of Poverty of (a) Naogaon; (b) Rajshahi; and (c) Chapai Nawabganj District

The district Chapai Nawabganj consists of five upazilas namely Bholahat, Chapai Nawabganj Sadar, Nachol and Gomastapur. The upazilas of this district had an average literacy rate ranging from 65%-80% approximately. This is a very impressive statistic that clearly shows the outcome of various institutional establishments such as the 100 government primary schools in Chapai Nawabganj District like Gomastapur and Nawabganj Sadar alone are paying off in all areas the percentage of educated males is greater than educated females.

Regarding healthcare, all upazilas in the district of Chapai Nawabganj are well equipped, all of them having their respective Upazila health complexes, several clinics as well as some specialized hospitals distinct to that area. Such as eye hospitals are in the Gomastapur area. While civil surgeon and nurse training centres can be found in Nawabganj Sadar. There is also the popularity of homeopathic apothecaries in Nachol as there are 20 nos. of those centres located only in that upazila alone in the entirety of the district. Only Nachol and Nawabgan Sadar have proper hospitals whereas other districts have a risk of availing those on time since not all medical emergencies can be taken care of mere clinics and health complexes.

Regarding career prospects, all districts are very agriculture intensive, these jobs however, are not always favoured by the inadequate water supply due to irregularity in rainfall patterns and over-abstraction of groundwater, as well as pollution in surface water. The highest amount of agricultural income seekers found in the Nachol Upazila boasting a little over 60%. Other sources of income include commerce, industries, transportation, and other non-agricultural activities. Nachol being the least industrialized having cottage industries as the closest operating machineries to produce goods only employs 0.29% of workers in the sector. This further portrays the lack of industrialization in the area and this is followed closely by Bholahat at 0.58%. Gomastapur and Nawabganj Sadar on the other hand has a higher employment rate in the industrial sector that crosses over 1 percent. Commerce jobs however have a greater traction in these areas both amounting at over 15%. So, socio-economically, Gomastapur and Nawabganj Sadar is more developed than Nachol and Bholahat.

Moving on to Rajshahi district, there are 9 upazilas. These are Tanore, Godagari, Durgapur, Charghat, Bagmara, Bagha, Paba, Puthia and Mohonpur upazila. The average

literacy rate in this district is significantly greater than that of Chapai Nawabganj District, and the rate is all over 90%. This already shows a more promising socioeconomic conditions for the area. There is a very notable disparity in terms of education access between male and females in this district, such as in Tanore and Bagmara. Females in Bagmara are lagging behind males by 16% while in tanore the difference is about 10%. This demands attention to the fact that females in these areas need to be educated more. Women after all have an integral part in water resource management as they are the key stakeholders in households when it comes to water collection and storage.

When looking at access to healthcare, Rajshahi seems to be not so well equipped. All Upazila have the minimum required health clinics and family planning centers. But only Godagari seems to have a proper hospital, but with only 31 beds. More effort should be given in this sector, since water shortages and droughts can lead to various cases of heat stroke, arsenic poisoning, cholera, and such other water related diseases and even famine due to low food productivity.

As for the career arena, there is still the prominence of the agriculture industry but at a lower rate. Here agriculture sector covers the employment rate within 50%-60% range. Industrial sectors seem to have still a low employment rate here and most areas not surpassing even 1%. However only Godagari is an exception to that as 2% of the upazilas work forces are engaged in the industrial sector.

Now lastly, the district of Naogaon, where there are 8 upazilas which includes, Raninagar, Naogaon Sadar, Dhamoirhat, Badalgacchi, Atrai, Manda, Niamatpur and Mahadebpur. The average literacy rate of the area seems to be falling in between 60%-80%. However, there is over 10% disparity in terms of literacy rate between males and females in every Upazila. The highest disparity among all was found in Niamatpur at almost at 20%. This shows the lack of equality in education access in the region which needs more attention in the community, since without women empowerment and education the society cannot progress in any aspect.

In regards to healthcare, the conditions are quite inadequate since only one Upazila seems to have a proper hospital, that being Dhamoirhat. There are no specialized hospitals such as for the eye or any other organ, or training centers either. This shows a weakness in the

upazilas ability to provide safe accessible healthcare. However, Niamatpur does have 29 clinics those can somewhat compensate the lacking of a proper hospital.

Income wise the dominant employer is again the Agricultural sector, covering a wide range of 50%-70% of the employment pool. This is less than that of Chapai Nawabganj but more than Rajshahi. This again strongly indicates that its socio-economic status falls in between the two districts. The labor pool overall is mainly spread out over the commerce and construction sectors. Industrial sectors seem to have the similar low dominance as observed for the Chapai Nawabganj district.

Overall, among the three districts, Rajshahi is the most socio-economically developed in terms of education and employment as they have broken barriers and advanced towards development. This can be further developed if the gender disparity in education is reduced as well as healthcare facilities are more focused upon. However, all ideas discussed above are just iterations and inferences from the collected information below.
Despite the various advancements in the socioeconomic sector of all the Upazila, there are still loopholes that remain mostly in gender disparity and literacy, that in turn affects water management, since both genders have an equal role to play. In Gomastapur due to the recent COVID19 outbreak the literacy rate has suffered immensely. Even despite the high literacy rate there are still high percentages of child marriage cases, for example in Nachol child marriage accounts for 80% of all marriages that took place in the last 10 years. In parts of Gomastapur child marriage has still increased in the last 10 years. On the contrary, there are success cases in the same Nachol Upazila, where aside from infrastructural developments such as 100% legal electric connection and 90% sanitary conditions, there has also been a low statistic of child marriage and dowry cases in the recent times. Almost all boys and girls eligible for 8^{th} and 5^{th} grade are enrolled in their respective schools. Violence against women have also reduce by 80%. The most successful case scenario can be seen in the Chapai Nawabganj district, where drinking safe water has been made almost fully accessible to all inhabitants and at the same time education rate for women have risen as well. Not to mention women in their families now have a higher valued opinion. 75% of all marriages do not require any dowry.
The water stress in the Barind region intensified the livelihood vulnerabilities of women. The participatory analysis shows their vulnerabilities are multidimensional in nature. Women encounter increased vulnerabilities in their social, economic and physical

aspects of life. Communities have stated that women experience these vulnerabilities both during and after the water related disasters. Their social vulnerabilities primarily arrive from the patriarchal structure of the society. Women in most Bangladeshi societies are dominated within families as well as communities by their male counterparts. Hence, it becomes extremely challenging for them to access information on disasters and required preparedness. Women remain highly dependent on the male members from the family and the community. According to some opinions, women often voluntarily depend on men for the feeling of safety and protection that comes with their presence. Therefore, it comes naturally for most women to let the men lead in the disastrous situations and depend on them to be taken care of. This common scenario does not indicate absolute powerlessness of women rather it demonstrates that women strategically ensure their safety. However, community members on board expressed similar opinion regarding the fact that women in these contexts do not have the autonomy and control over the decision-making process due to their subordinate positions in the society and it is one of the critical reasons for why women experience increased social vulnerability.

In the opinion of community, women have their specialized and individual social networking techniques and networks which often get destroyed or disrupted during water disasters. For an example, women within the community; often perform their household chores together, which helps them create a social network, safety net and fall-back mechanism. During disasters, many women get displaced. The woman who could lend money from their peer in general situations, cannot resort to taking help from them because of the adverse situations caused by the natural disasters. In most scenarios, women of the same community encounter similar vulnerabilities during natural disasters, which makes them unable to attend to others hardships.

Community also stated that, most often women facing extreme vulnerabilities and poverty; migrate to urban areas to pursue varied livelihood alternatives to sustain themselves and their families. Participatory analysis from an intersectional lens establish that these women often gain their economic independence at the cost of their social security that was previously prevalent in their native social settings. It puts them in a further disadvantaged position within society. In the absence of their fall-back

mechanism and at the intersection of their societal status, class, economic condition these women become even more marginalized.

Water disasters are often followed by many drastic changes to cope with the financial strain. Two of the most common changes that is brought in; in most families are marriage of their girl child and their dropping out of schools. It deprives the younger generation of the chances to get educated and achieve economic independence which would eventually alleviate their social position. Consequently, these children and adolescent girls pushed down further into poverty, vulnerabilities. Women's social vulnerability can impact their economic condition and heighten their physical vulnerabilities since their social standing ensures their access and control over many facilities like healthcare, microcredit and degradation in their social position accordingly decreases their economic security and chances of accessing care facilities in Barind region.

2.10 State of water resources

2.10.1 Surface Water

The Barind Tract is exposed on slightly elevated land (about 11-48m MSL) in comparison to the surrounding floodplains. It forms inliers within the floodplain and is crisscrossed by different rivers having highly dissected topography. The Tract is mainly an alluvial terrace, which abruptly merged into a recent floodplain. The Holocene channel-floodplain complexes lie along the Ganges (Padma), Mahananda, Punarbhaba, Kulik, Tangon, Atrai, Sib, Little Jamuna, and Tulsiganga Rivers. The elevations of these floodplains range from about 8-23m MSL. All the floodplains of the study area get deeply inundated annually. The low to moderate sinuosity of the Mahananda, Tangon, Punarbhaba, and Atrai Rivers indicate that this fan radiate on the gently sloping plains. The amount of surface water in Rajshahi district has decreased significantly which is about 50.6 sq. km. in the last 30 years (1990-2020) and on an average of 2.53 meters of groundwater table is going down in each year (Bari et al 2019). The elevation of this fan ranges from about 30-45 m MSL with regional slopes towards the southwest.

The Barind Tract shows the tightly meandering entrenched channels with dendritic drainage patterns, whereas the rivers in the floodplain are either meandering, braided, or anastomosing drainage channels. Two types of drainage channels are present in the Barind Tract; one has incised and highly meandering channels which are longer and more

sinuous and flow roughly towards the south and another type are shorter and less sinuous which flows towards the South-Southwest directions.

2.10.2 Groundwater

Groundwater level directly depends on recharge and discharge conditions of annual rainfall. In order to know groundwater level, there exists a network on groundwater observation wells in the study area. A map showing observation wells of BWDB and WARPO lying in the study area is given in the Figure 2-6. Maximum groundwater withdrawal happens during the dry period which starting from January and up to May (sometimes in June in some dry years). During this period the recharge amount is nearly zero, the rate of evaporation and evapotranspiration is way more, and river stages go down compared to the groundwater level, as a result, water loss happens in groundwater storage. Most of the river flows are derived from groundwater reservoirs as base flow in the Barind region (IWM, 2013).

The people in the Barind region have to cope with the impacts of water scarcity (droughts) in the dry period. In general, very little usage of surface water from river/khari/canal can be seen in this drought-prone area. Groundwater is used intensively to meet household, fisheries, livestock, municipalities and irrigation requirements. The groundwater table is currently being depleted due to the over-extraction of groundwater. Locals have already switched from the lever-operated (HTW) to the Tara pump to the submersible pump, which will make water extraction from the shallow aquifer more difficult in the future.

The abstraction of groundwater from shallow aquifer(s) has continued and deeper water reservoirs also became a subject to exploitation. With the advancement of technology, it has become easier to lift water from a depth of 90-170 feet in rural areas. But along with the extensive use, the groundwater is not allowed to be recharged with the abstraction rate. As a result, GWL goes deeper to deeper every year. The irrational withdrawal of

groundwater for irrigation purposes played an important role in groundwater table depletion in the study area.

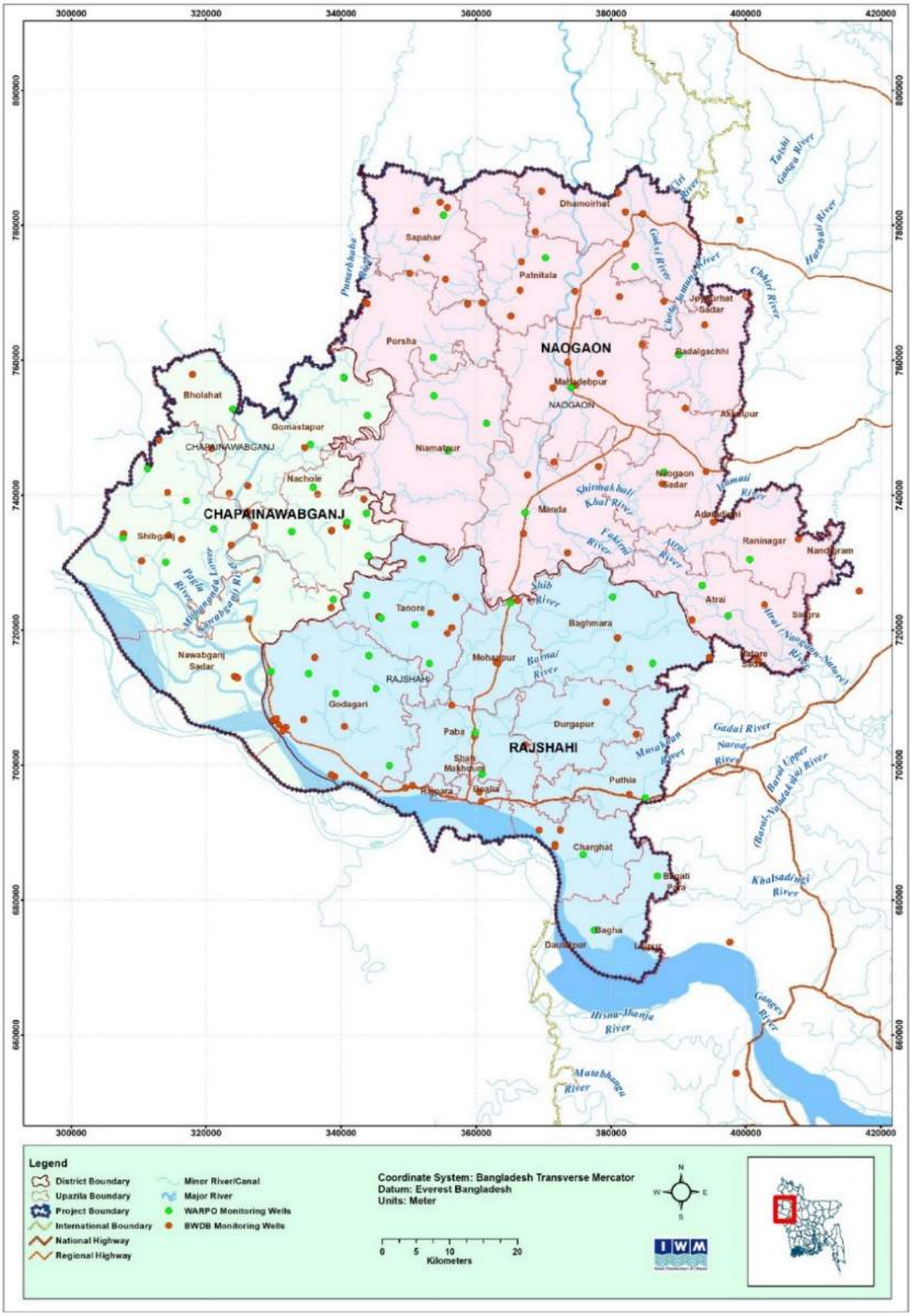


Figure 2-6: Monitoring Wells in the Study Area

2.10.3 Key Information in Connection with Water Resources

Table 2-6 to Table 2-14 provide key information in connection with meteorological and crop water demand of Naogaon district (Source: WARPO study, 2015)

Table 2-6: Monthly Average Rainfall (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Atrai	282	378	278	278	110	16	4	5	12	21	53	152
Badalgachhi	277	354	279	279	121	10	7	8	10	15	62	157
Dhamoirhat	260	358	275	273	103	8	7	8	7	15	60	144
Manda	244	317	268	268	112	11	7	8	9	22	55	129
Mahadebpur	259	348	280	279	109	11	6	8	9	17	57	144
Naogaon Sadar	265	336	273	269	116	12	7	8	10	19	60	149
Niamatpur	241	316	270	265	112	11	8	8	9	19	55	130
Patnitala	250	350	264	264	101	8	7	8	7	15	58	132
Porsha	255	335	264	259	112	10	6	9	9	15	54	124
Raninagar	280	371	279	276	110	16	5	5	11	20	57	152
Sapahar	248	348	251	252	110	8	5	8	7	14	56	118

Table 2-7: Monthly Average Evapotranspiration (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Atrai	127	114	117	110	105	87	70	71	100	137	161	153
Badalgachhi	122	113	116	109	106	88	70	71	100	135	152	146
Dhamoirhat	120	112	115	106	101	83	64	65	93	128	144	141
Manda	128	114	116	110	105	86	69	69	98	134	161	154
Mahadebpur	125	114	116	109	105	86	69	69	98	134	155	149
Naogaon Sadar	125	114	116	109	106	87	70	70	99	135	156	149
Niamatpur	128	114	116	110	105	86	68	68	97	133	160	153
Patnitala	121	113	116	107	101	83	64	64	93	129	145	142
Porsha	125	114	116	108	102	83	64	64	93	129	151	147
Raninagar	125	114	116	109	106	87	70	71	100	136	157	150
Sapahar	120	112	116	106	99	80	61	60	89	124	140	139

Table 2-8: Monthly Crop Water Demand in Dry Season (MCM)

Upazila	Nov	Dec	Jan	Feb	Mar	Apr	May
Atrai	3.3	1.0	1.0	17.0	28.3	31.5	25.6
Badalgachhi	12.5	1.6	1.5	12.7	21.2	29.4	25.6
Dhamoirhat	18.7	2.3	2.2	17.8	29.6	41.7	36.6
Manda	15.3	2.2	2.1	22.2	37.1	47.6	40.6
Mahadebpur	23.7	2.9	2.8	23.4	38.9	54.3	47.5
Naogaon Sadar	10.9	1.6	1.5	16.3	27.2	34.7	29.6
Niamatpur	29.1	3.5	3.4	27.1	45.1	63.9	56.1
Patnitala	23.6	2.8	2.7	21.8	36.3	51.5	45.3
Porsha	14.3	1.8	1.7	14.9	24.8	34.1	29.7
Raninagar	9.2	1.4	1.4	15.6	25.9	32.4	27.4
Sapahar	13.6	1.7	1.7	14.4	23.9	32.8	28.6
District	174.2	22.6	22.0	203.1	338.3	453.9	392.7

Table 2-9 to Table 2-11 provide key information in connection with meteorological and crop water demand of of Rajshahi district (Source: WARPO Study, 2015)

Table 2-9: Monthly Average Rainfall (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Bagha	261	298	254	262	122	15	8	8	12	26	58	143
Bagmara	272	352	272	275	113	15	5	6	11	22	53	146
Charghat	265	288	252	255	125	14	8	8	11	23	54	135
Durgapur	269	314	261	267	120	16	7	7	12	24	55	144
Godagari	242	284	242	250	103	13	6	8	12	22	52	131
Mohonpur	249	304	256	259	109	13	7	7	10	22	54	133
Paba	253	304	249	254	108	14	8	7	10	22	55	133
Puthia	273	314	263	270	124	17	7	8	12	24	55	148
Tanore	238	299	264	261	110	12	9	7	10	20	53	136

Table 2-10: Monthly Average Evapotranspiration (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Bagha	130	115	117	110	106	88	72	72	102	141	168	157
Bagmara	129	114	116	110	105	86	69	69	99	135	162	154
Charghat	129	114	116	110	105	86	69	69	98	135	163	155
Durgapur	129	114	116	110	105	86	68	68	98	134	162	154
Godagari	129	114	116	110	105	86	68	68	98	134	162	154
Mohonpur	129	114	116	110	105	86	68	68	98	134	162	154
Paba	129	114	116	110	105	86	68	68	97	133	161	154
Puthia	129	115	116	110	105	86	69	69	98	135	163	155
Tanore	129	114	116	110	105	86	68	68	98	134	162	154

Table 2-11: Monthly Crop Water Demand in Dry Season (MCM)

Upazila	Nov	Dec	Jan	Feb	Mar	Apr	May
Bagha	5.5	2.6	2.5	5.3	8.3	12.6	11.5
Bagmara	9.6	5.9	5.8	16.2	25.2	32.3	28.2
Charghat	5.5	2.5	2.4	5.0	7.8	12.2	11.1
Durgapur	7.4	3.7	3.6	8.4	13.0	18.8	16.9
Godagari	22.4	10.6	10.2	21.7	33.7	51.4	46.8
Mohonpur	5.0	2.8	2.7	6.9	10.6	14.5	12.8
Paba	13.6	6.5	6.3	13.8	21.4	32.1	29.1
Puthia	7.8	3.8	3.6	8.0	12.4	18.5	16.8
Tanore	14.3	6.7	6.5	13.7	21.4	32.7	29.7
District	91.1	45.1	43.6	99	153.8	225.1	202.9

Table 2-12 to Table 2-14 provide key information in connection with meteorological and crop water demand of Chapai Nawabgonj district (Source: WARPO Study, 2015).

Table 2-12: Monthly Average Rainfall (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Bholahat	240	330	271	256	104	11	7	8	10	17	53	121
Gomastapur	239	328	270	256	105	11	8	8	10	17	54	122
Nachol	232	301	275	265	111	12	10	7	9	17	52	142
Nawabganj Sadar	227	277	244	251	99	12	5	9	11	21	41	130
Shibganj	225	289	253	254	99	11	6	9	10	19	41	129

Table 2-13: Monthly Average Evapotranspiration (mm)

Upazila	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Bholahat	127	114	116	109	104	84	66	66	96	132	158	151
Gomastapur	128	114	116	110	104	85	67	67	97	133	160	153
Nachol	129	114	116	110	105	86	68	68	98	134	162	154
Nawabganj Sadar	129	114	116	110	105	86	68	68	98	134	162	154
Shibganj	129	114	116	110	105	86	68	68	97	133	161	154

Table 2-14: Monthly Crop Water Demand in Dry Season (MCM)

Upazila	Nov	Dec	Jan	Feb	Mar	Apr	May
Bholahat	2.4	0.9	1.0	5.2	8.2	14.3	13.3
Gomastapur	6.0	2.2	2.3	12.4	19.6	34.8	32.6
Nachol	8.1	2.4	2.4	12.9	20.4	41.0	39.4
Nawabganj Sadar	10.8	3.3	3.4	18.3	28.9	56.4	53.7
Shibganj	9.1	2.9	3.0	16.1	25.4	48.5	46.1
District	36.3	11.7	12.1	64.8	102.4	195.0	185.1

3 Key Acts, Plans and Policies

- **National Water Policy (1999)**

The National Water Policy of 1999 was passed to ensure efficient and equitable management of water resources, proper harnessing and development of surface and ground water, availability of water to all concerned, and institutional capacity building for water resource management. It has also addressed issues like river basin management, water rights and allocation, public and private investment, water supply and sanitation and water need for agriculture, industry, fisheries, wildlife, navigation, recreation, environment, preservation of wetlands, etc. The water policy, however, fails to address issues like consequences of trans-boundary water disputes and watershed management.
It provides the framework for the management of water resources of the country in a comprehensive, integrated and equitable manner. The NWP recognizes that water is essential for human survival, socio-economic development of the country, and preservation of its natural environment. It is vital that the continued development and management of the nation's water resources should include the protection, restoration, and preservation of the environment and its biodiversity.

- **Bangladesh Water Act 2013 and Bangladesh Water Rules 2018**

The Water Act 2013 is based on the National Water Policy, and designed for integrated development, management, extraction, distribution, usage, protection and conservation of water resources in Bangladesh. In general, if one takes a critical look at the Act, the new law has provided the right framework for better management of water resources in the country.

Bangladesh Water Rules 2018 was prepared and finalised following Bangladesh Water Act, 2013. Water Resources Planning Organization (WARPO) of Ministry of Water Resources has taken the lead coordination role to make it happened and organised several consultations with relevant stakeholders.

As per the Act, all forms of water (e.g., surface water, ground water, sea water, rain water and atmospheric water) within the territory of Bangladesh belong to the government on behalf of the people. The private landowners will be able to use the surface water inside

their property for all purposes in accordance with the Act. A worthwhile initiative is the requirement for permits/licenses for large scale water withdrawal by individuals and organizations beyond domestic use. Without prior permission issued by the ECNWRC, no individuals or organizations will be allowed to extract, distribute, use, develop, protect, and conserve water resources, nor they will be allowed to build any structure that impede the natural flow of rivers and creeks. Setting up a priority order for water usage in an area, where the water resources is in critical condition is also a significant step. The priority order as depicted in the Act is as follows: drinking water > domestic usage > irrigation > fish culture > bio-diversity > wildlife > instream flow > industry > salinity control > power generation > recreation > miscellaneous. It is mentionable that only drinking water and domestic usage are considered as basic rights.

- **Safe Drinking Water Supply and Sanitation Policy 1998**

The policy calls for nationwide access to safe drinking water and sanitation services at an affordable cost. The policy sets out the basic framework for the improvement of public health quality and to ensure an improved environment, together with a set of broad sectoral action guidelines. The objective is to improve public health and produce a safer environment by reducing water-borne disease and contamination of surface water and groundwater. The key objectives of the policy are: (i) to ensure proper storage, management and use of surface water and preventing its contamination; (ii) emphasis on the use of surface water over groundwater. According to the policy, it is desirable that water supply and sanitation works are considered within broader environmental considerations. As per the policy, provision for arsenic safe drinking water and adequate sanitation will have to be ensured for the proposed project. The water quality needs to be monitored to ensure that the supplied water is safe for drinking. The sanitation services must be hygienic (confinement of feces away from the environment), blocking the pathways for flies and other insects, proper ventilation of foul gases, proper maintenance for continual use with improved hygiene practice.

- **National Water Management Plan (NWMP)**

Coordination of water investments have been attempted through several national water management plans (NWMP 1986, NWMP 1991 and NWMP 2004). The NWMP is meant as an operationalization of the National Water Policy. It is a comprehensive water

resources plan in which 13 ministries and more than 30 agencies are involved. The National Water Management Plan has three central objectives consistent with National Water Policy aims and national goals.

These objectives are:

- Rational management and wise-use of Bangladesh's water resources
- People's quality of life improved by the equitable, safe and reliable access to water for production, health and hygiene
- Clean water in sufficient and timely quantities for multi-purpose use and preservation of the aquatic and water dependent eco-systems.

The Plan is structured in a manner that the objectives of 84 different programs planned for the next 25 years contribute individually and collectively to attainment of both the overall objectives as well as to intermediate sub-sectoral goals. The programs are grouped into eight sub-sectoral clusters and spatially distributed across eight planning regions of the country. Information on each, together with a wide range of planning data, is held on the National Water Resources Database, accessible through a Management Information System. The three main categories of programs are Cross-Cutting Programs, National-level Programs and Regional Programs. It is primarily a management plan. Within the existing institutional context, however, the NWMP shows many implementation issues, which are important to analyze and to consider as "lessons learnt".

- **Bangladesh Delta Plan 2100**

The objective of the 'Bangladesh Delta Plan 2100' was to develop a long-term strategic plan for the entire Bangladeshi Delta to tackle safety issues and structure the available water in relation to sudden climate changes and economic developments. The government of Bangladesh, in cooperation with the government of the Netherlands, aims to create the Bangladesh Delta Plan 2100. Since natural hazard and climate change risks affect almost the entire Bangladesh owing to its Deltaic formation and since integrated water management in the context of its interaction with climate change, environment, ecology, biodiversity, agriculture and land management is an integral part of the BDP 2100, the Plan has adopted the most expansive definition of the Delta Region. For water resource planning purposes, Bangladesh has been divided into 8 hydrological regions, which are the Northwest (NW), Northeast (NE), North-central (NC), Southeast (SE), South-central (SC), Southwest (SW), Eastern Hills (EH) and the main Rivers and

Estuaries (RE). Using the 8 hydrological zones as the starting point, the BDP 2100 sharpens the focus on the magnitude of the natural hazard vulnerabilities facing each of the hydrological regions. This has led to a modified grouping of districts and areas facing similar risks of natural hazards. These groups are called "Hotspots". The six Hotspots are:

- The Barind and Drought Prone Areas.
- The Chittagong Hill Tracts (CHT).
- The Coastal Zone.
- The Haor and Flash Flood Areas.
- The River Systems and Estuaries.
- The Urban Areas.

➢ **Eighth Five Year Plan (8th FYP)**

Bangladesh adopted a new Perspective Plan 2041 (PP2041) that defines a long-term vision of a poverty-free and prosperous Bangladesh. The Eighth Five Year Plan (8th FYP) is the first in the series of 4 medium term development plans aimed at implementing the PP2041. The proposed study is linked with the strategic objectives of 8th FYP as follows:

Strategies for Water Resource Management:

- ✓ Increasing water use efficiency in crop production and enhance the utilization of surface water irrigation;
- ✓ Ensuring conjunctive use of surface and groundwater for sustainable irrigation, securing groundwater conservation;
- ✓ Ensure proper use of water resources through active participation in the formulation of strategies and their proper implementation through inter-ministerial/inter-agency coordination.

Relevance of National Policies, Laws and Framework

The Table 3-1 shows the relevance of the relevant national policies, laws and frameworks in the context of the study.

Table 3-1: Relevance of National Policies, Laws and Framework in the Context of the Study

National Policies, laws and Frameworks	Linkage with Policies, laws and Frameworks
Bangladesh Water Act 2013	The Bangladesh Water Act 2013 comprises of the following sections which are related with the present study: Section 16: Issuance of clearance certificate for water resources developments. Section 17: Declaration of Water Scarce Area and management Section 18: Preferential use of water in the Water Scarce Arca and exemption Section 19: Fixing the lowest safe yield level of aquifer and restrictions on abstracting groundwater Section 28: Water pollution control The above sections require integrated water resources development and management, Water resources assessment, Protection of water resources, water quality, and aquatic ecosystem and finally Water and sustainable urban development which are most relevant with the present study.
National Water Policy 1999	This policy requires to facilitate availability of safe and affordable drinking water. This aspect is very much applicable for the present study.
Safe Drinking Water Supply and Sanitation Policy 1998	The key objectives of the policy are: (i) to ensure proper storage, management and use of surface water and preventing its contamination; (ii) emphasis on the use of surface water over groundwater which mostly complies with the present study.
National Water Management Plan (NWMP)	The NWMP is meant as an operationalization of the National Water Policy. The NWMP was formulated for (a) the rational management and wise-use of Bangladesh's water resources, (b) improvement of quality of life of people by the equitable, safe and reliable access to water for production, health and hygiene, and (c) ensure the clean water in sufficient and timely quantities for multi-purpose use and preservation of the aquatic and water dependent eco-systems which mostly complies with the present study.

National Policies, laws and Frameworks	Linkage with Policies, laws and Frameworks
Bangladesh Delta Plan 2100	Bangladesh Delta Plan 2100 has six goals among which the following goals are directly relevant with this study: *Goal 2: Enhance Water Security and Efficiency of Water Usages* Under this study, the water resources will be estimated, and the quality of water will also be determined which is under linked with this goal.
Eighth Five Year Plan (8th FYP)	The Eighth Five Year Plan (8th FYP) is the first in the series of 4 medium term development plans aimed at implementing the Perspective Plan 2041. The proposed study is linked with the strategic objectives of 8th FYP by ensuring conjunctive use of surface and groundwater for sustainable irrigation, securing groundwater conservation;

4 PRA Activities

4.1 General

Participatory Rural Appraisal (PRA) is the process of involving local people in the analysis and interpretation of their own situation of a given rural area. The local people i.e., the participants at mouza level in the present study share a comprehensive overview on state of water resources which reveals valuable information/data on the resources existing in the village. For management of water resources, PRA has been conducted to establish an effective rapport with the village community as well as to identify and define water scarce in the village itself. Moreover, PRA is a vital tool in understanding the social and institutional context at the village itself.

4.2 Data Collection for PRA

In order to achieve the objectives of the PRA study, various types of data are being collected from both primary and secondary sources. Primary source includes data collected from the field under this study program, whereas secondary sources include data collected from relevant government departments and previous reports. Secondary data have been procured from Population and Housing Census-2011, Community Report and District Statistics (BBS 2014), Banglapedia, District Portal, HIES 2016, The World Bank Survey 2011, Poverty Map 2016; etc.

4.3 PRA Works at the Field

Primary data have been collected at the Mouza level addressing different steps of PRA approach. A multi-disciplinary team intensively visited the entire study area and talked to the community people, who are the primary stakeholders. During the field visits the study team identified potential respondents and selected appropriate locations for conducting Focus Group Discussion (FGD) through Participatory Rural Appraisal (PRA) relation to gather information for fulfillment of the study objectives. PRA organizer also explored potential participants in consultation with the local government representatives, NGO personnel, local elite, etc. Collected primary and secondary data have been used to explore the base condition of the state of water resources in the study area (Rajshahi, Naogaon and Chapai Nawabganj Districts) under Rajshahi Division. Primary data has

been collected through FGD with the local stakeholders at the village/mouza level using the approved checklist and semi structure questionnaire.

4.3.1 Preparatory Works

The field team made a number of transact walks to observe existing settlement area, communication system, different types of institutions like religious, educational, social, etc., sources of water both for domestic and non-domestic uses, land use patterns and its management situation and community setting scenario. A series of PRAs through FGD sessions have been conducted. The study team used checklist for conducting the FGDs to maintain consistency and relevancy in discussion and recorded the views and perceptions of the participants properly. In the primary data collection campaign, attempts have been made to collect information on present condition of water uses for domestic, irrigation, agriculture and fisheries, environment issues, specific social issues, and future situation of the area.

4.3.2 Clustering of Mouzas

As per ToR the consultant has made 126 clusters covering all the mouzas of Barind region for conducting FGD through PRA. Each cluster consists of 40 (forty) mouzas. Consultants considered easy communication, among the mouzas for preparing the clusters where, most of the cases it was not possible to maintain upazila boundary for cluster formation rather than geographical and communication system. However, district boundaries have been strictly maintained for clustering the mouzas.

4.3.3 Team Mobilization

The consultant mobilized the study team on February 25, 2021 for preparatory works, necessary primary and secondary data collection. Adequate office space for the working team of the study has been made on the 4th floor of the main office building of IWM, located at House No. 6, Road No. 3C, Block – H, Sector – 15, Uttara, Dhaka-1230. Immediately after mobilization, a reconnaissance visit has been undertaken by the field facilitators of the study. Primary data collection program comprises mainly FGD meetings at Union with the participants from each Mouza level and validation of FGD findings through PRA at upazila level.

4.3.4 Orientation of PRA Team

IWM arranged 2 (two) days long orientation/training session for the field team members including the field facilitators for conducting FGD under PRA. The relevant experts including team leader conducted the orientation session. After completion of orientation session IWM has made evaluation to finding out eligible and qualified staffs for conducting FGD through PRA. Then after, two groups, (i) for organizing the event of FGD; and (ii) another for FGD facilitation were formed. At the field, PRA (facilitation) group were divided into 5 teams comprising one expert from each of water management, sociologist, agronomist, environmentalist, and gender specialist professionals.

4.3.5 Development of PRA Checklist

The Consultants developed a checklist for conducting PRA and got its approval from Water Resources Planning Organization is attached in Annex-D. All team members/experts have provided input for developing the PRA checklist from their own views so that the checklist can fulfill of the requirement of each discipline. After getting expert's inputs, it was submitted to the Project Director (PD) for review, comments, and finally for its approval. Before sending to the Project Director, field test on the draft checklist was made to receive local stakeholder's reviews on it. After field test on the draft PRA checklist, local stakeholder's views have been considered and addressed.

4.3.6 Transect Walk

Together with PRA team and local people, transect walk was undertaken in each of the clustered Mouza by putting information obtained by visual examination and by collecting from transect participants on a Google map with reconnaissance information. These transect walks have provided a good cross-section of information, those have been used for specific purposes of verification and appraisal. The touring team made several transact walks to observe existing settlement area, communication system, different types of institutions like religious, educational, social, etc., sources of both domestic and irrigation water use, land use patterns and community setting scenario. Moreover, the team has also discussed about the venue, date, and time to conduct the FGD. Transect walks have usually been carried out in the morning which, took couple of hours.

4.3.7 Selection of the Potential Participants

During the transect walks, the PRA teams sought out for interested local people in FGD with consideration of age, occupation, gender, etc. Potential participants were invited later to join the FGD's through phone calls three days in advance of the discussions so that, the potential respondents can attend in the PRA session and contribute to provide appropriate information. Participants those were unreachable, due to change in phone numbers or relocation, were randomly replaced from the same mouza.

4.3.8 Preparation of Venn Diagram

In this step of the PRA process, local stakeholder has expressed their opinion regarding available sources of water usage for their purposes such as, household, irrigation, and fisheries. This was provided in Venn diagram as shown in Figure 4-1. In PRA, a Venn diagram uses a simple closed curves drawn on a paper to illustrate simple issues (sets in statistics). The Venn diagram shown in Figure 4-1 would be helpful in conducting FGDs to address study theme.

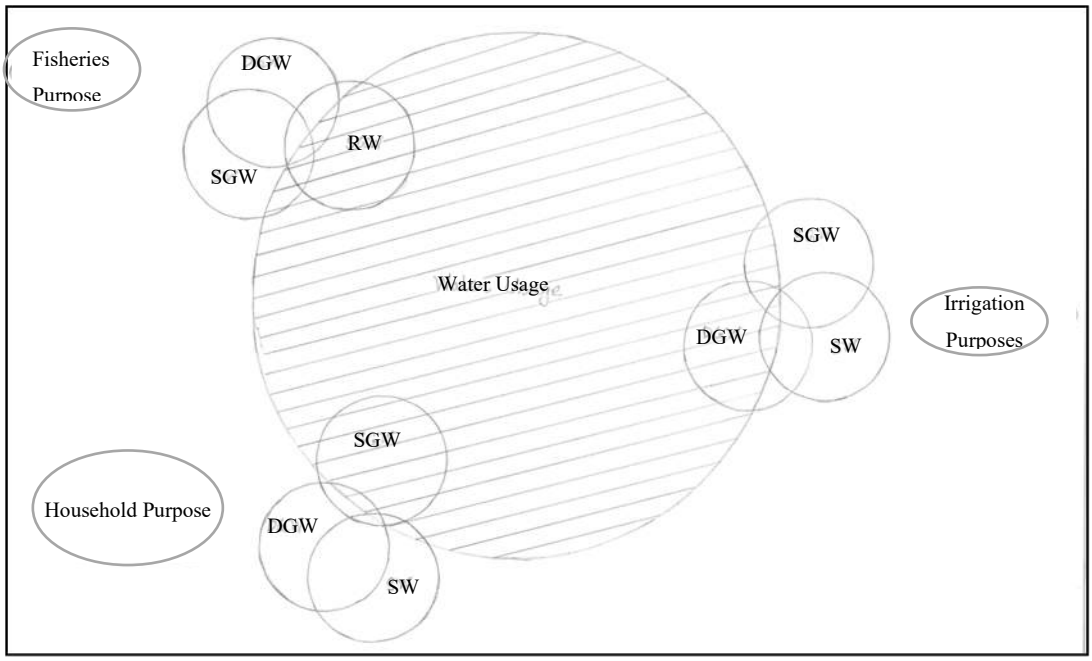


Figure 4-1: Venn Diagram on Water Usage

4.3.9 Conducting FGDs

In every FGD, the Water Management Expert welcomed all the participants and briefed the project, especially, importance of the study, type of data required and how they can

provide their input. Discussions were not treated as respondents to a questionnaire, but active participants in a semi-structured interview. Discussions have been conducted applying a checklist, which provides general and specific information about their knowledge, attitude and practice. The approved checklist of all the issues of PRA study was used as a basis for questions, not necessarily addressing all questions. Besides, the gender specialist asked the female participants about their availabilities/ difficulties in getting water for domestic uses, suggestions to overcome this situation etc. During the mapping exercise, participants identified the water scarce area, water availability area, nos. of STW/DTW and its operational status, sources of pollution etc. They were provided with different markers, large sheets of paper, board, flip chart, etc. The cluster-wise data for baseline study, water sources identification, present water use scenario and sectoral water demand up to mouza level of the Barind region through Participatory Rural Appraisal (PRA) process have been delineated. A total 126 nos. of cluster maps each having forty mouza have been prepared.

The FGD works was started on the 18th March, 2021 and completed by the 5th September 2021. Photographs taken during FGDs are given in Appendix-C, Volume-V. The participants of each cluster for carrying out the FGD programme were divided into two sessions; each session consisted of not more than 20 participants. The FGD discussions lasted for around 3 hours. Each of the FGD activity was monitored by professionals from Water Resources Planning Organization (WARPO) and Development Association for Self-Reliance Communication and Health (DASCOH) representative to ensure the data quality and to fulfill the study objectives.

4.3.10 Map Preparation using PRA Data

A base map of each cluster showing natural resources based on water usage with different purposes has been prepared during FGD. It implies that a dataset from all the mouzas of 25 upazilas under 3 districts of Barind region can be used for further analysis such as water availability, water use, water demand, water scarce, etc. Thereafter, upazila wise landuse map were prepared and presented for Upazila PRA validation meeting held later.

4.3.11 Validation of the PRA findings

The consultants made two-fold validation of PRA findings

i) PRA Validation Workshop at Upazila level:

A total 25 numbers of PRA Validation Workshop have been conducted from 26 December 2021 to 20 January 2022. As per the request of the consultants, the UNO of each of the 25 upazilas set the day of the workshop at their own convenience. The participants of each upazila PRA validation workshop were respective Upazila Chairman and Vice Chairmen, AC Land, PIO, Officer in-charge of Thana, UP Chairman/Secretary, relevant govt. officials at upazila level, WARPO and BWDB officials, WMG/WMA, expert team of the consultants, etc. The workshops were presided over by the respective UNO of each Upazila.

The Project Director of the project (and sometimes the Team leader of the PRA Study) described the background of the workshop in light of the Bangladesh Water Act 2013 and the Bangladesh Water Rules 2018. The PD/TL emphasized the importance it carries towards the participation of local government bodies in the findings of FGD conducted in connection with the state of water resources. The TL (and sometimes the PL of the PRA Study) outlined the objectives, methodologies, and analytical works on all the FGDs held in each upazila. In this connection, TL sought the participant's comments on the overall findings of FGD. The floor was then open for technical discussion. The Director, WARPO (and sometimes the Team leader of the PRA Study) facilitated the open dialogue and made it convenient for conversation.

The participants express their views, concerns and questions as and where required and the expert team of the consultants entertained their questions and addressed them with proper attention. Finally, the participants and the consultant team were agreed that some information need to be rechecked and updated.

(ii) PRA findings checked by the Relevant Department at Upazila Level:

The consultants also requested the relevant Govt. officials at the Upazila level to check the PRA findings with the recorded documents of the concern UNO. In this regard, IWM has disbursed the PRA findings to the relevant Govt. officials at the upazila level for

cross-checking/feedback and providing their appropriate information. Finally, the relevant Govt. officials checked the PRA findings and provide their comments/corrected data and accordingly the information in the PRA report has been updated.

5 Study Findings

5.1 General

This chapter provides district-wise PRA reports under this study. Each district PRA report deals with the socio-economic condition of the district. It includes population and demographic profile, quality of life, public health, transport and communication, public utility, etc. The demographic information was composed of considering the data of the Population and Housing Census 2011 and updated till 2021 from the respective Union Information Center.

From the discussions of the conducted FGDs and PRA validation workshops, it is observed that agriculture is the leading source of livelihood. Based on the workshop outcome, the district land use map covering agricultural land, water bodies, and river/canal network has been produced. The range of percentage of upazila-wise land used as a pattern for crop production, fish farming, orchard, and wood/timber farming is also presented in every district PRA report. Different types of seasonal vegetables cultivated in the respective Upazila are listed and included in the report. The main agricultural productions in various crop calendars are as follows: (i) "Kharif-1" season (16th Mar to 30th Jun); (ii) "Kharif-2" (1st Jul to 15th Oct); and (iii) "Rabi" (16th Oct to 15th Mar). Depending on the area of land cultivated, the farmers are classified as: (i) marginal farmers cultivating less than 50 decimals, (ii) small farmers cultivating 51 decimals to 2 acres, (iii) middle-class farmers cultivating 2.01 acres to 5.0 acres, and (iv) large farmers cultivating more than 5.0 acres. Considering biodiversity list of flora and fauna species has been discussed. The detail of biodiversity is given in the Upazila report of the Volume II to Volume-IV.

Several issues such as the groundwater abstraction zones (STW, DTW), surface water bodies (ponds, beels and rivers/canals) and rainwater harvesting have been considered to understand the status of water resources in all of Upazila. Different aspects of water resource usage such as domestic, agricultural, fish culture, and industrial sectors have also been taken into account and shown for each Upazila in the Volume-II to Volume-IV.

In demand calculation, no reduction of agricultural land is considered as the Agricultural Policy 2013 recommended no shifting of agricultural land to other uses. Depending on the perception of people and the population and demographic profile, the projected sector-wise water demand

for agriculture, fish farming, and domestic and industrial water has been estimated for 2030 and 2041. This information is provided in maps and tables for each Upazila.

All suction-mode pumps, including STW and HTW, utilize atmospheric pressure to lift water. The standard atmospheric pressure is 1.034 kg/cm^2, and it is equivalent to 10.34m of the water column. Therefore, the maximum theoretical lift for suction-mode tube wells for the groundwater abstraction is 10.34m, which reduces to 8m due to frictional head losses in the piping system. A further reduction in suction lift occurs due to the dynamic drawdown of GWT during the pumping period. On average 2m dynamic drawdown is considered in calculating the suction lift limit of STWs. Thus, 6m was considered the critical depth (maximum suction lift) for pumping groundwater by the suction-mode pumps. Tube-well density map has been developed for each district and incorporated in the report.

Considering the critical depth as mentioned above and suggestions received from PRA validation workshops at Upazila level, four types of water scarcity have been categorized under this study, which are as follows.

(i) depth of groundwater table ≤ 6m, scarce free;
(ii) depth of groundwater table > 6m to ≤ 12m, less scarce;
(iii) depth of groundwater table > 12m to ≤ 18m, moderate scarce; and
(iv) depth of groundwater table > 18m, severe scarce.

Accordingly, Water Scarce maps have been developed and presented for each of district.
Constraints and opportunities concerning the water resources for each Upazila have been identified. Based on those issues' recommendations have been framed and incorporated at the end of individual Upazila Reports.

Considering the knowledge on the present scenario of water resources, uses, and demand of all the upazilas as gathered through the conducted FGDs and PRA validation workshop, the recommendations have been framed at the end of the section of individual district.

5.2 Rajshahi District

Geographically Rajshahi district lies between 24°07′ to 24°43′ latitudes and between 88°17′ to 88°58′ longitudes. The total area of the district is 2,425.37 sq.km. The district is bounded by Naogaon District on the north, West Bengal of India, the Padma and Kushtia District on the south, Natore District on the east and Chapai Nawabganj District on the west. The base map of Rajshahi District is shown in Figure 5-1. The region consists of Barind tract, Diara and Char lands. Rajshahi town (City Corporation) stands on the bank of the river Padma. The area of the Rajshahi City Corporation is 96.72 sq km.

5.2.1 Socioeconomic Profile

Socioeconomic profile of Rajshahi district has been analyzed on the basis of primary and secondary information. According to the field study (FGD and Upazila validation workshop) 100% of the population are found *Bengalee*. As per the field study, a total 469,291 households with 1,851,819 population currently reside in the district. Average household's size is 3.94 and male to female ratio is 98.7 males per 100 females. Most of the households i.e., approximately 82.9% falls under the conjugal family type, while the rest are of joint family. About 83% people are literate and 98% attend school. Probable workforce of Rajshahi district is 66% (age between 15-64 years). Regarding the livelihood in the district about 59.35% people depends on agriculture where, 3.36% on non-agricultural laborer, 0.99% on industry, 14.25% on commerce, 4.36% on transport and communication, 8.97% on service, 1.45% on construction, 0.12% on religious services, 0.41% on rent and remittance and rest 6.74% on others. The study finding also revealed that 98% people use sanitary latrine, 99% dwellers of the study area are drinking safe water and 99% households are enjoying the electricity facilities.

5.2.2 Transportation

The roadway is the main communication network in the district and all the upazilas are well connected with the division/district headquarter. Bus, CNG operated auto-rickshaw, easy-bike, motorbike, charger van is used for local passenger transportation. Local van, engine trolley, pickup, truck, etc. are used in carrying commodities locally from one place to another. All upazilas have railway connection, except Mohonpur Upazila. As water transport, waterways (rivers and canals) are 48 km throughout the year, while waterways (rivers and canals) are 1556 km during monsoon.

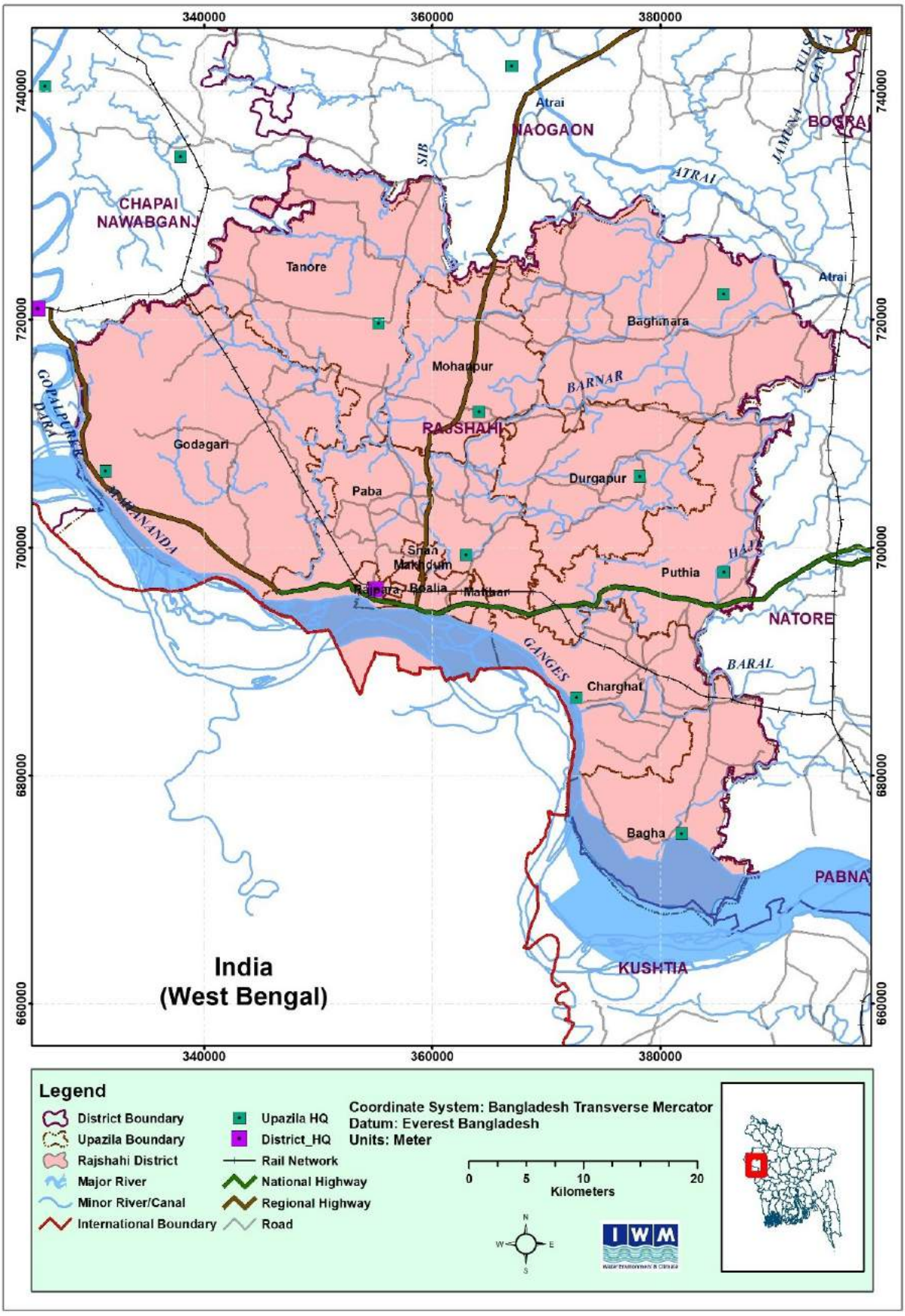


Figure 5-1: Base Map of Rajshahi District

5.2.3 Agricultural System

From the discussions of the conducted FGDs and validation workshop at upazila level, it is observed that agriculture is the leading source of livelihood in all upazilas. Overall land use pattern of Rajshahi district showing homesteads, agricultural lands, water bodies and river/canal network is given in the Figure 5-2. The trend in land use changes is being changed towards more beneficial livelihood such as aquaculture or even for urbanization, and sometimes vice versa also.

The PRA study revealed that the land use distribution of the agricultural land in this district, 40 to 71% is used for crop production, 15 to 34% for fish farming, 5 to 27% for orchard, and 5 to 27% for wood/timber cultivation.

About 71% of agricultural land is used for crop production in Tanore upazila, whereas only 40% in Bagmara upazila, but in Bagmara upazila orchard cultivation is highest of 27%. In this district, on average, 60% of agricultural land is used for crop production, 26% for fish farming, 12% for orchard, and only 2% for wood/timber cultivation.

The main crop cultivation in different crop calendars is as follows:

i) Kharif-1: Mango, Litchi, Corn, Peanuts, Pointed gourd, Betel Leaf (round the year), Sugarcane (round the year), Aus rice, Bottle gourd, Stem amaranth, Jackfruit, Jute, Cucumber, Guava, Papaya etc.
ii) Kharif-2: Aman rice, Green Chili, Bitter gourd, Banana (round the year), Pumpkin etc.
iii) Rabi: Boro rice, Wheat, Corn, Watermelon, Red Lentil (locally known as 'Mosur Dal'), Sunflower, Potato, Brinjal, Plum, Tomato, Mustard etc.

Depending on the area of land cultivated, the percent of farmers' classes is given in Table 5-1.

Table 5-1: Farmer Classes (%)

Upazila	Marginal Farmers	Small Farmers	Middle class Farmers	Large Farmers
Bagha	65	26	8	1
Bagmara	45	35	10	10
Charghat	50	25	22	3
Durgapur	65	23	10	2
Godagari	53	35	10	2
Mohonpur	60	20	15	5
Paba	55	33	10	2
Puthia	63	26	10	1
Tanore	25	20	45	10

Source: PRA Study (2021)

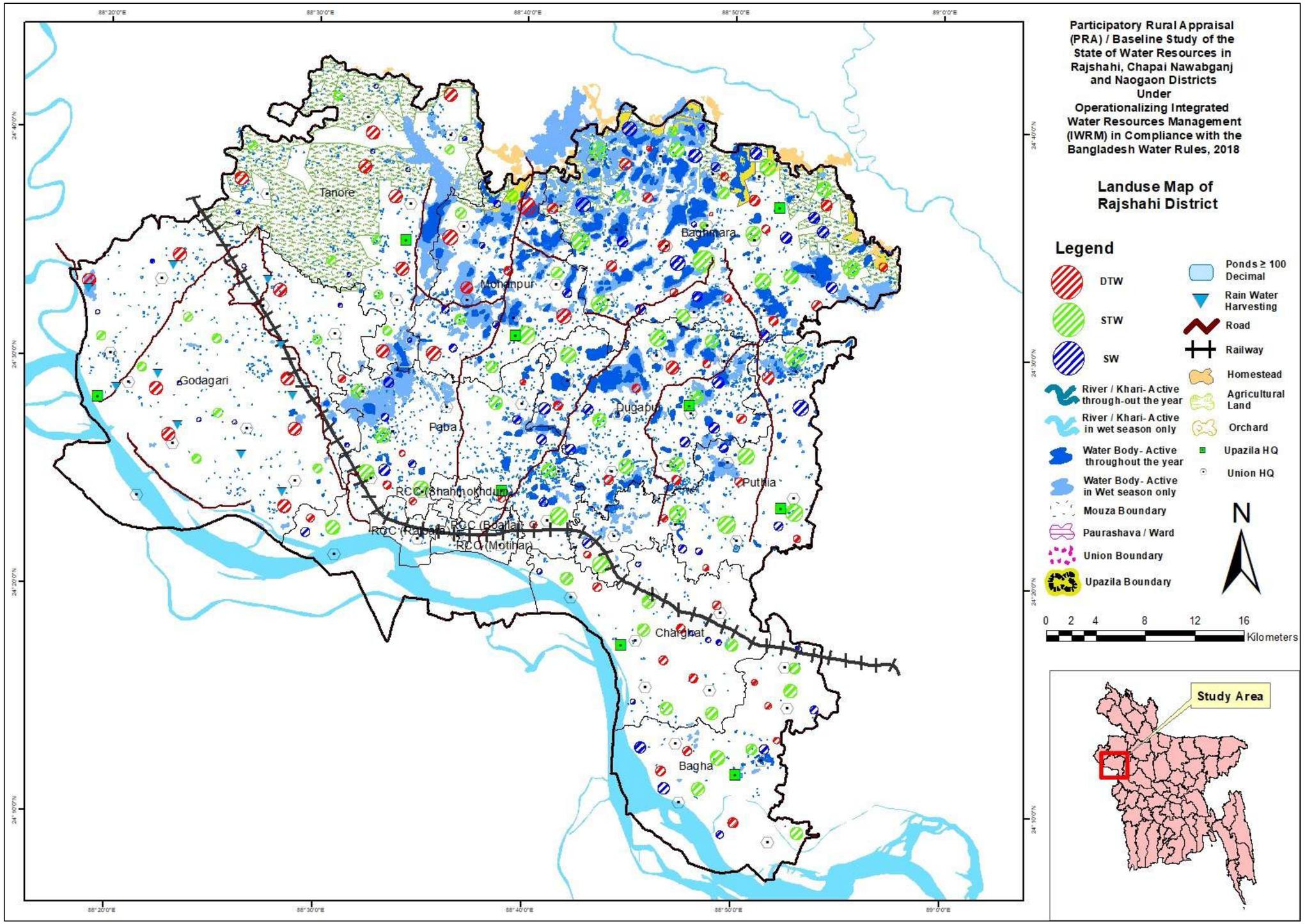


Figure 5-2: Land Use Map of Rajshahi District

5.2.4 Biodiversity

Flora

The areas of Rajshahi district which fall within the Northern Ganges Basin Flood Plain and Levee have soils sandy to sandy loam with grey colour and the areas under the Barind tract have the staff soil of reddish clayey loam. The people of Bagha Upazila rely on its plants for its medicinal properties. Such plants include Ulotkombul (*Abroma augusta L.f*), Apang (*Achyranthes aspera L.),* Kuch (*Abrus precatorius L.),* Khoer (*Acacia catechu (L.f.) Willd),* Muktajhuri (*Acalypha indica L*.), Bel (*Aegle marmelos (L.) Corr.),* amongst many others. There are also many fruits grown in the area which are deemed to be profitable such as mangoes (*Mangifera indica*), jackfruits (*Artocarpus heterophyllus*), litchis (*Litchi chinensis*), guavas (*Psidium guajava*) and dates (*Phoenix dactylifera*). The main fruits grown in Baghmara upazila are mangoes, bananas (Musa), jackfruits, litchis, papayas (*Carica papaya*), guavas (*Psidium guajava*), and plums (*Prunus domestica*). There are also some special medicinal plants found in the area such as Sheyal Kata/Mexican Poppy (*Argemone Mexicana*), Katanotey/Indian Spinach (*Amaranthus spinosus*) and Gaikhura (*Amaranthus viridis*). Main fruits of Paba Upazila are mango, black berry, jack fruit, litchi, banana. There are no unique plant resources in the Charghat upazila other than the fruits grown which includes mangoes, jackfruits, litchis, blackberry, watermelon, papayas, dates and bananas. The main fruits grown in Durgapur Upazila are mangoes, jackfruits, litchis, banana, papayas, and dates. Godagari Upazila is entirely reliant on agriculture. Paddy, wheat, and potato are notable agricultural crops. Throughout the year, Godagari Upazila cultivates a variety of crops such as paddy, wheat, maize, jute, gram, potato, tomato, sugarcane, and onion. Mango, jackfruit, guava, apple kul, and litchi are among the fruit and forest trees found in this Upazila. Betel, paddy, potato and many other vegetables are cultivated in Mohanpur Upazila. Sugarcane and mango are the major cash crops. There are 25 species of plants that identified the villages of Puthia. These are mainly trees. Shrubs, herb such as Durba, duttura, akanda, kochu, bel, varenda, dhonia, thankuni etc. The landscape of the Tanore Upazila is changing to meet the rapid growing food and water demand, which at the same time is destroying the bio-physical environment of the areas. In view of flora, plants grown in this Upazila mainly are mangoes and main crops are paddy, wheat, jute, betel leaf, potato, mustard, masur, kalai, vegetables. Among the extinct or nearly extinct crops barley, sesame, linseed, arahar, kaun, sweet potato etc. are mentionable. Main fruits here are mango, jackfruit, palm, papaya, banana, litchi, watermelon etc.

Fauna

There are no significant animals in the Bagha Upazila other than the ones commonly found in Rajshahi such as idur (*Bandicota bengalensis*), fox (*Canis aureus*) and tikkell's bat (*Herperoptenus tickelli*). Birds commonly found in this area include swallow (*Ploceus philippinus*), raj hash (*Anser indicus*), and water hens (*Oriolus xanthornus*). In Baghmara Upazila, there are around 72 species of Butterflies found in the Baghmara buffer zone Community Forest. Around 32 species are from the family of Nymphalidae, 13 species are from the family of Pieridae, 12 species are from the family of Hesperiidae, 11 are from the family of Lycaenidae and 4 species are from the family of Papilionidae. 39% of the butterfly's species are considered to be rare while 20% is very rare. Many reptiles' amphibian is found in Boalia upazila such as lizard, jait sap, dhora sap. Different kinds of birds can be seen in this area-for example, bulbul, sparrow, crow, woodpecker etc. In Charghat a lot of migratory birds visit and reside in this area especially ducks and gooses including the Bar-headed Goose (*Anser indicus*), Falcated Duck (*Anas falcata*), Gadwall (*A. strepera*), Ferruginous Duck (*A. nyroca*), Red-crested Pochard (*Netta rufina*) and Eurasian Wigeon (*6 A. Penelope*) amongst many others.

The common animals found in Barind areas of Rajshahi such as Durgapur include Wild cats (*Felis chaus*), foxes, mongooses (*Herpestes edwardsi*), kola badur (*Pteropus giganteus*), tikkell's bat (Herperoptenus tickelli), indian pipistrellus (*coromandra*), dura kathbirail (Funumbalus pennant), bhondar (*Lutra perspicillata*). Birds found here include row (*Corvus splendens*), raven (*Corvus macrohynchus*), machranga / kingfisher (*Alcedo atthis*), wood-pecker (Picus myrmecophoneus), bhat shalik (Acridotheres tristis), jhuti shalik (Acredotheres fuscus), choto fingey (*Dicurus macrocercus*), halde pakhi (*Oriolus xanthornus*), doyel (*Copsychus saularis*).

The Sultanganj area of tis upazila is the only place where pangas fish (*Pangasius pangasius*) in the Padma and Mahananda estuaries can be preserved. Other popular fish species include airh (*Mystus aor*), chitol (*Notopterus chitala*), koi (*Anabas testudineus*), gozar (*Channa marulius*), and others. However, some of these varieties, particularly those found in marshes and tanks, are becoming extinct because of overfishing and other factors such as the use of insecticides and pesticides in crop production, among others. Moreover, a small number of hilsa fish (*Hilsa ilisa*) is caught in the Padma River during monsoon. Fish is available due to Baranai River in Mohanpur upazila. Ruhi (*Lebeo rohita*), mrigel (*Cirrhinus mrigala*), kalboush

(*Labeo calbasu*), katla (*Catla catla*), magur (*Amblyceps mangois*), and shing (*Hetropneustes fossilis*) are also plentiful in beels and khals. Many other rivers and freshwater fish species can also be found. The most common are airh (*Mystus aor),* pangas (Pangasius pangasius), chitol (*Notopterus chitala*), koi (*Anabas testudineus*), gozar (*Channa marulius),* and others. However, some of these species, particularly those found in marshes and tanks, are becoming extinct. In Puthia upazila there different species are begi, guishap, badur, chamchika, katberali, edur, ghokra, bora etc. Because of these animal number of domestic animals decreased to a low number. Among the extinct or nearly extinct crops barley, sesame, linseed, arahar, kaun, sweet potato etc. are mentionable. Main fruits here are mango, jackfruit, palm, papaya, banana, litchi, watermelon etc. Considering fauna, mouse, metho mouse, negti mouse, common house mouse, tortoise, dora kathbirali, bhondar, kola badur, Indian pipistrelle, tickill's bat, jackal, bon biral etc. are the available mammalian fauna. Different species of birds used to be seen in this area for example, bulbul, sparrow, crow, woodpecker, etc.

5.2.5 State of Water Resources

Water usage of Rajshahi district has been classified based on groundwater abstraction (STW, DTW), surface water bodies (ponds, beels and rivers/khals) and rainwater harvesting. The total number of surface water bodies in the district is 18,934 (18,808 ponds having sizes >25 decimals and 126 beels). The main rivers in the district are the Baral Upper (Baral-Nandkuja), Khalsadingi, Ganges, Shib, Fakirni, Barnai, Baral Upper, Mohananda Lower, Musakhan, Hoja, and Narad**.**

For irrigation, fish farming and household purposes, groundwater is tapped through 3,656 nos. of deep tube wells (mainly for irrigation) and 180,508 nos. of active shallow tube wells as given in Table 5-2. Tubewell density map is given in Figure 5-3.

Approximately yearly sector-wise water demand in MCM has been found for domestic, agricultural, fisheries, and industries 33.8, 1982.65, 112.61 and 11.22 respectively. Again, the total water use was found to be 2140.29 MCM at the base year of 2021. Similarly, water demand has been estimated and it stands at 2147.92 MCM for 2030 and 2156.42 MCM for 2041 as given in Table 5-3.

The respondents in FGDs opined that groundwater abstraction started from shallow zone in 1980's. Due to over exploitation, groundwater level is observed in a declining trend. It revealed that the depth to groundwater table varies from 1.0 to 27 meters in the year of 2021.
Accordingly, union-wise groundwater scarce maps have been developed and presented in the Figure 5-4.

Constraints and opportunities concerning the water resources for each upazila have been identified. Based on those issues' recommendations have been framed and incorporated in details at the end of individual upazila reports as given in Volume-II to Volume-IV.

Table 5-2: Different Aspects of Water Resource Usage and Demand in Rajshahi District

Upazila	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Groundwater Scarcity
					Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
Bagha	172.81	15,094	Baral Upper (baral-Nandkuja), Khalsadingi, Ganges	520	158,270	916	2.89	105.61	2.66	0.58	111.74	112.05	112.39	18,288	52	2.5 to 9.5	Less to Scarce Free
Bagmara	342.09	29,090	Shib, Fakirni, Barnai	4330	335,491	981	6.12	915.07	23.67	0.43	945.29	946.82	948.18	26,456	913	1.0 to 14	Less to Scarce Free
Charghat	145.77	12,737	Baral Upper, Ganges	466	177,538	1,218	3.24	81.06	2.60	1.17	88.06	88.46	88.88	24,438	75	2.0 to 10.0	Less Scarce
Durgapur	172.67	15,058	Barnai	2568	167,578	971	3.06	106.73	14.18	2.46	126.43	127.40	128.52	13,907	340	1.5 to 18	Moderate to Scarce Free
Godagari	441.74	38,469	Mohananda Lower, Ganges	2463	285,872	647	5.22	270.67	15.24	3.20	294.33	295.57	296.98	13,614	774	7.5 to 22	Severe to Less Scarce
Mohonpur	147.48	12,865	Barnai, Shib	1992	158,910	1,078	2.90	88.60	10.78	0.40	102.69	103.30	104.05	11,950	322	5.0 to 18.5	Moderate Scarce
Paba	207.74	18,035	Barnai, Ganges	1630	241,466	1,162	4.41	126.18	14.52	0	145.11	145.93	146.93	31,235	245	3.5 to 18.5	Moderate to Scarce Free
Puthia	179.12	15,653	Musakhan, Barnai	2171	181,585	1,014	3.31	122.77	14.78	1.06	141.93	142.79	143.84	32,410	281	1.5 to 10	Less to Scarce Free
Tanore	238.76	20,713	Shib	2668	145,109	608	2.65	165.96	14.18	1.92	184.71	185.60	186.65	8,210	654	11 to 27.5	Severe to Moderate Scarce
Total	2048.18	177,714		18808	1851819		33.8	1982.65	112.61	11.22	2140.29	2147.92	2156.42	180508	3656		

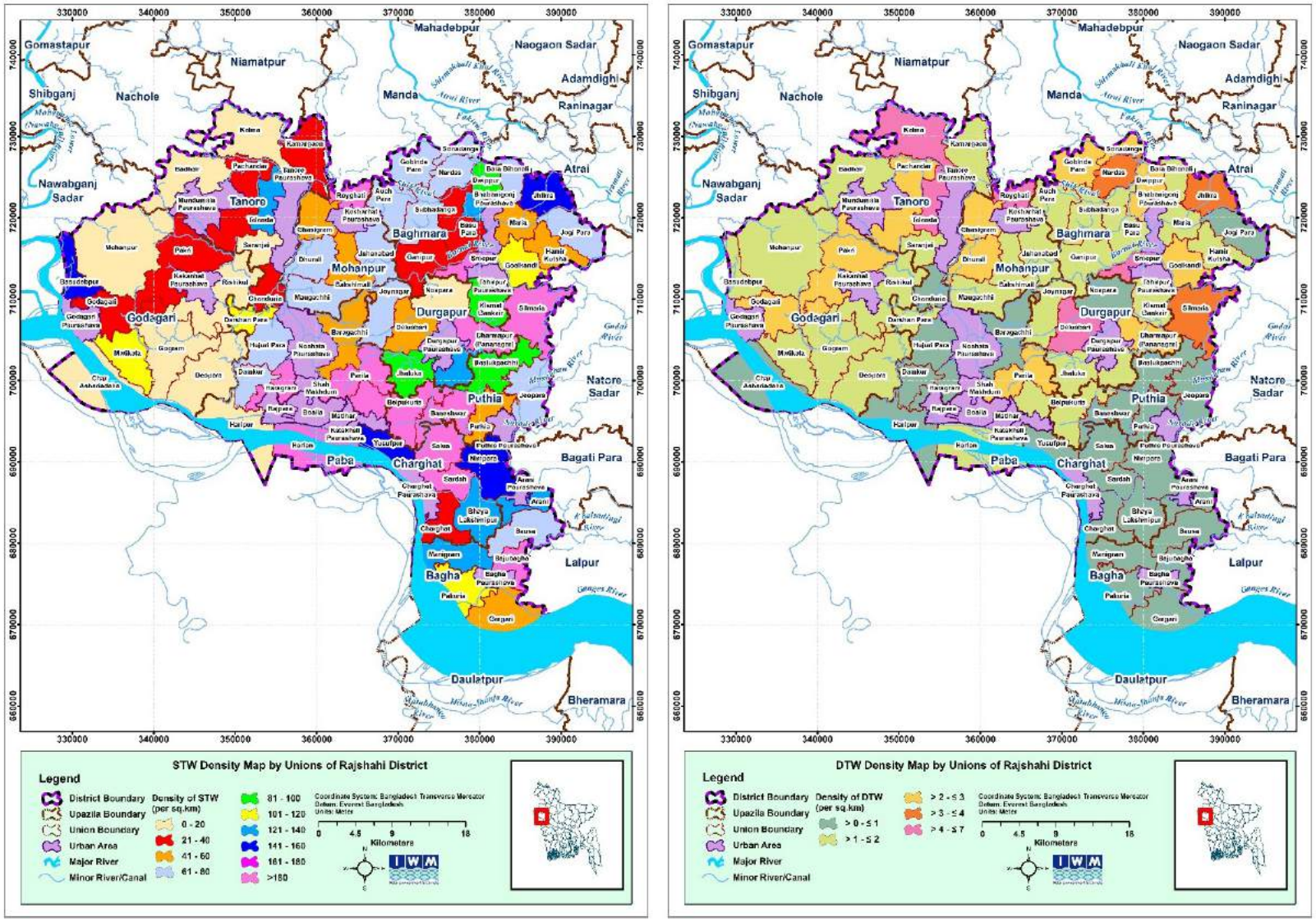


Figure 5-3: Tubewll Density (STW Density at the Left and DTW Density at the Right) Rajshahi District

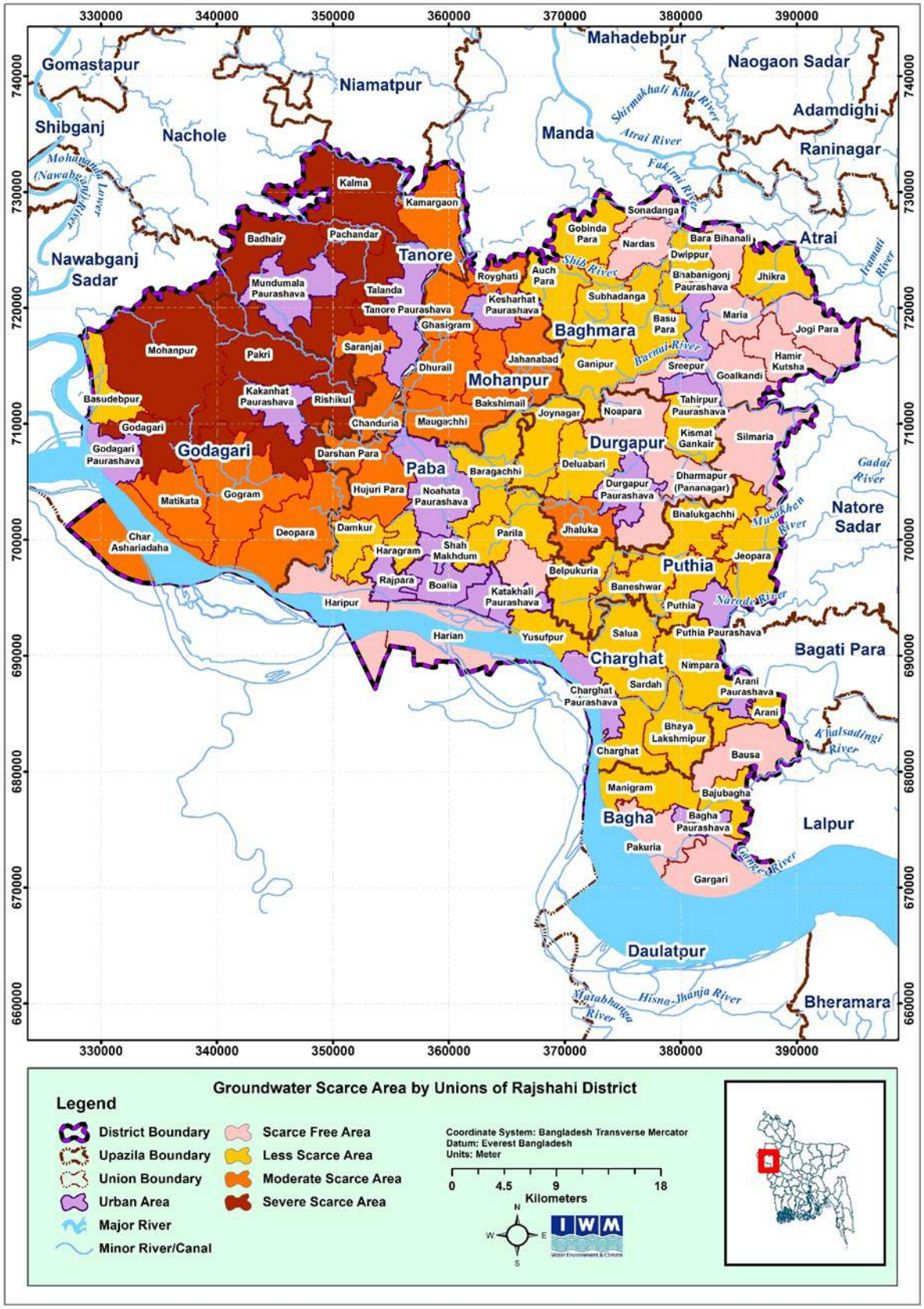


Figure 5-4: Groundwater Scarce Map of Rajshahi District

5.2.6 Recommendations

Having knowledge on the present scenario of water resources, uses, and demand of all the upazilas as received from the conducted FGDs and PRA validation workshop, the following recommendations are given based on PRA findings:

1. The major river and its tributaries and distributaries should be dredged/re-excavated to ensure better drainage and improve the water retention capacity. The surface water can be used for irrigation and fish farming.
2. The parts of the beels located in the central part of Rajshahi District should be re-excavated to deeper extents and the beel will be developed as potentials for surface water retention and preservation for irrigation year-round, fish culture and household purposes that will reduce the quantity of groundwater abstraction. Kantar beel of Puthia; beels at Darshan Para union of Paba; beels at two unions namely Dhurail and Royghati under Mohanpur; and beels of Baghmara and Durgapur.
3. There are 2835 nos. of ponds (>100 decimals) in the district needs to be re-excavated to a deeper extent for extensive use in fish farming and household purposes.
4. Present groundwater extraction in all upazilas of the district is alarming. As such, every upazilas should bring under cautious groundwater abstraction. The north-western part of the district (upazilas of Tanore, Godagari and Mohanpur) has been found severe to moderate scarce. The remaining part mostly shows moderate to less scarce.
5. Groundwater use should be reduced to ensure water resources for future generations, and conjunctive use of groundwater and surface water should be promoted. Accordingly, a regular awareness campaign should be organized.
6. Crop diversification is prescribed as cultivation of crops with less water requirement should be introduced instead of HYV Boro crop to improve the water management.
7. Awareness campaign should also be organized for crop diversification i.e. for cultivation of crop with less water requirement instead of HYV Boro crop to improve the water management and crop yield as well.

8. All re-excavation action specially for surface water retention and improved drainage should be taken up by the relevant implementing organization following a detail feasibility study.

5.3 Naogaon District

The total area of Naogaon district is 3435.65 sq.km, 9.09 sq.km of which is riverine and 19.45 sq.km is under forest. The district lies between 24º32' and 25º13' latitudes and between 28º23' and 89º10' longitudes. The district is bounded on the north by India, on the east by Joypurhat and Bogra districts, on the south by Natore and Rajshahi districts and on the west by Chapai Nawabganj district and India. The base map of Naogaon District is shown in Figure 5-5.

5.3.1 Socioeconomic Profile

Socioeconomic profile of Naogaon district has been analyzed on the basis of primary and secondary information. According to the field study (FGD and Upazila validation workshop) 100% of the population are found *Bengalee*. As per the field study, a total 637,351 households with 2,080,091 population currently reside in the district. Average household's size is 3.99 and male to female ratio is 99.5 males per 100 females. Most of the households i.e., approximately 86.2% falls under the conjugal family type, while the rest are of joint family. About 86% people are literate and 99% attend school. Probable workforce of Naogaon district is 65.6% (age between 15-64 years). Regarding the livelihood in the district about 59.35% people depends on agriculture where, 3.36% on non-agricultural laborer, 0.99% on industry, 14.25% on commerce, 4.36% on transport and communication, 8.97% on service, 1.45% on construction, 0.12% on religious services, 0.41% on rent and remittance and rest 6.74% on others. The study finding also revealed that 98% people use sanitary latrine, 99% dwellers of the study area are drinking safe water and 99% households are enjoying the electricity facilities.

5.3.2 Transportation

The roadway is the main communication network in the district and all the Upazila are well connected with the district headquarter. Bus, CNG operated auto-rickshaw, easy-bike, motorbike, charger van is used for local passenger transportation. Local van, engine trolley, pickup, truck, etc. are used in carrying commodities locally from one place to another. Two upazilas namely Atrai and Raninagar have railway connection with 12.0 km and 5.5 km respectively. Presently, water transportation has been found almost nil in this district.

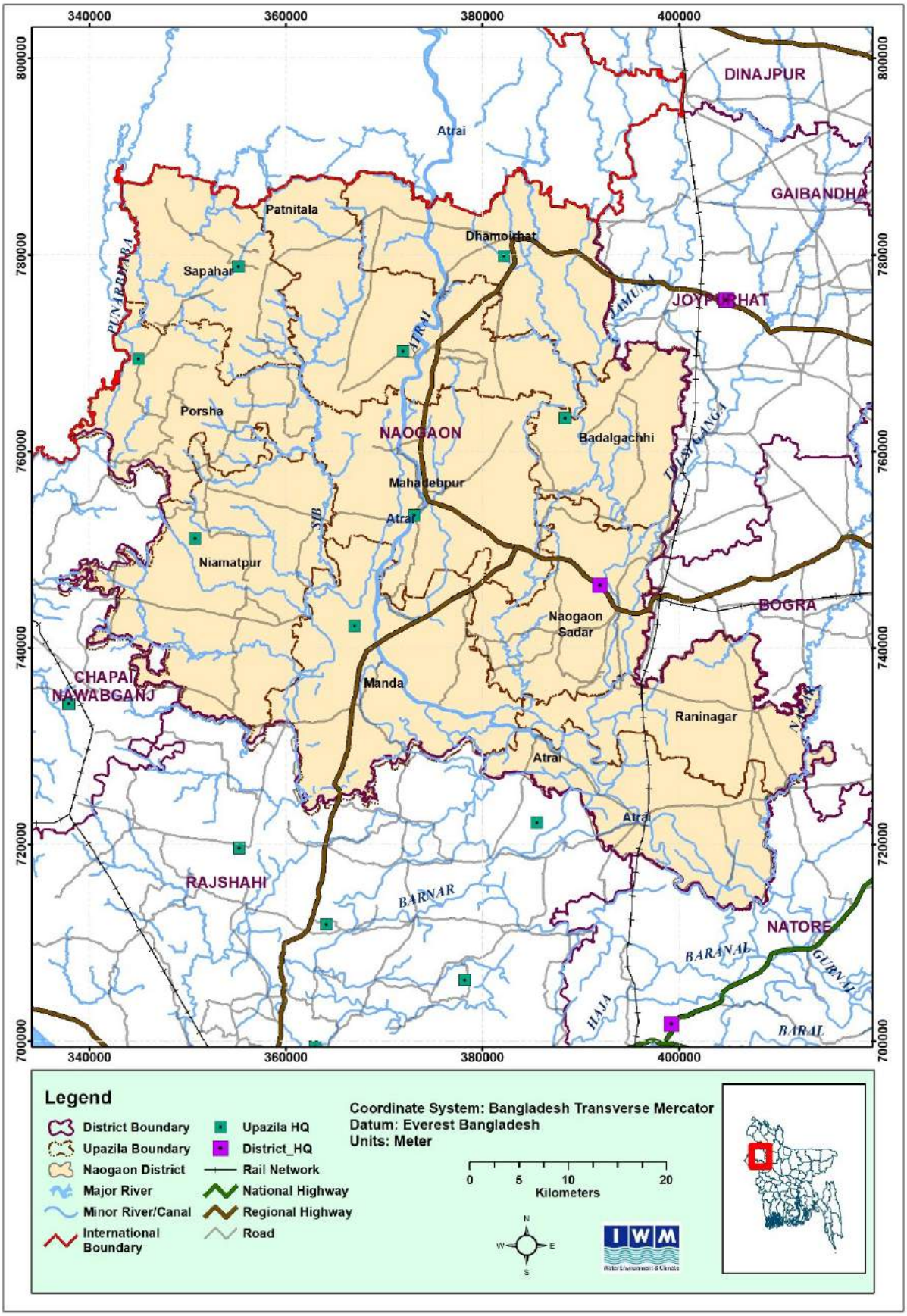


Figure 5-5: Base Map of Naogaon District

5.3.3 Agricultural System

From the discussions of the conducted FGDs and validation workshops at upazila level, it is observed that agriculture is the leading source of livelihood in all upazila. Overall land use pattern of Naogaon district showing homesteads, agricultural lands, water bodies and river/canal network is given in the Figure 5-6. The trend in land use changes is being changed towards more beneficial livelihood such as aquaculture or even for urbanization, and sometimes vice versa also.

This PRA study revealed that the land use distribution of the agricultural land is as follows:

i) Crop production –70 to 86%,
ii) Fish farming – 5 to 25%,
iii) Orchard – 2 to 20%,
iv) Wood/timber farming – 0.5 to 3%.

About 25% of agricultural land is used for fish farming in Atrai upazila, whereas only it is 5% in Porsha upazila. Both in Sapahar and Porsha upazila it stands to 20%, which is the highest in terms of orchard, where the minimum is visualized in Atrai Upazila as to 2%. Very little of agricultural land was found as distribution in wood/timber cultivation, which is in the range of 0.5 to 3% in this district. Badalgachi upazila shows the highest crop cultivation with 86% of agricultural land, and Sapahar upazila is of lowest coverage of 70%. The main crop cultivation in different crop calendars is as follows:

i) Kharif-1: Mango, Aus rice, Corn, Jute, Pointed gourd, Bottle gourd, Stem amaranth, Jackfruit, Cucumber, Papaya etc.
ii) Kharif-2: Aman rice, Banana (round the year), Green Chili, Bitter gourd, Banana (round the year), Pumpkin etc.
iii) Rabi: Boro rice, Wheat, Corn, Red Lentil (locally known as ‘Mosur Dal’), Watermelon, Potato, Brinjal, Radish, Tomato, Mustard etc.

Depending on the area of land cultivated, the percent of farmers at classes is given in Table 5-3 below.

Table 5-3: Farmers Classes (%)

Upazila	Marginal Farmers	Small Farmers	Middle class Farmers	Large Farmers
Atrai	53	30	15	2
Badalgachi	40	40	15	5
Dhamuirhat	26	50	22	2
Manda	50	30	15	5
Mohadevpur	45	35	15	5
Naogaon	55	28	15	2
Niamatpur	70	7	13	10
Patnitala	30	40	25	5
Porsha	45	35	15	5
Raninagar	60	25	12	3
Sapahar	33	30	20	7

Source: PRA Study (2021)

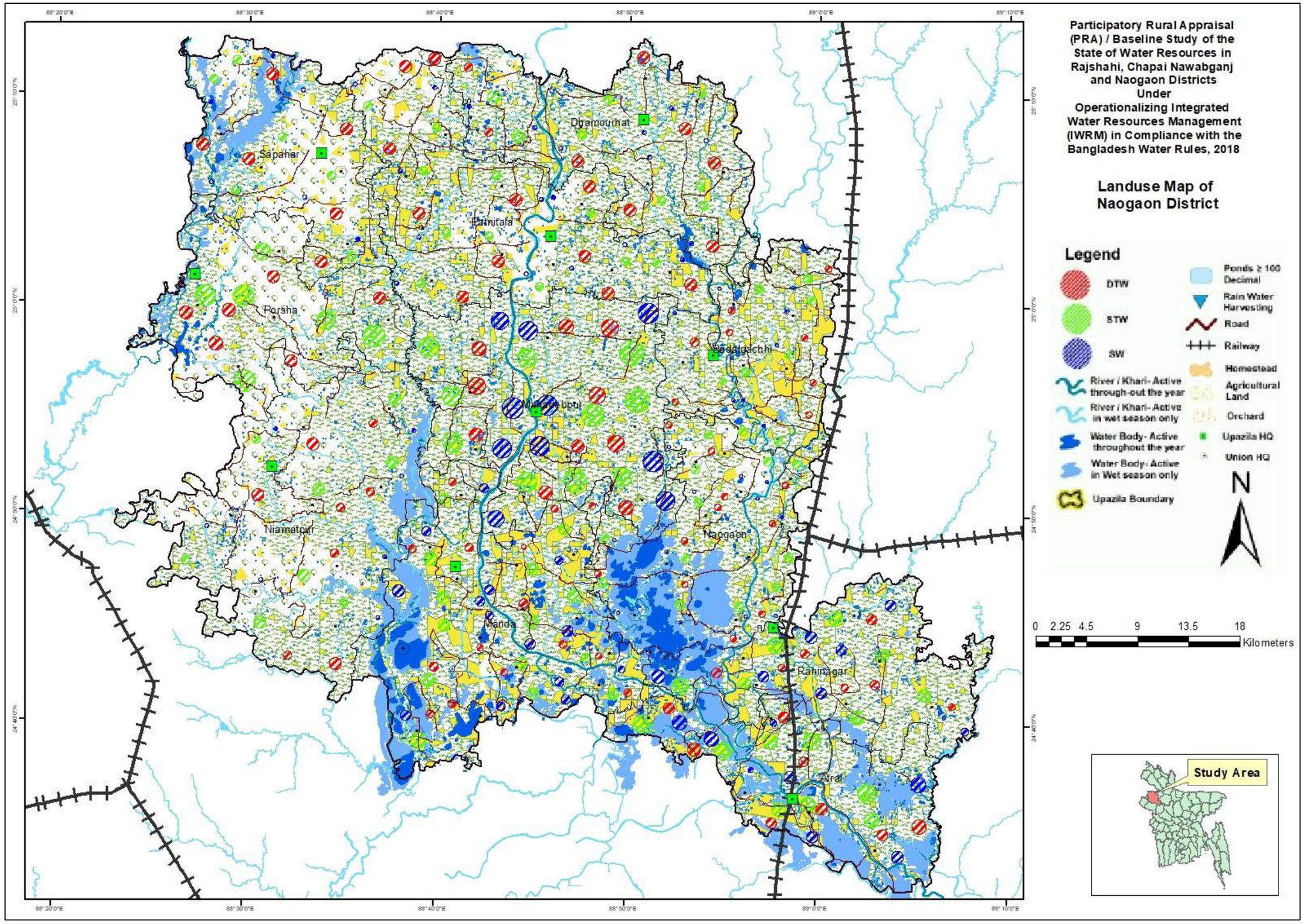


Figure 5-6: Land Use Map of Naogaon District

5.3.4 Biodiversity

Flora

A significant portion of the Naogaon district lies within the Barind region. The relief of this area is elevated and moderately undulating. A stiff soil of reddish clayey loam distinguishes it from the remaining portions of the district, which lie within the flood plains of the little Jamuna, the Atrai, and the Purnabhaba rivers, where soils are mainly silty in ridges and clays in basin centers in some areas and heavy clays in some other areas. There are perennial marshes in the district. In Atrai upazila the major forms of flora are found, which also benefit the community, include palm (*Arecaceae*), jackfruit (*Artocarpus heterophyllus*), litchi (*Litchi chinensis*), and papayas (*Carica papaya*). Major plants grown in Badalgacchi upazila mainly are mangoes (Mangifera indica), jackfruits, bananas (*Musa*), papayas, and litchis. Lots of Sal Forest can be seen in Dhamoirhat upazila, moreover, it is rich in different plants such as, Sal (*Shorearobusta*), Bohera (*Terminalia bellirica*), Amloki (*Phyllanthus emblica*), Jam (*Syzygiumcumini*), Bon-Sonalu (*Cassia fistula*), Dudhi tree (*Euphorbia hirta L.),* Palash (*Butea monosperma*) and Shimul (*Bombax*). Fruits grown in the area include mangoes, jackfruits, litchis, blackberry (Rubus), watermelon (*Citrullus lanatus*), papayas and guavas (*Psidium guajava*). In Patnitala, the production of litchi, Papaya, and mango, Jack fruit are very common. The familiar trees that can be seen in Porsha upazila are palm, banian, debdaru, tamal, krishnachura, Barak bamboo, etc. Some other plants such as, kamini, shefali Shonda, pui and basil, etc can be located here. Paddy, wheat, mustard, and vegetables are the main crops of Sapahar. Aus paddy, sesame, linseed, and Arahar are all extinct or virtually extinct crops. But in this area, mango cultivation is very prominent nowadays. At the same time jackfruit, banana, papaya, and watermelon are the main fruits as well. Mahadebpur upazila are lies within the flood plains of the little Jamuna, Atrai, and Purnabhaba rivers, where soils are primarily silty in ridges and clays in basin centres in some areas and heavy clays in others. Aus, aman, boro, jute, and wheat are the most important agricultural products in this upazila. Apart from, Rabi crops are very prominent include mustard, khesari, masur, mash, potato, sesame, gram, spices, barley, maize, tobacco, and sugarcane, among others. Tal (*palms*) abounds in the district's Barind region. Around homesteads, bamboo and mango are abundant. Bananas are frequently planted along the fields' borders. Manda upazila is also rich in agriculture products such as rice, jute, and wheat, mustard, lentils, potato, spices, barley, maize, tobacco, sugarcane. There are many palm trees. Around homesteads, bamboo and mango are abundant. Banana plants are frequently

planted along the fields' borders. The most notable one out of these beels is the Manda beel. It continues in a chain of beels to the south and the east. Rice is the main crop of Naogaon Sadar upazila. There are many palm trees. Around homesteads, bamboo and mango are abundant. Banana plants are frequently planted along the fields' borders. There is also an enormous stretch of perennial swamp all around Dublahati village. Aus, Aman, boro, jute, and wheat are the most important agricultural products in Niamatpur upazila. Besides, Rabi crops other crops such as mustard, khesari, Masur, mash, potato, sesame, gram, spices, barley, maize, tobacco, and sugarcane are included among others.

Fauna

In Atrai upazila of Naogaon district, 74 fish species are commonly found of which is dominated by 18 species of minnows and carps (*Cyprinidae*), 1 type of needlefishes (Belonidae), 1 type of anchovies (*Engraulidae*), and 2 types of Herrings (*Clupeidae*). As for birds, there are sightings of both local and migratory species. There are various species of doves available. Then there are kingfishers such as the Common Kingfisher, Pied Kingfisher, Stork-billed Kingfisher, and White Throated Kingfisher. There are also herons, kites, sandpipers, and ducks found in the area. The river Choto Jamuna runs along with Badalgacchi upazila, which contains a wide variety of fish species some of which are endangered such as Mola carplet (*Amblypharyngodon mola*), Bata (*Labeobata*), Chela (*Salmostomabacaila*), Lal chanda (*Chanda ranga*), Long-whiskered catfish, Mud eel (*Monopteruscuchia*) and many more. Many unique animals are found in the Dhamoirhat Sal Forest that makes the upazila stand out which includes Jackals (*Canis aureus*), Fox (*Vulpes vulpes*), Squirrel (*Sciuridae*), Dove (Columbidae), Owl (*Strigiformes*), Magpie (*Pica pica*), Kingfisher (*Alcedinidae*) and different types of snakes such as Russell's viper (*daboia russelii*). The Atrai River flows through the Patnitala. Also, there is a small Monohor river in that area. The Doyel, Red-whiskered bulbul can be seen in that area. Various species of frogs can be seen in Patnitala. Such as Nepal Cricket Frog, Pierre’s Cricket Frog, Asmat’s Cricket frog, Mangrover frog, Terai Cricket Frog, etc. In Porsha upazila, the available mammalian fauna is mouse, metho mouse, nengti mouse, common house mouse, tortoise, dorakathbirali, bhondar, kola badur, Indian pipistrelle, tickill’s bat, jackal, bon biral. Different species of birds used to be seen in that area, but the numbers have diminished significantly. The harm in biodiversity is caused because of the poor quality of the environment. However, the magpie, sparrow, bhat, martine, Jhuti martin, swallow, tuntuni, lal kite, crow, jack draw, kingfisher, woodpecker, tila dove, botkoletc can be seen usually. Besides of these local birds, a huge number of migrant birds can be seen in winter

season. In Raninagar upazila, different species of birds can be seen. They are Fulvous whistling duck, lesser whistling ducks, ruddy shelduck, common shelduck, spot-billed duck, Night-heron, Cinnamon bitten, little egret, grey plover etc. Dairies, fisheries, and poultry Fisheries are represented by 11, dairy is represented by 8, and poultry is represented by 32 in Sapahar Upazila. Natural habitats of ponds, creeks, beels and river fish populations are in many parts of Mahadevpur Upazila. The area is rich in Ruhi (*Labeo Rohita*), Katla (*Katla Katla*), Kalibaush (*LabeoCalabasu*), Mrigel (*SirinasMrigala*), Koi (*Anabas testudinus*), Shing (*Hetroponneustusfossilis*), Magur (*Clariusbatrachus*), Boiled fish etc. are available. Furthermore, exotic fish species such as tilapia, nilotica, silver carp, grass carp, and others are being cultivated in this upazilas.The main types of fishes are ruhi, catla (*catlacatla*), Kalibaush (*Labeocalbasu*), mrigel (*Cirrhinusmrigala*), koi (*Anabas testudineus*), shing (*Heteropneustesfossilis*), magur, airh (*Mystusaor*), boal (*Wallago attu*), pangas, shoil (*Channastriatus striatus*), bele (*Glossogobiusgiuris*), chital (*Notopteruschitala*), pabda (*Ompokpabda*), tengra (*Mystusvittatus*), phali (*NotopterusNotopterus*) which are very available in Manda upazila. In Naogaonsadar upazila the principal types of fishes are ruhi, catla, Kalibaush, mrigel (*Cirrhinusmrigala*), koi, shing, magur (*Clariasbatrachus*), airh, boal, pangas (*Pangasius pangasius*), shoil, bele, chital, pabda, tengra (*Mystusvittatus*), phali (*NotopterusNotopterus*).In Niamatpur upazila there are many ponds, creeks, beels, and rivers that serve as a natural habitat for fish populations. Ruhi, catla, kalibaush (*Labeocalbasu*), mrigel (*Cirrhinusmrigala*), koi, shing, magur, airh, boal, Furthermore, exotic fish species such as tilapia, nilotica, silver carp, grass carp, and others are being cultivated in the upazilas.

5.3.5 State of Water Resources

Water usage of Naogaon district has been classified based on groundwater abstraction (STW, DTW) and surface water bodies (ponds, beels and rivers/khals). The total number of surface water bodies in the district is 29,102 (28,877 ponds having sizes >25 decimals and 225 beels). The main rivers in the district are the Atrai, the Punarbhaba, Little Jamuna, Nagar, Tulsi Ganga etc. For irrigation, fish farming and household purposes, groundwater is tapped through 4,533 nos. of deep tube wells (mainly for irrigation) and 340,944 nos. of active shallow tube wells as given in Table 5-4. Tubewell density map is given in Figure 5-7.

Approximate yearly sector-wise water demand in MCM has been found for domestic, agricultural, fisheries, and industries 45.82, 2289.42, 164.14 and 23.48 respectively. Again, the

total water use was found to be 2522.83 MCM at the base year of 2021. Similarly, water demand has been estimated and it stands at 2534.94 MCM for 2030 and 2547.82 MCM for 2041 as given in Table 5-4.

The respondents in FGDs opined that groundwater abstraction started from shallow zone in 1980's. Due to over exploitation, groundwater level is observed in a declining trend. It revealed that the depth to groundwater table varies from 1.5 to 22.5 meters in the year of 2021. Accordingly, union-wise groundwater scarce maps have been developed and presented in the Figure 5-8.

Constraints and opportunities concerning the water resources for each upazila have been identified. Based on those issues' recommendations have been framed and incorporated in details at the end of individual upazila reports as given in Volume – II to Volume-IV.

Table 5-4: Different Aspects of Water Resource Usage and Demand in Naogaon District

Upazila	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Groundwater Scarcity
					Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
Atrai	284.41	24186	Atrai, Iramati, Nagar Lower, Fakirni, Chota Jamuna	2344	202767	761	3.70	166.17	14.53	1.28	185.69	186.59	187.66	48061	294	1.5 to 10.0	Less to Scarce Free
Badalgachi	213.98	18196	Chata Jamuna, Tulshi Ganga	1047	211409	988	3.86	138.29	5.59	0.74	148.47	148.97	149.54	10242	320	2.5 to 8.0	Less Scarce
Dhamoirhat	289.64	24630	Atrai, Ciri, Chata Jamuna	2135	178380	616	3.26	198.75	15.00	1.43	218.43	219.35	220.43	44310	359	4.0 to 13.0	Less to Scarce Free
Manda	397.13	33771	Atrai, Shib, Fakirni	3590	380084	1006	6.94	266.69	18.18	-	291.80	292.89	294.02	55000	483	2.5 to 14.5	Less to Scarce Free
Mahadebpur	395.52	33237	Atrai, Shib	4077	308110	779	5.62	279.68	21.44	4.77	311.51	314.02	315.94	70596	571	2.0 to 11.5	Less to Scarce Free
NaogaonSadar	238.69	20297	Little Jamuna, Tulshi Ganga	1625	268932	1127	4.91	174.06	8.29	3.98	191.23	192.13	193.07	37230	249	3.5 to 11.0	Moderate to Less Scarce
Niamatpur	449.14	37294		4049	261139	581	4.77	319.78	23.32	0.62	348.49	349.73	351.26	18716	790	6.5 to 17.5	Moderate to Less Scarce
Patnitala	343.17	29181	Atrai	3725	221307	645	4.04	253.84	23.33	7.65	288.86	290.77	292.87	39906	443	7.0 to 16.5	Moderate Scarce to Less Scarce
Porsha	271.88	22576	Punarhava	2127	116341	508	2.12	121.91	11.73	0.27	136.03	136.64	137.39	4124	282	7.0 to 22.5	Severe to Less Scarce
Raninagar	258.32	21191	Choto Jamuna, Nagor, Atrai	2374	192762	947	3.52	186.69	13.48	2.73	206.41	207.41	208.55	11660	419	3.5 to 10.0	Less to Scarce Free
Sapahar	244.60	20057	Punarhava	1784	168781	690	3.08	183.56	9.25	0.01	195.91	196.44	197.09	1099	323	7.5 to 18.0	Less to Moderate Scarce
Total	***3386.48***	***284616***		***28877***	***2510012***		***45.82***	***2289.42***	***164.14***	***23.48***	***2522.83***	***2534.94***	***2547.82***	***340944***	***4533***		

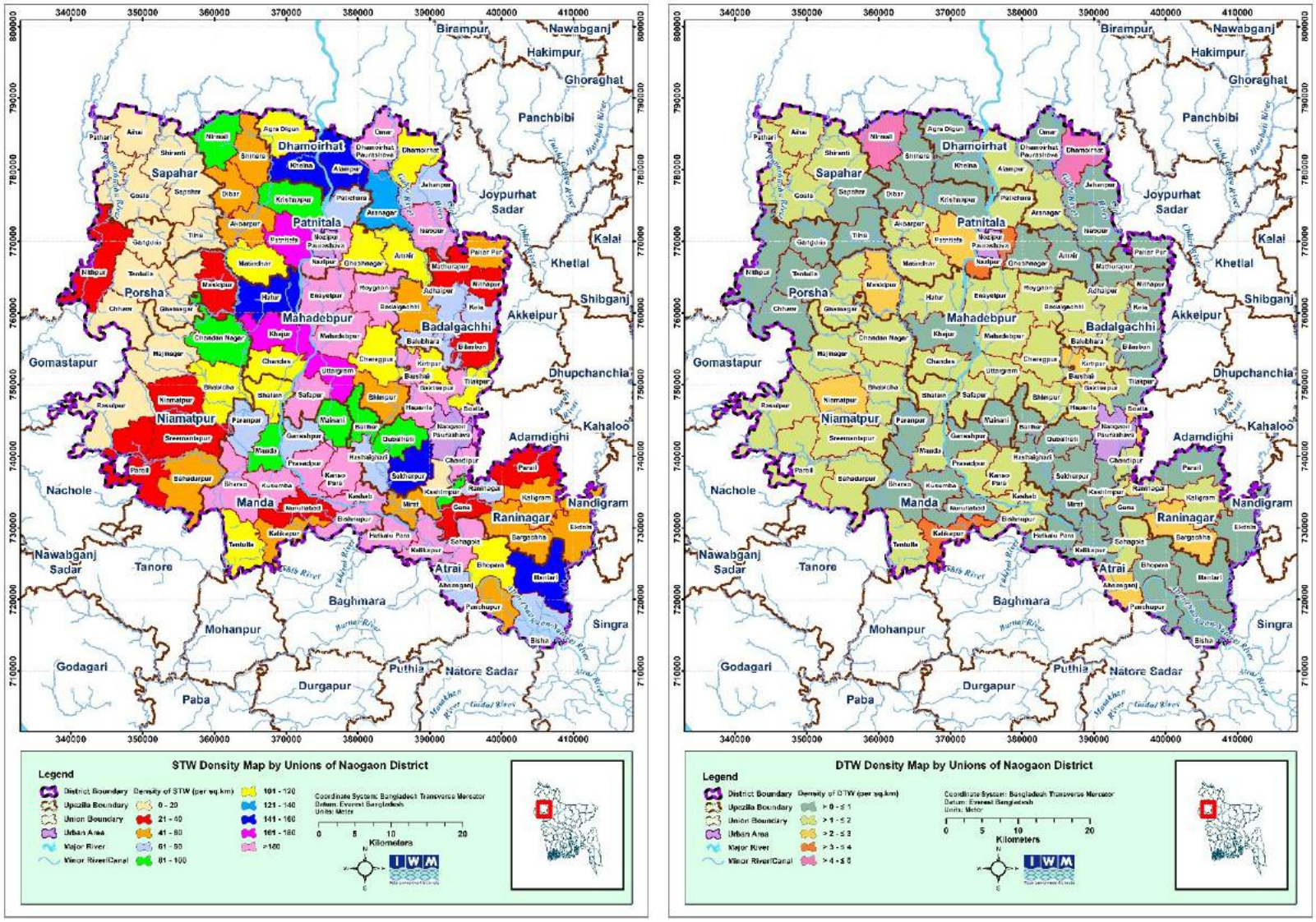


Figure 5-7: Tubewll Density (STW Density at the Left and DTW Density at the Right) Naogaon District

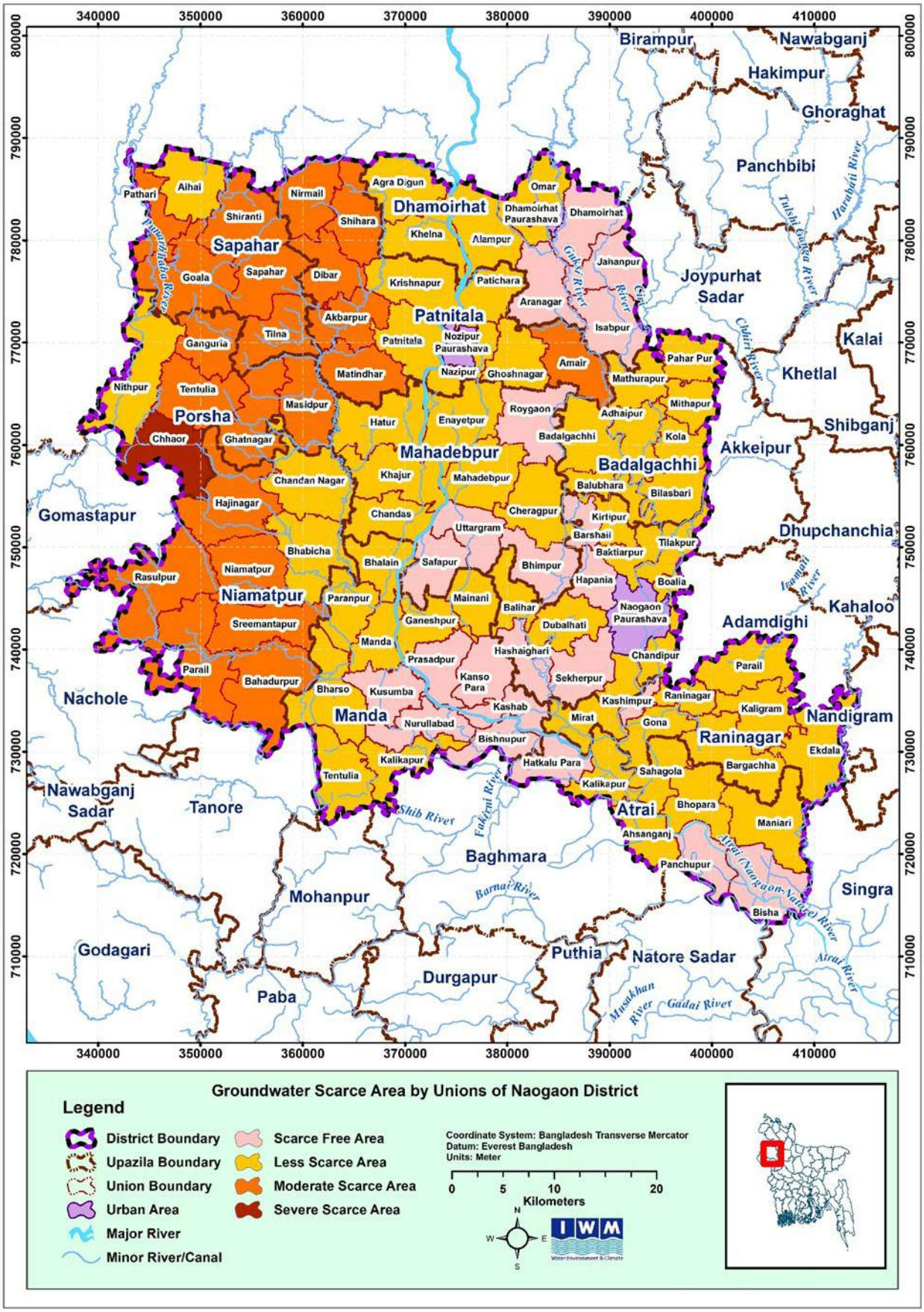


Figure 5-8: Groundwater Scarce Map of Naogaon District

5.3.6 Recommendations

Considering the knowledge on the present scenario of water resources, uses, and demand of all the upazilas as gathered through the conducted FGDs and PRA validation workshop, the following recommendations are given based on PRA findings:

1. The major river and its tributaries and distributaries should be re-excavated to ensure better drainage and improve the water retention capacity. The surface water can be used for irrigation and fish farming.
2. The beels lies in Atrai, Raninagar, Manda and Naogaon Sadar upazilas have to be developed as potentials for surface water retention and preservation for irrigation year-round, fish culture and household purposes. Beels at four unions of Atrai namely Bisha, Kalikapur, Maniari and Panchupur; Masho and Chuary Beels of Raninagar; Beels at two unions of Manda namely Bharso and Tentulia; beels at three unions of Naogaon Sadar namely Sekherpur, Dubalhati and Hashaighari are considered for this purpose.
3. The beels at Sapahar, Porsha and Niamatpur should be re-excavated to enlarge the water retention capacity both by volume and for most part of the year for using the surface water for irrigation, which will reduce the dependency on groundwater. There are several beels in Sapahar among which Damudahar Beel, Dak Beel at Aihai union, Kayamar Beel at Pathari union and Baksha Beel, Puroil Beel, Mahil Beel, Jaba Beel at Goala union; beels at Nithpur union of Porsha; and Chhatra Beel of Niamatpur.
4. There are 3800 nos of ponds (>100 decimals) in the district needs to be re-excavated to a deeper extent for extensive use in fish farming and household purposes.
5. Based on PRA study, present groundwater situation in Niamatpur, Porsha and Sapahar upazilas are in severe groundwater scarce zone as found is alarming and discouraging. As such these upazilas should bring under restricted/limited abstraction. The remaining part mostly shows less scarce.
6. Groundwater use should be reduced to ensure water resources for future generations, and conjunctive use of groundwater and surface water should be promoted. Accordingly, a regular awareness campaign should be organized.
7. Crop diversification is prescribed as cultivation of crops with less water requirement should be introduced instead of HYV Boro crop to improve the water management.

8. Awareness campaign should also be organized for crop diversification i.e. for cultivation of crop with less water requirement instead of HYV Boro crop to improve the water management and crop yield as well.
9. All re-excavation action specially for surface water retention and improved drainage should be taken up by the relevant implementing organization following a detail feasibility study.

5.4 Chapai Nawabganj District

Chapai Nawabganj district is bounded on the north by India, on the east by Naogaon and Rajshahi districts, on the south and west by India. The total area of the district is 1702.54 Sq.km. (657.35 sq.miles). The district lies between 24˚25′and 24˚58′ latitudes and between 88˚01′ and 88˚30′ longitudes. The base map of Chapai Nawabganj District is shown in Figure 5-9.

5.4.1 Socioeconomic Profile

Socioeconomic profile of Chapai Nawabganj district has been analyzed on the basis of primary and secondary information. According to the field study (FGD and Upazila validation workshop) 100% of the population are found *Bengalee*. As per the field study, a total 308,185 households with 1,423,490 population currently reside in Chapai Nawabganj district. Average household's size is 4.76 and male to female ratio is 98.8 males per 100 females. Most of the households i.e. approximately 87.2% falls under the conjugal family type, while the rest are of joint family. About 88% people are literate and 99% attend school. Probable workforce of the district is 60.6% (age between 15-64 years). About 57.13% people depends on agriculture where 5.16% non-agricultural laborer, 1.35% industry, 17.05% commerce, 1.76% transport and communication, 4.64% service, 2.90% construction, 0.17% religious services, 0.69% rent and remittance and rest 9.15% others. The study finding also revealed that 97% people use sanitary latrine, 98% dwellers of the study area are drinking safe water and 96% households are enjoying the electricity facilities.

5.4.2 Transportation

The roadway is the main communication network in the district and all the upazilas are well connected with the district headquarter. Bus, CNG operated auto-rickshaw, easy-bike, motorbike, charger van is used for local passenger transportation. Local van, engine trolley, pickup, truck, etc. are used in carrying commodities locally from one place to another. All upazilas have railway connection, except Bholahat and Shibganj upazila. As water transport, waterways (rivers and canals) are 43.91 km throughout the year, while waterways (rivers and canals) are 212.38 km during monsoon.

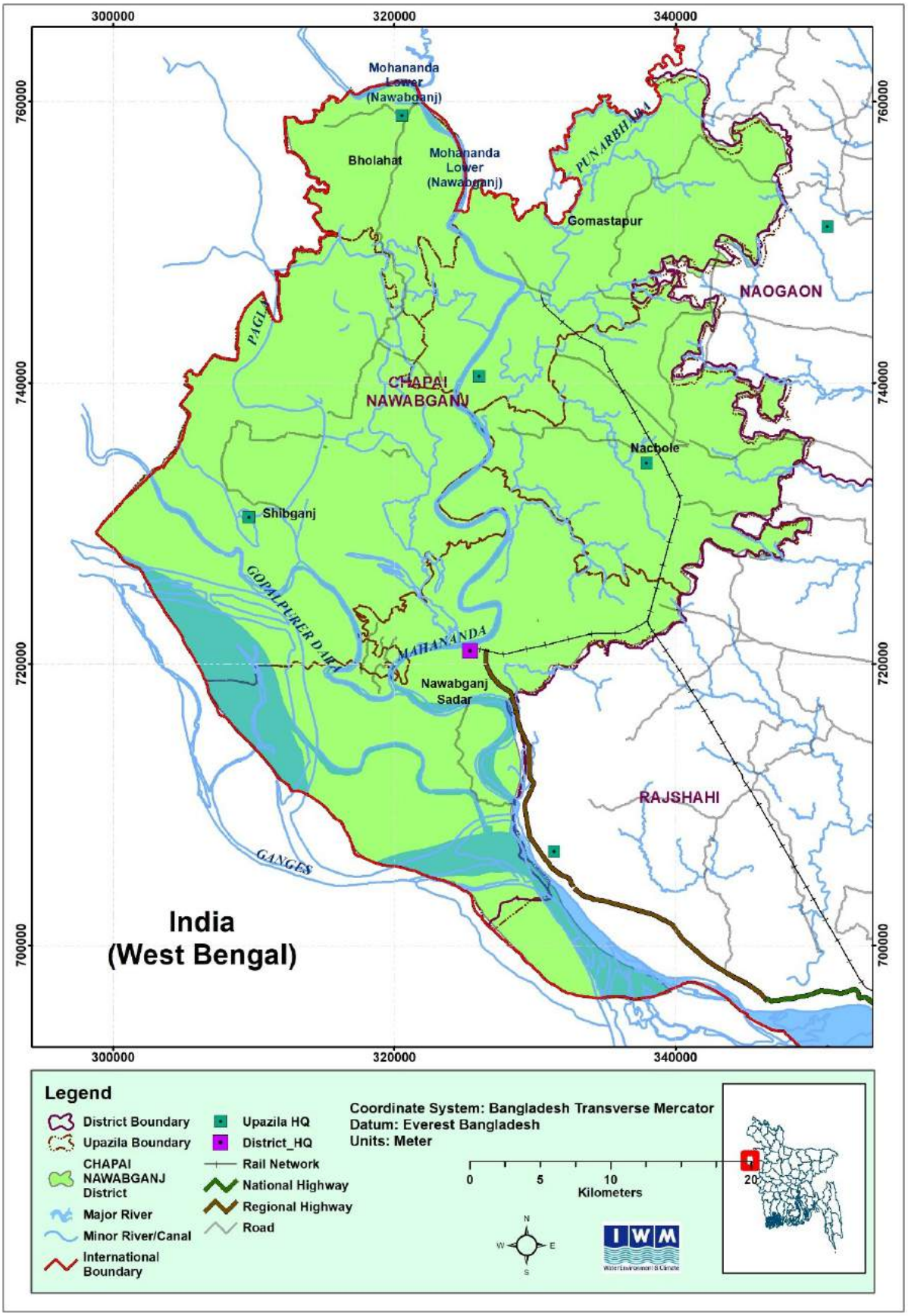


Figure 5-9: Base Map of Chapai Nawabgabj District

5.4.3 Agricultural System

From the discussions of the conducted FGDs and validation workshop at upazila level, it is observed that agriculture is the leading source of livelihood in all upazilas. Overall land use pattern of Chapai Nawabganj district showing homesteads, agricultural lands, water bodies and river/canal network is given in the Figure 5-10. The trend in land use changes is being changed towards more beneficial livelihood such as aquaculture or even for urbanization, and sometimes vice versa also.

The present PRA study revealed that the land use distribution of the agricultural land in this district, 40 to 75% is used for crop production, 5 to 15% for fish farming, 12 to 50% for Orchard, and 1 to 3% for Wood/timber cultivation.

About 75% of agricultural land is used for crop cultivation in Nachole upazila, whereas only 40% in Shibganj upazila, but in Shibganj upazila orchard cultivation shows the highest value of 50%. In this district, on average, 62% of agricultural land is used for crop cultivation, 9% for fish farming, 27% for orchard, and only 2% for wood/timber farming.

The main crop cultivation in different crop calendars is as follows:

i) Kharif-1: Mango, Corn, Jute, Pointed gourd, Bottle gourd, Aus Rice, Peanuts, Stem amaranth, Jackfruit, Cucumber, sesame seeds, Papaya etc.
ii) Kharif-2: Aman Rice, Banana (round the year), Green Chili, Bitter gourd, Banana (round the year), Pumpkin etc.
iii) Rabi: Boro rice, Potato, Wheat, Corn, Pulses, Watermelon, Brinjal, Radish, Tomato, Mustard etc.

Depending on the area of land cultivated, the percent of farmers' classes is given in Table 5-5.

Table 5-5: Farmer Classes (%)

Upazila	Marginal Farmers	Small Farmers	Middle class Farmers	Large Farmers
Bholahat	63	30	5	2
Chapai Nawabganj	45	40	10	5
Gomostapur	55	30	10	5
Nachole	65	20	12	3
Shibganj	35	50	10	5

Source: PRA Study (2021)

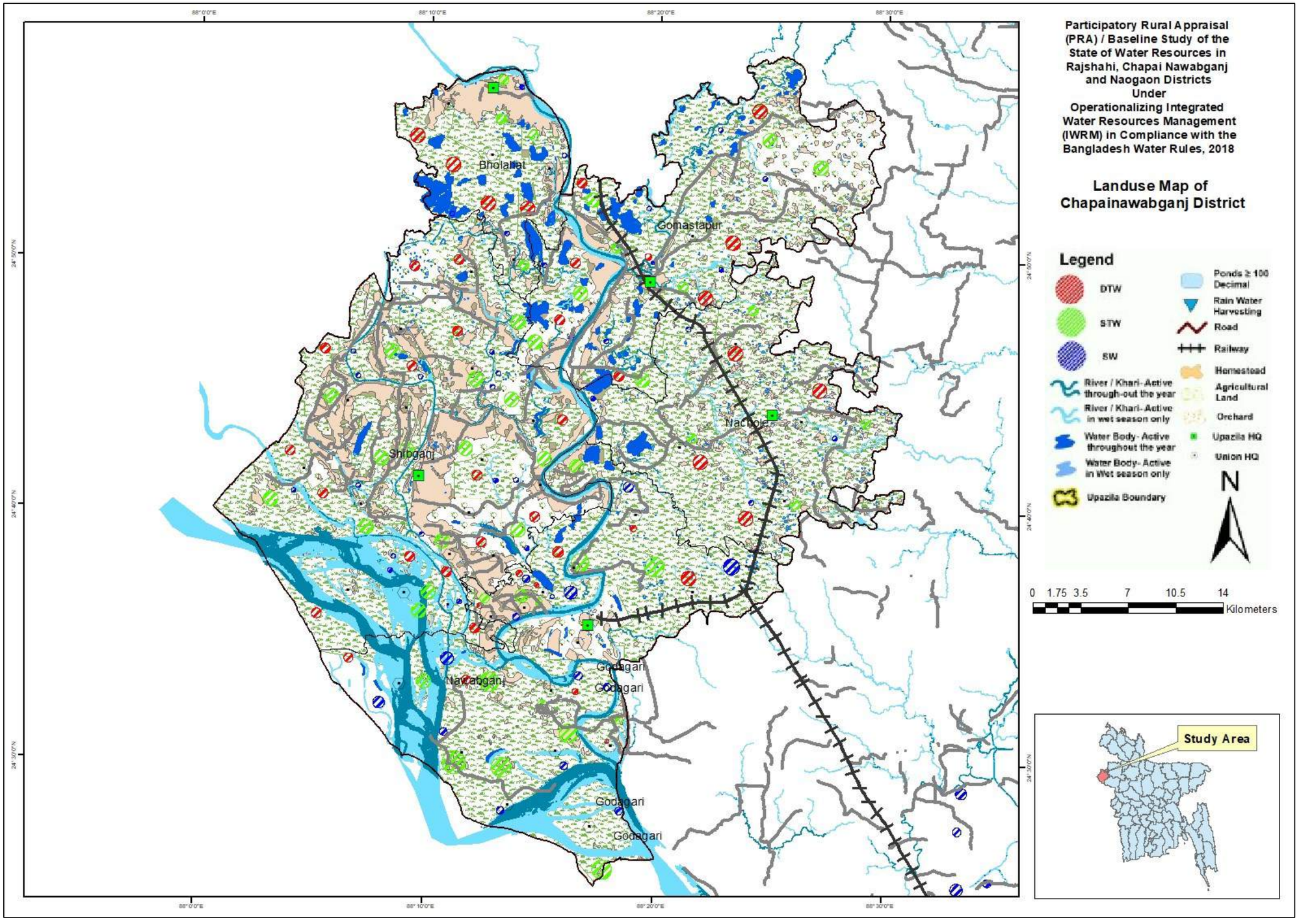


Figure 5-10: Land Use Map of Chapai Nawabganj District

5.4.4 Biodiversity

Flora

In most of the upazilas of the Chapai Nawabganj district, the relief is that of broad flood plain ridges and basins with broad high ridges along the Mahananda and pagla rivers. Basins and lawer ridges have clays, with loams on the higher ridges. A small part of Bholahat, the eastern part of Gomastapur and part of Chapai Nawabganj upazilas of the district lie in the Barind Tiact belonging to an older alluvium formation.

The main fruits grown in Bholahat upazila includes mangoes (*Mangifera indica*), jackfruits (*Artocarpus heterophyllus*), litchis (*Litchi chinensis*), blackberry (*Rubus*), palm (*Arecaceae*), coconut (*Cocos nucifera (L.)),* watermelon (*Citrullus lanatus*) and plums (*Prunus domestica*). Main cash crops are jute, mesta, sunhemp, cotton, sugarcane and tobacco in Gomastapur upazila. Wheat cultivation is becoming more widespread. Mulberry is grown on raised plots for silkworm rearing. Rabi crops include mash, mustard, barley, gram, masur, khesari, motor, sesame, onion and garlic, maize and potato, and vegetables. In addition to mango, there are orchards of jackfruit, lichi, guava, and other fruits. Bamboo is also cultivated. The village homesteads are usually covered by assorted tree species, shrubs and thickets of bamboos. Nachol is reliant on agriculture, which is completely dependent on rainfall. The main crops are paddy, wheat, pulse, vegetables. Main fruits are mango, jackfruit, litchi, blackberry, palm, coconut, watermelon, plum. Trees that are widely grown in this area are khair (*Acacia catechu*), palm tree (*Borassus flabellifer*), babla/acacia (*Acacia nilotica*), siris (Abizzia lebbeck), bilati siris (*Samanea saman*), shet khoiyer (*Acacia suma*), chakua koroi (*Albizia chinensis*) etc. Mango, litchi, jackfruit, papaya trees can be seen in Shibganj upazila.

Fauna

There are no known significant animals found in Bholahat upazila. However, in the Chapai Nawabganj district in general animals such as jackal (*Canis aureus*), banbiral (*Felis chaus*), Bara benji (*Herpestes edwardsi*), rat (*Bandicota bengalensis*), metho mouse (*Mus booduga*), nengti mouse (*Mus musculus*), common house rat (Rathus rattus), and monkey. The most common freshwater fish species has identify such as ruhi (*Labeo rohita*), catla (*Catla catla*), Airh (*Mystus aor*), chital (*Notopterus chitala*), pangas (Pangas ius pangasius), koi (Anabas testudineus), magur (Clarias batrachus), shing (*Heteropneustes fossilis),* sarpunti (*Barbus sarana*), and other fish species. The most common freshwater fish species found in Nachol

upazila are ruhi, catla (*Catla catla*), mrigel (*Cirrhinusa mrigala*), and kalibaush (*Labeo calbasu*). Airh (*Mystus aor*), chital (*Notopterus chitala*), pangas (*Pangas ius pangasius*), koi (*Anabas testudineus*), magur (*Clarias batrachus*), shing (*Heteropneustes fossilis),* sarpunti (*Barbus sarana*), and other fish species. Furthermore, a few exotic varieties of fish are available. In Chapai Nawabganj Sadar, there are vast open water bodies. There is a natural habitat of various aquatic resources including wild fishes and prawns about 260 species of freshwater fishes, 24 species of prawns, 50 species of reptiles, 24 species of mammals, 475 species of marine fishes and 36 species of shrimps. The most common freshwater fish species found in this upazila are ruhi, catla (Catla catla), and kalibaush (*Labeo calbasu*). Chital (*Notopterus chitala*), koi (*Anabas testudineus*), shing (*Heteropneustes fossilis),* sarpunti (*Barbus sarana*), and other fish species as well.

5.4.5 State of Water Resources

Water usage of Chapai Nawabganj district has been classified based on groundwater abstraction (STW, DTW) and surface water bodies (ponds, beels and rivers/khals). The total number of surface water bodies in the district is 5184 (4944 ponds having sizes >25 decimals and 240 beels). The main rivers in the district are the Ganges, Mohananda Lower, Punarbhaba, Tulshi Ganga and Pagla. For irrigation, fish farming and household purposes, groundwater is tapped through 1,644 nos. of deep tube wells (mainly for irrigation) and 96,418 nos. of active shallow tube wells as given in Table 5-6. Tubewell density map is given in Figure 5-11.
Approximate yearly sector-wise water demand in MCM has been found for domestic, agricultural, fisheries, and industries 25.93, 948.22, 10.56, and 1.87 respectively. Again, the total water use was found to be 986.55 MCM at the base year of 2021. Similarly, water demand has been estimated and it stands at 988.67 MCM for 2030 and 990.95 MCM for 2041 as given in Table 5-6.

The respondents in FGDs opined that groundwater abstraction started from shallow zone in 1980's. Due to over exploitation, groundwater level is observed in a declining trend. It revealed that the depth to groundwater table varies from 3.0 to 27.5 meters in the year of 2021.
Accordingly, groundwater scarce maps have been developed and presented in the Figure 5-12. Constraints and opportunities concerning the water resources for each upazila have been identified. Based on those issues' recommendations have been framed and incorporated in details at the end of individual upazila reports as given in Volume-II to Volume-IV.

Table 5-6: Different Aspects of Water Resource usage and Demand in Chapai Nawabganj District

Upazila	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Groundwater Scarcity
					Nos.	Density (nos. per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
Bholahat	123.52	10725	Mohananda Lower	155	93,363	756	1.70	73.90	0.5	0.16	76.26	76.39	76.52	8093	246	3.0 to 14.0	Less Scarce
Chapai Nawabganj Sadar	418.95	36414	Ganges, Mohananda Lower, Pagla	827	363,272	885	6.77	292.20	1.76	0.80	301.51	302.07	302.66	52118	206	4.0 to 12.5	Less Scarce
Gomostapur	303.57	26334	Punarbhaba, Mohananda Lower, Tulshi Ganga	1144	241,667	796	4.41	175.94	1.91	0.39	182.65	183.02	183.42	19435	425	5.0 to 29.0	Severe to Less Scarce
Nachol	271.69	23758	Mohananda Lower	2017	136,088	501	2.48	194.19	3.78	0.22	200.66	200.97	201.32	3255	522	9.0 to 27.5	Severe to Moderate Scarce
Shibganj	489.69	42635	Pagla, Mohananda Lower, Ganges	801	589100	1303	10.57	211.99	2.61	0.30	225.47	226.22	227.03	13517	245	3.0 to 10.5	Less to Scarce Free
Total	***1607.42***	***139866***		***4944***	***1423490***		***25.93***	***948.22***	***10.56***	***1.87***	***986.55***	***988.67***	***990.95***	***96418***	***1644***		

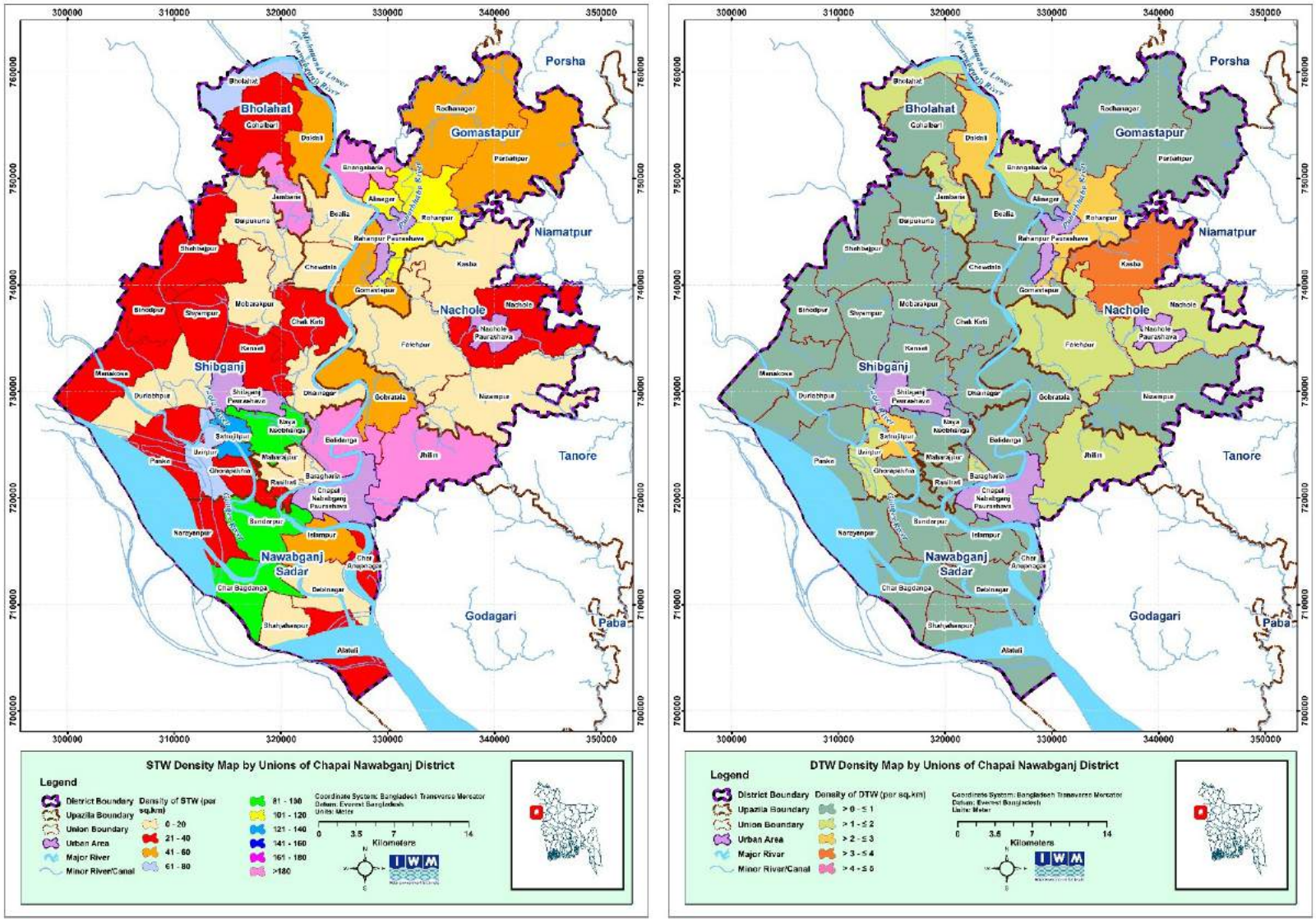


Figure 5-11: Tubewll Density (STW Density at the Left and DTW Density at the Right) Chapai Nawabganj District

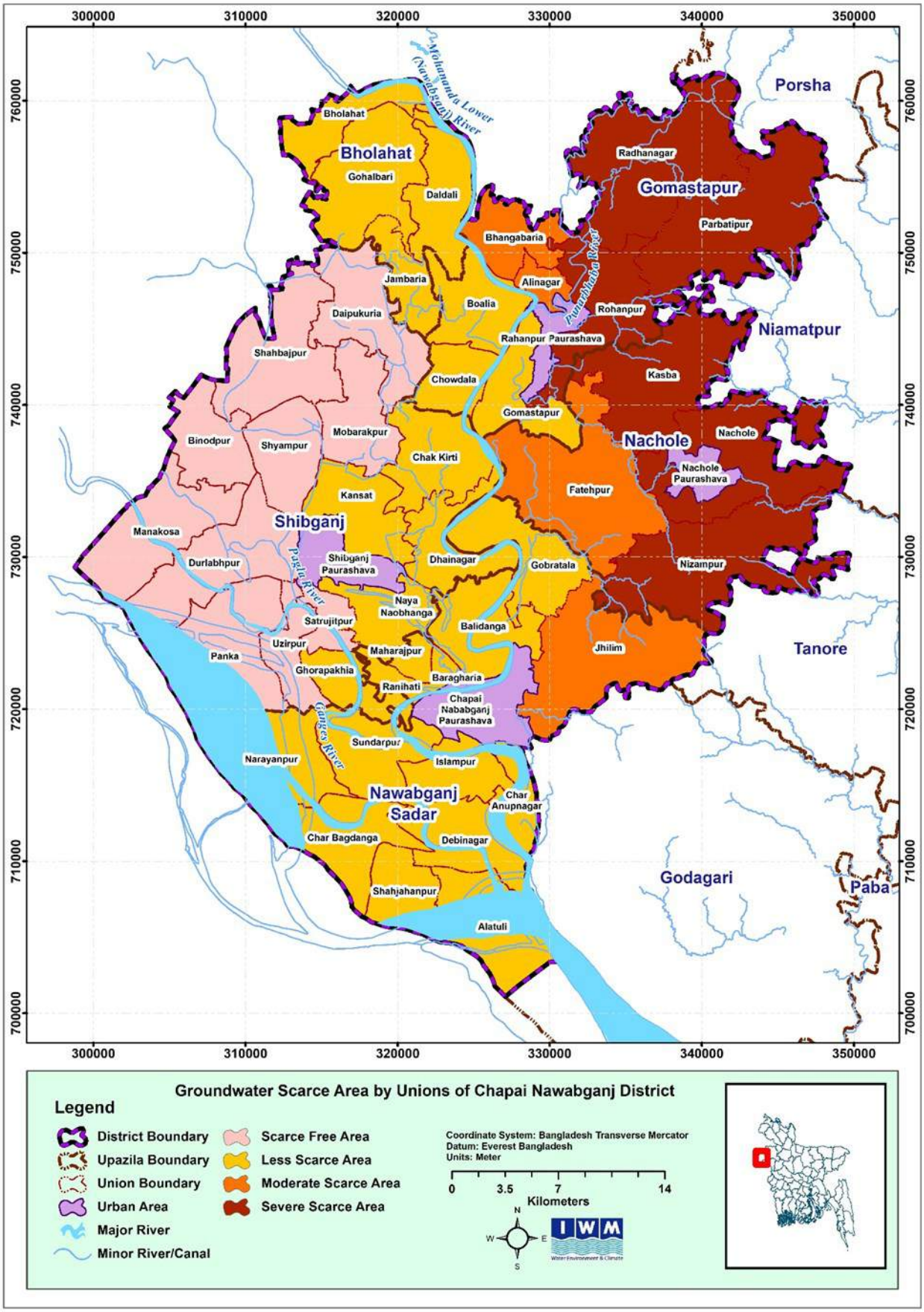


Figure 5-12: Groundwater Scarce Map of Chapai Nawabgabj District

5.4.6 Recommendations

Considering the knowledge on the present scenario of water resources, uses, and demand of all the upazilas as gathered through the conducted FGDs and PRA validation workshop, the following recommendations are given based on PRA findings:

1. The major river and its tributaries and distributaries should be re-excavated to ensure better drainage and improve the water retention capacity. The surface water can be used for irrigation and fish farming.
2. The beels at Bholahat, Gomostapur and Nachole upazilas should be re-excavated to enlarge the water retention capacity both by volume and for most part of the year for using the surface water for irrigation, fish culture and household purposes as well, which will reduce the dependency on groundwater. The beels at Bholahat includes Bhatia Beel, Sonajal Beel and Amgachi Beel; beels at Radhanagar union of Gomastapur; and Tali Beel and Anil Beel of Nachol.
3. There are 663 nos of ponds (>100 decimals) in the district needs to be re-excavated to a deeper extent for extensive use in fish farming and household purposes.
4. Present groundwater extraction in Nachole and Gomastapur upazilas are in severe groundwater scarce zone as found is alarming and discouraging. As such these upazilas should bring under restricted/limited abstraction. The remaining part mostly shows moderate to less scarce.
5. Groundwater use should be reduced to ensure water resources for future generations, and conjunctive use of groundwater and surface water should be promoted. Accordingly, a regular awareness campaign should be organized.
6. Rainwater harvesting practices should also be encouraged, especially for household purposes.
7. Crop diversification is prescribed as cultivation of crops with less water requirement should be introduced instead of HYV Boro crop to improve the water management.
8. Awareness campaign should also be organized for crop diversification i.e. for cultivation of crop with less water requirement instead of HYV Boro crop to improve the water management and crop yield as well.
9. All re-excavation action specially for surface water retention and improved drainage should be taken up by the relevant implementing organization following a detail feasibility study.

5.5 Summary

Information summary of the data for each Union at a glance is shown in Table 5-7.

Table 5-7: Union Wise Information Summary

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
Rajshahi District																			
1	Bagha	Arani	11.17	950	Baral Upper (baral-Nandkuja), Khalsadingi, Ganges	47	10,906	976	0.20	7.06	0.20	0.04	7.50	7.52	7.54	1,382	1	9-2.5	Less Scarce
		Bajubagha	14.25	1,254		114	14,584	1,024	0.27	8.80	0.73	0.04	9.84	9.88	9.94	5,425	8	9-3	Less Scarce
		Bausa	30.59	2,723		132	29,831	975	0.54	19.82	0.56	0.09	21.01	21.07	21.13	1,995	10	9-3	Scarce Free
		Chakrajapur	10.86	934		-	11,194	1,031	0.20	6.39	0.11	0.10	6.81	6.83	6.86	-	-	-	
		Gargari	43.90	3,865		14	29,207	665	0.53	25.86	0.07	0.13	26.59	26.64	26.68	2,409	2	8.5-2.5	Scarce Free
		Manigram	32.26	2,775		170	33,295	1,032	0.61	19.00	0.77	0.09	20.46	20.53	20.61	3,900	13	9.5-3.5	Less Scarce
		Pakuria	29.78	2,592		43	29,253	982	0.53	18.68	0.23	0.09	19.53	19.57	19.62	3,177	18	9.5-3	Scarce Free
2	Bagmara	Auch Para	27.36	2,326	Shib, Fakirni, Barnai	381	28,094	1,027	0.51	72.96	1.90	0.01	75.38	75.50	75.61	1,922	66	14-7.5	Less Scarce
		Bara Bihanali	15.43	1,312		158	13,129	851	0.24	41.67	0.98	0.06	42.96	43.02	43.08	1,003	31	8.5-2.5	Scarce Free
		Basu Para	28.78	2,447		354	28,366	986	0.52	76.79	1.83	0.01	79.14	79.26	79.37	936	63	13-3.5	Less Scarce
		Dwippur	13.74	1,169		88	10,372	755	0.19	36.60	0.57	0.04	37.39	37.43	37.47	1,182	38	9.5-3	Less Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Ganipur	36.23	3,081		541	38,395	1,060	0.70	96.62	3.10	0.01	100.43	100.63	100.80	1,369	86	11-3	Less Scarce
		Goalkandi	24.06	2,046		350	25,557	1,062	0.47	64.34	2.50	0.05	67.36	67.51	67.65	2,639	75	3-1	Scarce Free
		Gobinda Para	27.00	2,296		426	23,906	885	0.44	72.76	2.03	-	75.22	75.34	75.45	1,898	76	11-5.5	Less Scarce
		Hamir Kutsha	21.90	1,862		226	20,863	953	0.38	59.01	1.07	0.04	60.50	60.58	60.65	1,119	37	6-1	Scarce Free
		Jhikra	24.94	2,121		278	23,189	930	0.42	66.51	1.51	0.05	68.49	68.59	68.68	3,691	112	9-1.5	Less Scarce
		Jogi Para	28.42	2,416		342	26,141	920	0.48	75.79	1.76	0.01	78.04	78.15	78.25	1,878	37	6-1	Scarce Free
		Kachari Koali Para	5.77	490		45	7,905	1,371	0.14	15.43	0.26	0.03	15.86	15.88	15.91	770	20	13-3.5	Less Scarce
		Maria	18.41	1,566		231	20,516	1,114	0.37	49.63	1.21	0.05	51.27	51.36	51.43	871	43	10.5-2.5	Scarce Free
		Nardas	23.85	2,028		281	20,559	862	0.38	63.63	1.56	0.01	65.59	65.69	65.77	1,758	87	8.5-2.5	Scarce Free
		Sreepur	10.49	892		89	9,143	871	0.17	28.27	0.47	0.03	28.93	28.97	29.00	2,835	53	8.5-1.5	Scarce Free
		Subhadanga	11.29	960		131	12,411	1,100	0.23	30.10	0.77	-	31.09	31.14	31.19	1,918	58	12.5-5.5	Less Scarce
		Sonadanga	24.42	2,076		409	26,944	1,103	0.49	64.95	2.16	0.01	67.62	67.76	67.87	666	30	5.5-3	Scarce Free
3	Char ghat	Bhaya Lakshmipur	26.87	2,285	Baral Upper, Ganges, Musakhan	72	30,510	1,135	0.56	14.62	0.35	0.22	15.74	15.81	15.88	3,391	12	9.5-2.5	Less Scarce
		Chargha t	20.55	1,810		117	22,210	1,081	0.41	10.83	0.70	0.16	12.09	12.15	12.23	497	19	9.5-3	Less Scarce
		Nimpara	36.97	3,292		111	34,341	1,020	0.63	21.12	0.55	0.30	22.59	22.68	22.77	5,302	32	9-2	Less Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Salua	25.82	2,273		106	37,713	1,234	0.69	14.83	0.60	0.21	16.32	16.41	16.50	4,726	-	9-2.5	Less Scarce
		Sardah	16.97	1,460		23	31,870	1,231	0.58	9.67	0.16	0.13	10.54	10.59	10.64	7,642	4	9.5-2.5	Less Scarce
		Yusufpur	18.59	1,618		37	20,894	1,848	0.38	9.99	0.24	0.16	10.77	10.82	10.86	2,880	8	10-2.5	Less Scarce
4	Durgapur	Deluabari	27.51	2,339	Barnai	342	25,978	944	0.47	16.44	2.51	0.39	19.81	19.98	20.17	1,176	114	11.5-2.5	Less Scarce
		Dharmapur	21.29	1,874		331	18,906	888	0.35	13.21	0.83	0.30	14.69	14.77	14.86	4,236	68	8.5-1.5	Less Scarce
		Jhaluka	24.11	2,074		455	24,939	1,034	0.46	14.75	2.84	0.34	18.39	18.57	18.77	2,275	29	25-10.5	Moderate Scarce
		Joynagar	29.78	2,651		393	29,094	977	0.53	18.68	2.23	0.42	21.87	22.03	22.21	1,811	45	12.5-4	Less Scarce
		Kismat Gankair	24.17	2,055		459	22,123	915	0.40	15.03	2.77	0.34	18.55	18.72	18.91	2,412	29	11-1.5	Less Scarce
		Maria	15.72	1,384		231	17,428	1,109	0.32	9.61	1.35	0.22	11.51	11.60	11.71	1,910	28	9-2	Scarce Free
		Noapara	30.09	2,679		357	29,110	967	0.53	19.01	1.64	0.43	21.61	21.74	21.90	87	26	11-2	Less Scarce
5	Godagari	Basudebpur	18.85	1,603	Mohananda Lower, Ganges	51	27,946	1,482	0.51	11.91	0.43	0.14	12.99	13.05	13.12	2,838	29	13-7.5	Less Scarce
		Char Asharia daha	32.58	2,770		5	22,403	688	0.41	20.58	0.45	0.16	21.59	21.65	21.72	-	-	-	
		Deopara	50.86	4,478		221	36,318	714	0.66	31.42	1.49	0.38	33.95	34.08	34.24	433	65	14.5-8.5	Moderate Scarce
		Godagari	47.78	4,254		273	19,781	414	0.36	30.96	1.45	0.35	33.12	33.24	33.37	1,489	121	19.5-16	Severe Scarce
		Gogram	59.03	5,197		198	32,600	552	0.59	34.77	1.29	0.44	37.10	37.23	37.37	1,109	110	16-11.5	Moderate Scarce
		Matikata	42.30	3,639		100	47,843	1,131	0.87	24.91	0.44	0.31	26.54	26.64	26.74	4,458	71	14.5-9.5	Moderate Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Mohanpur	87.70	7,633		753	42,138	481	0.77	55.00	4.38	0.66	60.81	61.10	61.43	1,327	159	20.5-17.5	Severe Scarce
		Pakri	47.32	4,024		480	27,671	585	0.50	28.03	2.80	0.35	31.68	31.86	32.07	1,440	116	22-18.5	Severe Scarce
		Rishikul	55.32	4,871		382	29,173	527	0.53	33.09	2.51	0.41	36.54	36.72	36.92	520	103	21-15.5	Severe Scarce
6	Mohonpur	Bakshimail	22.15	1,883	Barnai, Shib	363	27,322	1,234	0.50	13.90	2.03	0.06	16.49	16.60	16.74	1,123	38	18-5	Moderate Scarce
		Dhurail	27.68	2,437		421	28,446	1,028	0.52	17.10	2.55	0.08	20.25	20.38	20.55	2,104	70	16.5-9	Moderate Scarce
		Ghasigram	23.43	2,086		304	22,055	941	0.40	13.38	1.40	0.06	15.25	15.33	15.43	1,403	52	18.5-14	Moderate Scarce
		Jahanabad	29.65	2,610		389	30,464	1,028	0.56	17.46	2.03	0.08	20.13	20.25	20.39	2,124	51	15.5-6.5	Moderate Scarce
		Maugachhi	31.32	2,695		328	37,444	1,195	0.68	18.44	2.04	0.08	21.25	21.37	21.52	2,343	47	17-8	Moderate Scarce
		Royghati	13.25	1,154		187	13,179	994	0.24	8.31	0.73	0.04	9.33	9.37	9.42	2,853	64	16-9.5	Moderate Scarce
7	Paba	Baragachhi	38.45	3,269	Barnai, Ganges	469	40,854	1,063	0.75	24.29	3.34	-	28.37	28.55	28.76	1,792	35	13.5-4.5	Less Scarce
		Damkur	17.98	1,583		99	21,964	1,221	0.40	11.11	0.67	-	12.18	12.23	12.28	1,122	13	12.5-6	Less Scarce
		Darshan Para	14.19	1,264		115	14,011	987	0.26	8.11	0.62	-	8.98	9.02	9.06	1,472	25	18.5-9.5	Moderate Scarce
		Haragram	17.23	1,517		21	40,379	2,343	0.74	10.15	0.09	-	10.98	11.02	11.07	3,531	18	11.5-5.5	Less Scarce
		Harian	9.56	822		0	25,957	2,716	0.47	5.63	1.22	-	7.32	7.39	7.48	11,148	15	12-4	Scarce Free
		Haripur	50.49	4,395		72	29,738	589	0.54	31.67	0.41	-	32.63	32.67	32.72	496	3	12.5-4	Scarce Free
		Hujuri Para	27.49	2,337		384	27,932	1,016	0.51	15.88	2.77	-	19.16	19.30	19.47	1,885	33	16-7	Moderate Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Parila	32.35	2,848		470	40,631	1,256	0.74	19.35	5.41	-	25.50	25.75	26.07	9,789	103	11.5-3.5	Less Scarce
8	Puthia	Baneshwar	25.74	2,189	Musakhan, Barnai	310	37,436	1,454	0.68	16.48	1.61	0.16	18.94	19.05	19.19	5,976	9	9-2	Less Scarce
		Belpukuria	28.16	2,479		217	21,013	746	0.38	17.63	2.54	0.17	20.72	20.86	21.03	8,519	49	10-2.5	Less Scarce
		Bhalukgachhi	33.90	3,019		450	37,379	1,102	0.68	22.78	2.80	0.21	26.47	26.64	26.84	3,114	27	8-1.5	Less Scarce
		Jeopara	33.46	2,945		179	31,062	928	0.57	25.13	1.13	0.19	27.03	27.12	27.23	2,264	24	8-1.5	Less Scarce
		Puthia	15.72	1,353		178	15,611	993	0.28	10.73	0.99	0.09	12.09	12.16	12.23	644	7	8.5-1.5	Less Scarce
		Silmaria	42.14	3,668		837	39,084	927	0.71	30.01	5.71	0.25	36.67	36.96	37.32	11,893	165	7-1.5	Scarce Free
9	Tanore	Badhair	43.51	3,700	Shib	354	19,642	451	0.36	29.78	2.51	0.26	32.90	33.05	33.22	636	103	27.5-25	Severe Scarce
		Chanduria	16.60	1,461		400	12,577	758	0.23	11.03	0.83	0.32	12.42	12.49	12.58	742	34	19.5-11	Moderate Scarce
		Kalma	51.63	4,442		171	34,181	662	0.62	36.12	2.84	0.27	39.86	40.03	40.24	992	92	24-22.5	Severe Scarce
		Kamargaon	37.89	3,374		569	27,606	729	0.50	26.92	2.23	0.13	29.78	29.91	30.07	1,706	93	18.5-16.5	Moderate Scarce
		Pachandar	45.77	3,892		432	28,611	625	0.52	31.79	2.77	0.39	35.48	35.65	35.86	1,395	132	23.5-21.5	Severe Scarce
		Saranjai	16.88	1,486		506	10,334	612	0.19	11.19	1.35	0.31	13.04	13.14	13.24	627	80	21.5-16	Moderate Scarce
		Talanda	26.48	2,358		236	12,158	459	0.22	19.14	1.64	0.23	21.23	21.33	21.45	2,112	120	22.5-21	Severe Scarce
Naogaon District																			
10	Atrai	Ahsanganj	49.73	4,229	Atrai, Iramati, Nagar Lower,	294	25,605	515	0.47	29.06	1.70	0.06	31.29	31.39	31.51	1,079	3,212	10-1.5	Less Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Bhopara	36.28	3,085	Fakirni, Chota Jamuna	347	25,795	711	0.47	21.19	2.05	0.09	23.81	23.92	24.06	1,164	3,991	8-2	Less Scarce
		Bisha	42.66	3,628		384	27,175	637	0.50	24.93	2.80	0.10	28.33	28.48	28.66	988	2,902	6.5-1.5	Scarce Free
		Hatkalu Para	26.13	2,222		265	22,731	870	0.41	15.27	1.60	0.13	17.42	17.52	17.63	3,692	8,799	7.5-3.5	Scarce Free
		Kalikapur	28.44	2,419		154	22,701	798	0.41	16.62	0.98	0.16	18.16	18.24	18.33	4,172	10,546	8-2.5	Less Scarce
		Maniari	49.04	4,171		568	25,727	525	0.47	28.65	3.53	0.32	32.98	33.18	33.42	2,176	7,577	8.5-2	Less Scarce
		Panchupur	28.77	2,446		174	29,914	1,040	0.55	16.81	0.87	0.27	18.50	18.59	18.69	205	1,578	5.5-1.5	Scarce Free
		Sahagola	23.36	1,987		158	23,119	990	0.42	13.65	0.99	0.14	15.20	15.28	15.37	3,165	9,456	8.5-2.5	Less Scarce
11	Badalgachi	Adhaipur	27.71	2,356	Chata Jamuna, Tulshiganga	95	26,773	966	0.49	17.91	0.59	0.09	19.08	19.14	19.20	1,834	50	8-2.5	Less Scarce
		Badalgachhi	39.70	3,376		327	31,346	790	0.57	25.65	1.82	0.14	28.18	28.30	28.44	1,841	88	4.5-1.5	Less Scarce
		Balubhara	21.67	1,843		73	20,622	952	0.38	14.01	0.33	0.08	14.79	14.83	14.88	1,378	33	7.5-3	Less Scarce
		Bilasbari	31.12	2,646		58	27,997	900	0.51	20.11	0.27	0.10	21.00	21.04	21.09	943	24	8-3.5	Less Scarce
		Kola	21.84	1,858		107	24,785	1,135	0.45	14.12	0.54	0.08	15.19	15.25	15.31	1,351	31	8-3.5	Less Scarce
		Mathurapur	27.39	2,329		125	25,043	914	0.46	17.70	0.74	0.09	18.99	19.06	19.13	1,104	37	7-2.5	Less Scarce
		Mithapur	21.61	1,838		90	25,986	1,203	0.47	13.97	0.41	0.08	14.93	14.98	15.03	792	25	8-3	Less Scarce
		Paharpur	22.94	1,951		172	28,857	1,258	0.53	14.82	0.88	0.08	16.31	16.38	16.46	999	31	8.5-3	Less Scarce
12		Agra Digun	35.93	3,055	Atrai, Ciri, Chata Jamuna	442	19,431	541	0.35	24.65	2.84	0.17	28.02	28.17	28.35	3,989	19	13-10.5	Less Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
	Dhamoirhat	Alampur	40.81	3,471		283	25,188	617	0.46	28.01	2.48	0.19	31.14	31.28	31.45	5,999	60	9.5-7	Less Scarce
		Aranagar	38.49	3,273		280	26,069	677	0.48	26.41	1.58	0.21	28.67	28.78	28.91	5,255	55	9-4	Scarce Free
		Dhamoirhat	34.96	2,973		175	21,578	617	0.39	23.99	1.37	0.17	25.92	26.01	26.12	3,899	142	9-4	Scarce Free
		Isabpur	37.57	3,195		309	23,637	629	0.43	25.78	2.02	0.18	28.41	28.54	28.68	6,919	29	8.5-4	Scarce Free
		Jahanpur	34.57	2,940		195	27,078	783	0.49	23.72	1.45	0.17	25.83	25.93	26.05	2,158	12	8-4.5	Scarce Free
		Khelna	35.75	3,040		301	17,167	480	0.31	24.53	2.03	0.18	27.06	27.18	27.31	5,226	17	11.5-10	Less Scarce
		Omar	31.56	2,684		150	18,232	578	0.33	21.65	1.23	0.16	23.37	23.46	23.55	10,865	25	8.5-4	Less Scarce
13	Manda	Bhalain	30.69	2,610	Atrai	298	24,027	783	0.44	20.61	1.62	-	22.67	22.75	22.84	3,321	34	9-6	Less Scarce
		Bharso	52.06	4,427		337	35,851	689	0.65	34.96	1.76	-	37.38	37.48	37.59	10,421	49	11-8.5	Less Scarce
		Bishnupur	28.47	2,421		237	20,615	724	0.38	19.12	1.26	-	20.75	20.82	20.90	6,450	33	4.5-2.5	Scarce Free
		Ganeshpur	26.23	2,230		218	28,397	1,083	0.52	17.61	1.09	-	19.22	19.29	19.37	2,074	19	8.5-6	Less Scarce
		Kalikapur	28.53	2,426		154	24,615	863	0.45	19.16	0.98	-	20.58	20.65	20.71	1,234	86	9-5.5	Less Scarce
		Kanso Para	21.99	1,870		307	25,386	1,155	0.46	14.76	1.22	-	16.44	16.52	16.59	5,430	33	7-4	Scarce Free
		Kashab	15.96	1,357		206	21,045	1,319	0.38	10.72	0.95	-	12.05	12.11	12.17	4,356	30	6-3.5	Scarce Free
		Kusumba	28.79	2,448		239	38,848	1,349	0.71	19.34	1.40	-	21.44	21.54	21.63	5,580	26	5.5-3	Scarce Free
		Mainani	25.65	2,181		201	23,061	899	0.42	17.22	0.93	-	18.58	18.64	18.70	2,173	16	9.5-4.5	Less Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Manda	21.48	1,827		209	30,749	1,431	0.56	14.43	1.23	-	16.22	16.30	16.38	2,028	34	11.5-4.5	Less Scarce
		Nurulla bad	28.89	2,456		242	28,764	996	0.52	19.40	1.05	-	20.97	21.04	21.11	695	20	3-2.5	Scarce Free
		Paranpu r	26.96	2,293		265	27,309	1,013	0.50	18.11	1.38	-	19.98	20.06	20.15	1,973	25	10.5-5	Less Scarce
		Prasadp ur	22.69	1,930		237	24,527	1,081	0.45	15.24	1.02	-	16.71	16.77	16.84	4,629	30	7-4.5	Scarce Free
		Tentulia	38.74	3,294		440	26,890	694	0.49	26.02	2.31	-	28.81	28.93	29.06	4,638	48	14.5-9.5	Less Scarce
14	Mah adeb pur	Bhimpu r	33.49	2,814	Atrai, Shib	295	29,294	875	0.53	23.68	1.82	0.40	26.43	27.46	27.69	1,528	52	7-4.5	Scarce Free
		Chandas	31.67	2,661		353	27,900	881	0.51	22.39	1.72	0.38	24.99	25.13	25.28	3,636	42	9.5-8	Less Scarce
		Cheragp ur	41.73	3,507		486	25,169	603	0.46	29.51	2.26	0.51	32.73	32.90	33.09	4,613	71	7-6	Less Scarce
		Enayetp ur	46.17	3,880		518	31,295	678	0.57	32.65	2.50	0.56	36.28	36.46	36.68	14,079	67	8.5-5.5	Less Scarce
		Hatur	51.86	4,358		457	28,517	550	0.52	36.67	2.81	0.62	40.63	40.83	41.06	7,683	70	11.5-9.5	Less Scarce
		Khajur	44.40	3,731		452	33,559	756	0.61	31.40	2.41	0.53	34.95	35.13	35.34	7,619	36	10-8.5	Less Scarce
		Mahade bpur	40.46	3,400		453	42,029	1,039	0.77	28.61	2.19	0.49	32.06	32.24	32.44	10,718	66	10.5-7	Less Scarce
		Roygao n	41.63	3,498		464	32,961	792	0.60	29.44	2.26	0.51	32.80	32.97	33.17	8,206	61	2.5-2	Scarce Free
		Safapur	33.99	2,856		294	26,624	783	0.49	24.03	1.84	0.41	26.77	26.92	27.07	7,356	64	8-6	Scarce Free
		Uttargra m	30.12	2,532		305	30,762	1,021	0.56	21.30	1.63	0.36	23.86	23.99	24.14	5,158	42	7.5-6	Scarce Free
15	Naog aon	Baktiarp ur	17.35	1,476	Little Jamuna Tulshi Ganga	130	19,217	1,107	0.35	12.65	0.58	0.29	13.87	13.93	14.00	4,211	19	8.5-4.5	Less Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
	Sadar	Balihar	23.53	2,001		268	19,031	809	0.35	17.16	1.49	0.39	19.39	19.51	19.63	2,084	19	9-4	Less Scarce
		Barshail	14.83	1,261		94	20,539	1,385	0.37	10.82	0.59	0.25	12.03	12.09	12.16	3,241	36	7-3.5	Scarce Free
		Boalia	7.54	641		71	19,368	2,569	0.35	5.50	0.28	0.13	6.26	6.30	6.34	3,671	21	11-7	Less Scarce
		Chandipur	14.90	1,267		74	28,773	1,931	0.53	9.25	0.44	0.25	10.47	10.53	10.60	4,100	30	9.5-4.5	Less Scarce
		Dubalhati	29.75	2,530		96	20,522	690	0.37	10.87	1.21	0.49	12.94	13.05	13.16	2,775	21	7-4	Less Scarce
		Hapania	18.69	1,590		222	27,506	1,472	0.50	21.69	0.94	0.31	23.44	23.53	23.63	5,135	28	6-4.5	Scarce Free
		Hashaighari	23.95	2,037		198	26,480	1,106	0.48	13.63	0.86	0.40	15.37	15.46	15.56	1,789	15	6.5-4	Scarce Free
		Kirtipur	18.11	1,540		166	19,384	1,071	0.35	17.46	0.36	0.31	18.49	18.54	18.59	2,175	21	7.5-3.5	Less Scarce
		Sailgachhi	12.69	1,079		86	14,117	1,112	0.26	13.20	0.46	0.21	14.12	14.17	14.22	199	1	8-4	Less Scarce
		Sekherpur	34.18	2,907		135	20,211	591	0.37	24.92	0.70	0.57	26.57	26.65	26.74	5,346	28	4.5-3.5	Scarce Free
		Tilakpur	23.17	1,970		85	33,784	1,458	0.62	16.89	0.39	0.39	18.29	18.36	18.44	2,504	10	8.5-5	Less Scarce
16	Niamatpur	Bahadurpur	56.45	4,687		566	36,456	646	0.67	40.19	3.00	0.08	43.93	44.09	44.29	2,707	112	15.5-13	Moderate Scarce
		Bhabicha	52.97	4,398		353	33,760	637	0.62	37.71	1.89	0.08	40.30	40.41	40.55	5,383	79	9.5-6.5	Less Scarce
		Chandan Nagar	51.87	4,307		459	27,227	525	0.50	36.93	2.99	0.08	40.49	40.65	40.84	4,745	77	11.5-10.5	Less Scarce
		Hajinagar	61.93	5,142		538	29,920	483	0.55	44.09	3.18	0.08	47.90	48.06	48.27	1,107	115	17.5-12	Moderate Scarce
		Niamatpur	44.38	3,685		394	29,771	671	0.54	31.60	2.02	0.06	34.23	34.35	34.49	1,782	92	16.5-13.5	Moderate Scarce

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							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Parail	58.14	4,827		657	32,756	563	0.60	41.39	3.50	0.08	45.57	45.75	45.97	1,202	94	17-16	Moderate Scarce
		Rasulpur	75.59	6,276		730	40,201	532	0.73	53.82	4.67	0.10	59.32	59.56	59.85	447	145	17.5-14.5	Moderate Scarce
		Sreemantapur	47.81	3,970		352	31,049	649	0.57	34.04	2.07	0.06	36.75	36.86	37.01	1,343	76	14.5-12	Moderate Scarce
17	Patnitala	Akbarpur	34.12	2,901	Atrai	407	22,608	663	0.41	25.24	2.34	0.76	28.76	28.95	29.16	1,762	70	14-12.5	Moderate Scarce
		Amair	34.06	2,896		261	21,615	635	0.39	25.19	1.90	0.76	28.25	28.42	28.61	3,513	-	16.5-12.5	Moderate Scarce
		Dibar	31.50	2,679		354	17,470	555	0.32	23.30	2.37	0.70	26.69	26.87	27.08	1,485	-	15.5-11.5	Moderate Scarce
		Ghoshnagar	30.36	2,581		463	23,027	759	0.42	22.45	2.92	0.67	26.47	26.68	26.91	3,111	-	10.5-9	Less Scarce
		Krishnapur	41.43	3,523		261	23,931	578	0.44	30.65	1.59	0.92	33.59	33.77	33.96	4,051	-	12-10.5	Less Scarce
		Matindhar	35.28	3,000		472	21,516	610	0.39	26.09	2.81	0.79	30.08	30.30	30.53	4,011	62	13.5-12	Moderate Scarce
		Nazipur	20.06	1,706		275	12,908	643	0.24	14.84	1.61	0.44	17.12	17.24	17.38	10,945	63	10.5-8.5	Less Scarce
		Nirmail	12.52	1,065		236	13,685	1,093	0.25	9.26	1.14	0.29	10.94	11.02	11.12	1,070	90	18.5-9.5	Moderate Scarce
		Patichara	31.74	2,699		304	20,581	648	0.38	23.48	2.18	0.71	26.75	26.93	27.12	2,340	54	10-7	Less Scarce
		Patnitala	35.05	2,980		440	22,618	645	0.41	25.92	2.97	0.78	30.08	30.30	30.54	6,107	81	12-9	Less Scarce
		Shihara	37.05	3,151		252	21,348	576	0.39	27.40	1.51	0.82	30.12	30.29	30.46	1,511	23	14.5-10.5	Moderate Scarce
18	Porsha	Chhaor	43.07	3,577	Punarbhaba	288	19,520	453	0.36	19.31	1.61	0.04	21.31	21.40	21.51	504	23	22.5-15	Severe Scarce
		Ganguria	41.23	3,424		219	16,667	404	0.30	18.49	0.90	0.04	19.73	19.79	19.86	141	30	15-10	Moderate Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Ghatnagar	50.63	4,204		454	22,230	439	0.41	22.70	2.74	0.05	25.90	26.03	26.20	687	79	16-12.5	Moderate Scarce
		Moshidpur	36.03	2,992		426	21,323	592	0.39	16.15	2.32	0.04	18.90	19.02	19.17	1,186	88	14-12.5	Moderate Scarce
		Nitpur	58.41	4,850		300	13,041	223	0.24	26.19	1.85	0.06	28.34	28.43	28.55	1,395	50	17-7	Less Scarce
		Tentulia	42.51	3,530		440	23,560	554	0.43	19.06	2.31	0.04	21.84	21.96	22.10	210	12	17.5-10.5	Moderate Scarce
19	Rani nagar				Atrai, Choto Jamuna, Tulshi Ganga, Iramati, Lower Nagar														
		Bargachha	44.56	3,792		397	23,331	643	0.43	33.41	2.30	0.65	36.78	36.96	37.16	2,469	147	9.0-4.0	Less Scarce
		Ekdala	24.95	3,655		447	28,634	826	0.52	32.20	0.85	0.39	33.97	34.07	34.17	1,815	53	10.0-7.5	Less Scarce
		Gona	39.60	2,047		139	20,616	705	0.38	18.03	2.95	0.27	21.63	21.79	21.99	842	25	9.0-3.5	Less Scarce
		Kaligram	10.03	3,248		433	27,930	2,060	0.51	28.62	0.26	0.32	29.71	29.78	29.85	1,636	64	10.5-8.0	Less Scarce
		Kashimpur	27.67	823		49	20,669	714	0.38	7.25	0.91	0.34	8.87	8.96	9.06	866	17	9.5-3.5	Scarce Free
		Mirat	49.50	2,270		108	19,745	545	0.36	20.00	3.50	0.31	24.17	24.36	24.59	1,242	27	10.0-6.5	Less Scarce
		Parail	15.79	4,061		657	26,974	1,575	0.49	35.77	0.67	0.19	37.13	37.20	37.28	1,747	59	10.5-6.5	Less Scarce
		Raninagar	46.22	1,295		144	24,863	505	0.45	11.41	2.04	0.26	14.16	14.30	14.45	1,043	27	9.5-3.5	Less Scarce
20	Sapahar	Aihai	38.03	3,118	Punarhava	350	21,990	578	0.40	28.54	1.84	-	30.78	30.88	30.99	52	69	16-7.5	Less Scarce
		Goala	57.91	4,749		414	37,351	645	0.68	43.46	2.38	0.01	46.53	46.67	46.83	137	90	18-10.5	Moderate Scarce
		Pathari	28.60	2,345		51	26,422	924	0.48	21.46	0.23	-	22.17	22.21	22.24	492	44	17.5-10	Moderate Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Sapahar	39.21	3,215		258	29,978	765	0.55	29.42	1.05	-	31.02	31.09	31.17	172	17	18-11.5	Moderate Scarce
		Shiranti	40.51	3,322		315	29,189	721	0.53	30.40	1.64	-	32.57	32.66	32.78	94	63	17.5-10	Moderate Scarce
		Tilna	40.34	3,308		396	23,852	591	0.44	30.28	2.12	-	32.84	32.94	33.08	152	40	14.5-10.5	Moderate Scarce
Chapai Nawabganj District																			
21	Bholahat	Bholahat	22.00	1,871	Mohananda Lower	35	14,469	658	0.26	13.90	0.03	0.03	14.22	14.23	14.25	1,407	54	14-3	Less Scarce
		Daldali	32.17	2,832		71	31,050	965	0.57	19.87	0.33	0.04	20.81	20.85	20.91	1,728	90	13.5-6	Less Scarce
		Gohalbari	50.87	4,377		37	29,127	573	0.53	29.43	0.10	0.06	30.13	30.17	30.21	1,201	58	13-3.5	Less Scarce
		Jambaria	18.48	1,645		12	18,718	1,013	0.34	10.70	0.04	0.03	11.11	11.13	11.16	3,757	44	10.5-5	Less Scarce
22	Chapai Nawabganj Sadar	Alatuli	36.60	3,112	Ganges, Mohananda Lower, Pagla	0	17,606	481	0.32	25.80	-	0.06	26.19	26.22	26.24	1,043	-	12-6	Less Scarce
		Balidanga	40.62	3,576		49	39,162	964	0.71	28.18	0.15	0.08	29.12	29.17	29.23	9,649	45	10.5-4	Less Scarce
		Baraghria	7.25	645		0	25,504	3,519	0.47	4.81	-	0.01	5.28	5.31	5.34	120	13	11.5-4.5	Less Scarce
		Char Anupnagar	22.63	1,992		2	12,536	554	0.23	15.38	0.01	0.04	15.66	15.68	15.70	643	1	11.5-5.5	Less Scarce
		Char Bagdanga	34.93	3,005		0	22,146	634	0.40	23.67	-	0.06	24.13	24.17	24.20	2,945	-	10.5-4.5	Less Scarce
		Debinagar	34.26	2,982		0	28,934	870	0.54	24.56	-	0.06	25.17	25.21	25.25	454	-	10-4.5	Less Scarce
		Gobratala	35.32	3,004		154	28,807	843	0.54	24.02	0.27	0.06	24.89	24.94	24.99	1,931	40	10.5-4	Less Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Islampur	22.97	2,022		1	28,383	1,273	0.53	15.82	0.01	0.04	16.41	16.44	16.48	1,077	3	10.5-4	Less Scarce
		Jhilim	60.53	5,269		609	26,961	458	0.51	42.59	1.30	0.12	44.51	44.60	44.71	29,277	95	12.5-4	Moderate Scarce
		Maharajpur	8.96	771		3	27,675	3,184	0.52	5.98	-	0.01	6.51	6.54	6.58	67	1	10.5-4.5	Less Scarce
		Narayanpur	43.62	3,753		1	17,629	416	0.33	29.24	-	0.09	29.66	29.69	29.72	1,172	4	9.5-4	Less Scarce
		Ranihati	9.81	873		8	32,987	3,467	0.62	6.92	0.02	0.03	7.59	7.63	7.67	178	3	10.5-4.5	Less Scarce
		Shahjahanpur	30.40	2,646		0	22,630	767	0.43	21.93	-	0.06	22.42	22.45	22.49	478	-	11.5-5	Less Scarce
		Sundarpur	31.05	2,765		0	32,272	1,070	0.61	23.30	-	0.06	23.97	24.01	24.05	3,084	1	10.5-4	Less Scarce
23	Gomostapur	Alinagar	15.59	1,326	Punarbhaba, Mohananda Lower, Tulshi Ganga	4	16,148	1,036	0.29	9.21	0.02	0.03	9.54	9.56	9.59	1,632	7	14.5-10	Moderate Scarce
		Bhangabaria	19.80	1,743		27	27,094	1,368	0.49	11.40	0.03	0.03	11.94	11.97	12.01	4,312	28	15.5-10	Moderate Scarce
		Boalia	30.11	2,681		71	28,449	945	0.52	18.66	0.03	0.04	19.25	19.28	19.32	312	21	11.5-6	Less Scarce
		Chowdala	18.59	1,637		2	37,249	2,004	0.68	10.45	0.01	0.03	11.16	11.20	11.25	63	3	9.5-5.5	Less Scarce
		Gomastapur	28.11	2,418		25	30,195	1,074	0.55	15.40	0.07	0.04	16.06	16.09	16.13	1,446	23	11.5-5	Less Scarce
		Parbatipur	75.82	6,599		594	39,029	515	0.71	44.37	0.68	0.09	45.85	45.93	46.02	4,273	133	26-19.5	Severe Scarce
		Radhanagar	81.12	6,898		291	42,763	527	0.78	44.74	0.69	0.10	46.31	46.39	46.48	3,496	103	29-20	Severe Scarce
		Rohanpur	34.43	3,032		130	20,740	602	0.38	21.73	0.39	0.04	22.53	22.57	22.62	3,901	107	18.5-15.5	Severe Scarce
24	Nachol	Fatehpur	73.97	6,290	Mohananda Lower	295	34,932	472	0.64	53.22	0.47	0.05	54.38	54.44	54.50	755	105	14-9	Moderate Scarce

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Kasba	61.44	5,409		375	34,899	568	0.64	43.53	0.61	0.05	44.83	44.90	44.97	527	228	22-20.5	Severe Scarce
		Nachol	61.45	5,471		601	36,782	599	0.67	45.46	1.23	0.05	47.41	47.50	47.61	1,279	118	19.5-18	Severe Scarce
		Nizampur	74.83	6,588		746	29,475	394	0.54	51.98	1.46	0.06	54.04	54.13	54.24	694	71	27.5-26	Severe Scarce
25	Shibganj	Binodpur	29.31	2,493	Ganges, Mohananda Lower, Pagla		44,279	1,511	0.81	13.38	-	0.01	14.20	14.25	14.30	805	17	8-4	Scarce Free
		Chak Kirti	34.02	2,995		45	39,501	1,161	0.72	14.84	0.15	0.03	15.74	15.79	15.84	708	11	10.5-4	Less Scarce
		Daipukuria	43.01	3,830		139	42,647	991	0.78	19.98	0.48	0.03	21.26	21.33	21.40	659	6	9.5-4	Scarce Free
		Dhainagar	27.59	2,429		16	41,799	1,515	0.76	11.24	0.01	0.01	12.03	12.08	12.12	361	18	11-3	Less Scarce
		Durlabhpur	51.74	4,423		20	58,968	1,140	0.90	21.16	0.02	0.04	22.11	22.17	22.23	400	4	6.5-3	Scarce Free
		Ghorapakhia	22.20	1,932		3	18,040	1,140	0.33	8.27	0.13	0.01	8.75	8.77	8.80	585	15	10-4.5	Less Scarce
		Kansat	30.91	2,629		24	42,663	813	0.78	12.89	0.16	0.03	13.86	13.91	13.97	898	13	9.5-4	Less Scarce
		Manakosa	30.80	2,681		7	56,708	1,049	1.03	13.38	0.08	0.03	14.52	14.58	14.65	699	-	7.5-3.5	Scarce Free
		Mobarakpur	50.98	4,488		91	32,297	1,380	0.59	21.24	0.21	0.03	22.07	22.11	22.16	847	22	9.5-4	Scarce Free
		Naya Naobhanga	22.33	1,922		12	44,964	1,112	0.82	10.94	0.02	0.01	11.80	11.85	11.90	2,122	17	10-4	Less Scarce
		Panka	50.25	4,323		2	34,917	2,013	0.64	20.31	0.02	0.03	21.00	21.04	21.08	1,444	13	8.5-3.5	Scarce Free
		Satrujitpur	10.38	924		2	21,793	695	0.40	4.63	0.00	0.01	5.04	5.06	5.09	1,314	26	9.5-4	Scarce Free

Sl. No.	Upazila	Union	Area (sq km)	Irrigable Area (ha)	Existing River	Nos. of Ponds (>25 decimal)	Population		Sector-Wise Water Demand (MCM per Year)				Water Uses (MCM)	Water Demand (MCM)		Nos. of Tube wells		Depth to GWT (m)	Status of Groundwater
							Nos.	Density (nos per sq.km)	Domestic	Agricultural	Fisheries	Industries	2021	2030	2041	STW	DTW		
		Shahbaj pur	52.67	4,584		438	56,747	2,099	1.04	23.83	1.30	0.01	26.17	26.29	26.42	1,096	44	9.5-4	Scarce Free
		Shyamp ur	19.13	1,703		2	43,554	1,077	0.79	9.08	0.03	0.01	9.92	9.97	10.02	546	17	8.5-4	Scarce Free
		Uzirpur	14.36	1,279		0	10,233	2,277	0.19	6.82	-	0.01	7.02	7.03	7.05	1,033	21	9-4	Scarce Free

6 Recommendations and Limitations

6.1 Recommendations

The Baseline study to identify the state of surface and groundwater resources in the Barind region up to Mouza level through Participatory Rural Appraisal (PRA) approach for supporting pilot operationalization of the Bangladesh Water Rules, 2018 has been completed. To make it effective and achieve the objective of the Project the following recommendations are made:

1. Strong demands were received in the conducted FGDs and Upazila PRA Validation Workshop that the rivers / canals / kharies should be embanked and re-excavated to allow channelized flow and retain water even up-to the dry season.
2. Water resources are limited, so its equitable use should be encouraged. Therefore, emphasis is recommended on the use of surface water to reduce dependence on groundwater.
3. The respective departments need to be made aware to improve the efficiency of agricultural water use, diversify cropping patterns, and produce low water consuming crops.
4. Regular and rigorous monitoring of wells at various locations is required to determine the exact groundwater level for future research.
5. The time span for PRA study is recommended for enlargement and rational for the effective achievement for the future project(s).

6.2 Limitations

Following limitations were felt during the base line study:

1. Because of confusions on definitions about reservoirs like small ponds, beels (marshy areas), undefine cannel and small / branch rivers for the local people, sometimes it was felt difficult to know the exact number of surface water bodies.
2. Although data on biodiversity, livestock, fisheries, reserve and social forest was collected through limited scope of FGD, these types of data have been cross-checked with the data from secondary sources.
3. People were found very much comfortable and interested to use DTW rather than STW or surface water to get required water easily, causing negative impact on the environment.

4. The presence of iron (Fe) in shallow depth prompts people to use deep tube wells for groundwater abstraction.

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Annex-A: Terms of Reference

Government of the People's Republic of Bangladesh

Ministry of Water Resources

Water Resources Planning Organization

Terms of Reference (ToR)

for

Participatory Rural Appraisal (PRA) and baseline study of the state of water resources in the High Barind region

of the Project

"Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018"

(সমন্বিত পানি সম্পদ ব্যবস্থাপনায় বাংলাদেশ পানি বিধিমালা, ২০১৮ কার্যকরকরণ)

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1. Introduction:

Sustainable solutions to water problems require a paradigm shift from compartmental sub-sector-wise development to holistic water governance. Such a paradigm is encapsulated in the Integrated Water Resources Management (IWRM) concept. IWRM challenges conventional, fractional water development and management systems and emphasizes an integrated approach with coordinated decision making across sectors and scales. Furthermore, to face the growing challenges regarding water rights, protection of resources, water use, and water services management, Bangladesh has enacted a comprehensive legal framework called the Bangladesh Water Act, 2013 which received the President's assent on 2nd May 2013. This act outlines a coordinated and comprehensive regime for the development, management, extraction, allocation, use and conservation of water resources.

Therefore, to put the Bangladesh Water Act, 2013 into practice and to understand local economic and social dynamics related to water management in line with IWRM concept, a Project named "Institutionalization of Integrated Water Resources Management (IWRM) process in compliance with Bangladesh Water Act, 2013" has been implemented through Water Resources Planning Organization (WARPO), partnered with the Swiss Development and Cooperation Agency (SDC). The development of the Bangladesh Water Rules, 2018 and its participation in the UN-WB High Panel on Water clearly demonstrates that Bangladesh has been advancing its goal of the sustainable development of water resources and realisation of the rights of its citizens. At a local scale, the problems of water scarcity on the High Barind continue unchecked, existing irrigation and drinking water wells are being abandoned or operate at reduced capacity, the water table continues to fall unsustainably. Awareness of the problems, inside and outside the region, has increased but initiatives to reverse the trends have been piecemeal, uncoordinated and inadequate in scale. The first IWRM project has taken important steps to correct the problems, but much more is needed to coordinate, implement and facilitate water-saving and water-enhancing actions.

WARPO is dealing with nationwide water resources planning and is designated by the Bangladesh Water Act, 2013 as the nodal agency for coordinating IWRM and is mandated as the lead agency for implementation of the Act and its Rules and the regulation of water resources development. Progress on legislation and institutional reforms in the first IWRM project has eventually bring major changes in WARPO across the country but it will take a few years before any impacts are visible to the external stakeholders. The momentum built up under the first IWRM project should not be lost. Current activities in the High Barind region offer the only real opportunity for WARPO to bring about a solution to a major water problem in the short or medium term. Hence, the resources available for the next IWRM Project should be concentrated. WARPO will implement this IWRM Project in compliance with the Bangladesh Water Rules, 2018 with financial support from Swiss Development and Cooperation Agency (SDC), in the High Barind region to protect the water sources and aquifers and develop sustainable water resources management in solving practical problems of water scarcity.

Bangladesh, being an agricultural country, is highly dependent on groundwater irrigation given the fact that the existence of this resource was seen as abundant till recent years. As the surface water supply is decreasing day by day during the dry season, but the demand for irrigation is ever increasing, so the increasing trend in agricultural production is leaving the aquifer in vulnerable brink. In Bangladesh, about 95% of the total irrigated land is being covered by minor irrigation. Groundwater irrigation drastically increased in Bangladesh since the last three decades. But the source is limited and it is declining day by day due to intensive use of tube wells during dry season. According to Bangladesh Water Act, 2013 and its Rules, it is important to identify the water scarce areas and sustainable water resources management. The paradigm shift from 'groundwater development' to 'groundwater management' in Bangladesh as laid out in Bangladesh Water Rules, 2018 through aquifer mapping in different hydro-geological settings require robust groundwater management plans at the appropriate scale to be devised and implemented. As one of the major sources of water for the country as well as an inevitable part of the hydrological system, groundwater resource needs to be seen as limited resource and therefore its management plan should associate the specification of sustainable abstraction limit.

The recent downward trend in groundwater levels in the High Barind region, in the northwestern part of Bangladesh, is evidently representing the alarm, coined with the rapid urbanization which is persistently decreasing the potential recharge area. Groundwater recharge in Bangladesh is mainly take place by monsoon rainfall and flooding. Geographically the Barind area is slightly elevated compared to the other part of Bangladesh (9 to 45 meter from MSL), thus located in flood free zone. So the main source of groundwater recharge in this region is only rainfall. But the lowest amount of rainfall occur in this part of the country, and thus the Barind area has become severely drought prone zone. On the other hand, thick sticky clay surface of Barind Tract act as aquitard which impede groundwater recharge and increase surface runoff. As a result, groundwater table in this region is successively falling by years with increasing withdrawal of water for irrigation. Water Resources Planning Organization (WARPO) will implement this IWRM Project in compliance with the Bangladesh Water Rules 2018, with financial support from Swiss Development and Cooperation Agency (SDC), in the High Barind region to protect the water sources and aquifers and develop sustainable water resources management in solving practical problems of water scarcity.

Participatory Rural Appraisal (PRA) is the process of involving local people in the analysis and interpretation of their own situation of a given rural area. The local people i.e. the participants take a leadership role in collecting, analyzing, interpreting and presenting information and in this process imparts knowledge and development insight to the specialists and extension agents. PRA approach embodies a whole range of techniques which reveals valuable information/data on the resources and skills existing in the village, wealth structure and dynamics of caste and class. For management of water resources, PRA is conducted to establish rapport with the village community as well as to identify and define problems for prioritization in the village itself.

Numerous studies are conducted on groundwater depth fluctuation, recharge potentials and aquifer characteristics for the High Barind region on a broader scale revealing the vulnerability of the aquifer and groundwater resources. However, actual representation of the aquifer system and water budget is required to examine the present and future vulnerability scale. The Bangladesh Water Rules, 2018 keeps the provision of determining the lowest safe yield level of aquifer up to Mouza level, and declaration of Water Stress Area for a specific period, which seeks a clear understanding of the state of water resources of the designated area to have proper monitoring of the implementation of the Rules. Based on the principle of listening and learning, PRA is the technique of immediate analysis and survey of village resources for participatory micro-planning and development. PRA is a way of enabling rural people to analyze their living conditions, share the outcomes and plan their activities. PRA will give a comprehensive overview of the perceptions of the different local interest groups (farmers, labors, fishermen, women, minorities etc.) concerning water in its broadest sense in the project area. It is a way of learning from and with community members to investigate their need assessment, analyze and evaluate constraints and opportunities and find out priorities in the area of agriculture, small scale rural enterprises and any other socio-economic development programs addressed to village development.

2. Project area:

The Project will promote and facilitate the operationalizing of the Bangladesh Water Act, 2013 and the Bangladesh Water Rules, 2018; however, most of the activities will be targeted at piloting the implementation of the Act, its Rules, Guidelines, IWRM interventions and assessment of state of water resources in the administrative limits of Rajshahi, Chapai Nawabganj and Naogaon districts in the High Barind region (Figure 1). An active water management area will be precisely aligned during the Inception period to coincide with mouza boundaries. The coverage of the project activities will extend within different administrative units of the three districts of Rajshahi, Chapai Nawabganj and Naogaon in the High Barind region. The numbers of upazila, municipality, union and mouza for each district are shown in the Table 1.

Table 1: Number of administrative units in Rajshahi, Nawabganj and Naogaon districts

District	Area (sq km)	Upazila	Municipality	Union	Mouza
Rajshahi	2407.01	9	14	71	1718
Chapai Nawabganj	1744.33	5	4	45	787
Naogaon	3435.67	11	3	99	2565
Total	**7587.01**	**25**	**21**	**215**	**5070**

Figure 1: Administrative limits of Rajshahi, Chapai Nawabganj and Naogaon in the High Barind

3. Objective:

The main objective of this component is to perform baseline study to identify the state of surface and groundwater resources (water availability, demand and use) in the High Barind region up to mouza level through Participatory Rural Appraisal (PRA) approach for supporting pilot operationalization of the Bangladesh Water Rules, 2018.

The specific objectives of this study are:

(i) to identify the water sources, present water use scenario and sectoral water demand up to union/mouza level of the High Barind region,

(ii) to prepare detail assessment report of the baseline condition incorporating local people's needs, views and preferences on water resources management required for operationalizing the Bangladesh Water Rules, 2018, and

(iii) to facilitate monitoring with a view to create improved environment for sustainable water resources planning and management in the High Barind region.

4. Scope of Work:

The major scope of work for PRA shall include, but will not necessarily limited to – (a) an inventory of all local water resources and the way they are presently used; (b) the perceptions of local interest groups on water related constraints in relation to domestic, agricultural, fisheries, navigational, environmental and other usage; and (c) the perceptions of the various local interest groups on solutions to resolve the constraints identified and their positive and negative impact on the various local interest groups.

Activities to perform:

- Perform the baseline study, identify the water sources, present water use scenario and sectoral water demand up to union/mouza level of the High Barind region through Participatory Rural Appraisal (PRA) process.
- Conduct Focus-Group Discussion (FGD) meetings through PRA at mouza level; each meeting will cover 40 mouzas, with 1 participant from each mouza. At least one-third of the participants will be women.
- Identify the current location and status of observation/monitoring wells and irrigation borehole logs for each union/mouza of the High Barind region.
- Establish baseline condition concerning population, natural resources, land use and farming systems, agricultural practices and their constraints and opportunities.
- Ensure equitable account of views of different socio-economic group: identify special needs and aspirations of specific group like women, marginal farmers, land less group, fishermen and minority groups.

- Incorporate people's needs, views and preferences in regarding water availability, water demand and water use in the study area through people's participation and associated consultation process at local level with PRA approach.
- Prepare all physical features of land use inventory using GIS application and satellite image processing; develop GIS, RS and Time Series database collected from different primary and secondary sources.
- Prepare a detail PRA report with comprehensive maps for water availability, water use, water demand, water scarce areas, water zoning, aquifer formation and location and status of monitoring wells in the High Barind region.
- Validate the PRA report at upazila level for each upazila in the High Barind region.

5. Expected Output:

The major outputs of the study are as follows:

- Comprehensive maps for water availability, water use, water demand, water scarce areas, water zoning, aquifer formation and recharge potentials in the study area.
- Base map of the study area using information from PRA process showing observation/ monitoring wells, rivers and canals and wetlands.
- Maps showing population, natural resources, all physical features of land use inventory and agricultural practices in the study area.

6. Data Collection and Methodology:

The methodology and tools to conduct PRA will be of standard type as in PRAs conducted in other similar projects. However, the approach to execute the baseline study through PRA and collection of hydrological, meteorological, hydro-geological, morphological data, aquifer properties, groundwater level, existing DTWs/STWs and monitoring wells, are to be submitted by the Consultant before commencement of the study.

7. Work Plan and Manning Schedule:

The Work Plan and the manning schedules of the study for PRA personnel are to be submitted by the Consultant before commencement of the study.

8. Professional input:

It is estimated that for carrying out the above mentioned PRA study including relevant data collection, it will require about **130 man-months** of local professional staff. The estimated personnel requirements for the study have been given below in the following table:

Sr. No.	Description of the Position	Number of Personnel	Input (man-month)
1.	Senior Water Resources Planner/Team Leader	1	6
2.	Water Management Expert	3	30
3.	Socio-economist	3	30
4.	Environmentalist	2	24
5.	Agronomist	2	24
6.	GIS Expert	1	8
7.	Gender Specialist	1	8
	Total	**13**	**130**

There will be 3 PRA teams formed in 3 districts to carry out the study. Each PRA team will consist of a Water Management Specialist and a Socio-economist who will contribute 10 man-months to each team. Each Environmentalist and each Agronomist will join and input 4 man-months to each PRA team. The Gender Specialist and the GIS Specialist will join and input to each PRA team.

9. Qualification and Responsibilities of the PRA Personnel:

The educational qualification, required experiences and the tasks and responsibilities of each of the PRA Personnel for this Component have been described in details in **Annexure – III (a)**.

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10. PRA Meetings:

The Consultants have to perform following numbers of Focus-Group Discussion (FGD) meetings through PRA at mouza level, and PRA report validation meeting at upazila level:

PRA meetings in 3 Districts			
Sl. no	Meeting type	Unit	Quantity
1	FGD meeting through PRA at mouza level	Nos.	127
2	PRA validation meeting at upazila level	Nos.	25
Total			**152**

11. Duration of the Contract:

The Consultant for PRA study will be procured for a period of **1 (one) year** from the date of commencement according to the Contract.

12. Major Deliverables:

- Detail PRA assessment on present water availability, water use, water demand, aquifer formation and recharge potential in the High Barind region.
- Detail assessment on the current location and status of monitoring wells and borehole logs in each of the 3 districts in the High Barind region.

13. Reporting Requirement:

The following major Reports must be submitted after completion of the PRA study:

- Detail PRA assessment report, validated by appropriate authority, on present water availability, water use and water demand in each of the 3 districts the High Barind region.
- Detail assessment report with comprehensive maps on water scarce areas, water zoning, aquifer formation and recharge potential in each of the 3 districts the High Barind region.
- Detail report on the current location and status of monitoring/observation wells, and further requirement for sinking wells in each of the 3 districts in the High Barind region.

In addition to the above Reports, the following reports are required time to time:

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Sl. No.	Report	Deadline	Copies
1.	Inception Report	end of the 2nd Month	20 Copies
2.	Mid Term Report	end of the 6th Month	20 Copies
3.	Draft Final Report	end of the 10th Month	20 Copies
4.	Final Report	end of the 11th Month	25 Copies

14. Mode of Payment:

All payment of the procured Consultant will be made through satisfactory completion of the work. Initially after approval of the Inception Report, the Consultant will get **10%** of the total Contract amount. After submitting the Mid-Term Report, the Consultant will get **40%** of the total Contract amount. After submitting the Draft Final Report, the Consultant will get **30%** of the total Contract amount. The remaining **20%** of the Contract amount of the Consultant will be made after successful completion of the tasks and submission of the Final Report. All the Reports must be approved by the Director General of WARPO before making any of the above payments. As per government rules, VAT and IT will be deducted from all of the payments to the Consultant.

15. Duties and Responsibilities:

WARPO's Responsibilities:

The Project Director will ensure that the objectives of the study as detailed in the Terms of References (ToR) are achieved within the agreed time schedule. He will in the context of the ToR direct the study process and supervise the execution of the study and monitor progress according to the said objectives. The Deputy Project Director and specialised professionals of WARPO shall assist the project team as required for the study.

The PRA Consultants will have regular meetings with the Project Director and the Deputy Project Director to discuss technical and project management issues. Any unresolved issue should be taken up with the Director General, WARPO for appropriate solution. The Consultants will also report to Director General, WARPO regarding institutional strengthening support and other matters requiring specific guidance.

WARPO will be responsible for arranging the following facilities:

- All hydrological, hydro-geological, meteorological data from National Water Resources Database (NWRD) free of cost.
- Satellite images and previous reports available with WARPO.
- Make available information from other study components.

Consultant's Responsibilities

The PRA Consultants shall work under the direct supervision of the Project Director (PD) of WARPO. The Consultants shall carry out the services as detailed in the "Scope of Works" and "Responsibilities of the Consultants" in the best interest of the study with reasonable care, skill and diligence with sound engineering, administrative and financial practices and shall be responsible to the executing agency (WARPO) for discharge of responsibilities. The Team Leader will be responsible to the Director General, WARPO for proper and timely execution of all the activities of the study mentioned in the ToR of the project.

The PRA Consultants will be responsible for arranging the following facilities:

- Discussion with WARPO to avoid any duplication in the data collection.
- Handing over the collected data and study results to WARPO for their use and records.
- Making necessary arrangements for additional hydrological data collection from secondary source as needed for the study.
- Carrying out activities as per scope of work and delivering the study report.
- Making necessary arrangements for site visit and primary data collection.

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Annexure-III (a)

Qualification, Experience and Responsibilities of PRA Personnel for
Performing Participatory Rural Appraisal (PRA) and baseline study in the High Barind region

Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Senior Water Resources Planner/Team Leader	He/she must have a Bachelor's degree, preferably with a Master's degree, in Civil Engineering/Water Resources Engineering/Water Resources Management/Hydrology from a well reputed university.	He/she must be a nationally reputed figure in water sector in Bangladesh and having minimum 20 (Twenty) years of working experience in water resources planning, IWRM and resource management. He/she must have practical experience of working at field level in similar water management projects with multi-disciplinary and multi-cultural team.	▪ Overall responsibility for conducting Participatory Rural Appraisal (PRA) component of the project. ▪ Full responsibility for all aspects of planning, liaison and reporting for the PRA team. ▪ Study and review of previous water resources development projects in the study area. ▪ Orient the conceptual and strategic work plan to carry out the PRA activities. ▪ Conduct PRA meetings and stakeholder consultation ensuring equitable account of views of different socio-economic groups. ▪ Coordinate and supervise the tasks of other specialists in the PRA team. ▪ Supervise for identification of water sources and monitoring wells and borehole logs in the study area. ▪ Prepare the PRA report and validate the report with appropriate authority. ▪ Prepare proceedings of all consultation meetings. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Water Management Expert	He/she must have a Bachelor's degree in Civil Engineering/ Water Resources Engineering from a well reputed university.	He/she must have minimum 5 (five) years of working experience in water resources management and conducting community level consultations. He/she must have practical experience of working in similar water resources management related activities with multi-disciplinary and multi-cultural team.	▪ Responsibility for planning, liaison and reporting for the PRA team. ▪ Study and review of previous water resources development projects in the study area. ▪ Arrange extensive PRA meetings and stakeholder consultation at mouza, union, upazila and district level. ▪ Coordinate the tasks of other specialists in the PRA team. ▪ Data collection for water use, water demand and location and status of monitoring wells and borehole logs in the study area. ▪ Analyze all types of primary and secondary data under guidance from the Team Leader. ▪ Prepare preliminary assessment report of the existing situation and need assessment for the study. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Socio-economist	He/she must have a Bachelor's degree in Social Science/Social Welfare/Sociology/Economics from a well reputed university.	He/she must have minimum 5 (five) years of working experience in specific social development-focused program and conducting community level consultations. He/she must have practical experience of working in similar projects at grass root level with multi-disciplinary and multi-cultural team.	▪ Study and review of previous water resources development projects in the study area. ▪ Undertake socio-economical assessment through PRA process ensuring equitable account of the views different socio-economic groups. ▪ Assess community, including women's needs and views on existing project objectives and management. ▪ Assess the economic consequences of environmental impacts resulting from previous projects. ▪ Prepare preliminary assessment report of the existing situation and need assessment for the study. ▪ Prepare different reports including people's views and needs regarding water use and water demand ▪ Perform economic analysis of specific proposed projects by utilizing standard economic evaluation techniques. ▪ Facilitate the local level institutional development process. ▪ To assist the Team leader in preparation of the PRA report. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Environmentalist	He/she must have a Bachelor's degree in Civil Engineering/ Water Resources Engineering/ Environmental Science/ Fisheries/Forestry/Soil Science from a well reputed university.	He/she must have minimum 5 (five) years of working experience in impact assessment of environmental changes on ecosystem, biodiversity, fisheries etc. He/she must have practical experience of working in similar environmental related activities with multi-disciplinary and multi-cultural team.	▪ Study and review of previous water resources developement projects in the study area. ▪ Develop methodologies for PRA and participatory planning. ▪ Provide guidelines and technical supports in developing environmental impact assessments. ▪ Analyze all types of primary and secondary data under guidance from the Team Leader. ▪ Assist in identifying changes in life cycle of flora and fauna due to changes in environmental condition as a result of climate change. ▪ Assist in identifying possible impacts of changes in fishery resources, biodiversity and ecosystem in the study area. ▪ Prepare preliminary assessment report of the existing situation and need assessment for the study. ▪ To assist the Team leader in preparation of the PRA report. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Agronomist	He/she must have a Bachelor's degree in Agriculture/ Agronomy/Agricultural Engineering from a well reputed university.	He/she must have minimum 5 (five) years of working experience in agriculture related activities and conducting community level consultations. He/she must have practical experience of working in modelling monsoon cropping pattern, land use and similar water resources management projects.	▪ Study and review of previous water resources development projects in the study area. ▪ Undertake agricultural assessment through PRA process ensuring equitable account of the views different socio-economic groups. ▪ Establish baseline condition in respect of land resources and agricultural practices in the study area. ▪ Data collection and analysis of water availability, water use and water demand in the study area. ▪ Prepare technically, socially, and environmentally viable production plans for efficient water use. ▪ Advise on appropriate methods and techniques to enable crop diversification for water conservation, and effective water management. ▪ Prepare preliminary assessment report of the existing situation and need assessment for the study. ▪ Provide necessary support for preparing database and institutional improvement. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
GIS Expert	He/she must have a Bachelor's degree in Geography/Civil Engineering/Water Resources Engineering/Urban and Rural Planning/ Environmental Science/Geology from a well reputed university.	He/she must have minimum 5 (five)years of working experience in GIS application, Satellite image processing, GPS survey and ESRI software like ArcGIS, ArcInfo Desktop, ArcSDE, ArcView etc. He/she must have practical experience in similar GIS related activities in producing GIS coverage, contour maps, Digital Elevation Model (DEM) etc.	▪ Prepare plan for GIS application in consultation with other specialists of the PRA team. ▪ Collection of reports/maps/data from different secondary sources. ▪ Develop GIS, RS and Time Series database collected from different primary and secondary sources. ▪ Analyze all types of primary and secondary data under guidance from the Team Leader. ▪ Prepare all physical features of land use inventory using GIS application and satellite image processing. ▪ Prepare maps for water availability, water use, water demand and location and status of monitoring wells and borehole logs in the study area. ▪ Provide guidance to prepare GIS based maps of water stress areas, water zoning, aquifer formation maps. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

Name of the Post	Educational qualification	Experience	Responsibilities
1	2	3	4
Gender Specialist	He/she must have a Bachelor's degree in Social Science/ Sociology/Social Welfare/ Development Studies or a relevant field from a well reputed university.	He/she must have minimum 5 (five) years of working experience in formulating interventions to reduce the gender gaps and in specific social development-focused program. He/she must have practical experience of working at grass root level in similar projects with multi-disciplinary and multi-cultural team.	▪ Study and review of previous water resources development projects in the study area. ▪ Undertake social assessment through PRA process ensuring equitable account of the views different socio-economic groups. ▪ Assist the team to identify the special needs and aspirations of specific group like women, marginal farmers, land less group, fishermen and minority groups. ▪ Identify the issues of social conflicts. ▪ Assist to develop and execute a monitoring and evaluation of women and disadvantaged groups. ▪ Assess community, including women's needs and views on existing project objectives and management. ▪ Prepare preliminary assessment report of the existing situation and need assessment for the study. ▪ To assist the Team leader in preparation of the PRA report. ▪ Any activity assigned by the Project Director for the interest of the project. ▪ Maintain close contact with the Project Director and the Deputy Project Director for briefing his/her output.

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Annex-B: Minutes of Technical Committee Meeting

Government of the People's Republic of
Bangladesh
Ministry of Water Resources
Water Resources Planning Organization
www.warpo.gov.bd

Memo No. – 42.02.0000.005.14.002.20- 1276 Date: 02/0/2022

Subject: Discussion Meeting minutes to finalize the final PRA (Participatory Rural Appraisal) report under the "Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018" project.

Chairperson: Md. Delwar Hossain, Director General (Additional Secretary), WARPO

Date and Time: 02 June, 2022 at 11.00 AM

The Chairperson of the scheduled meeting opened the session with welcoming the participants of the meeting. He informed the participants that the final PRA report should be submitted by 15 June,2022 as per the decisions taken in the 4th PIC meeting dated on 30 May,2022. Therefore, he requested the consultant team of IWM to give a brief presentation on the completed activities of the PRA component under the TAPP titled "Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018".

Then on behalf of IWM consultant team Mr. Md. Rezaul Hasan, Senior Specialist gave a short presentation of their field level activities and described the progress of the PRA component.

During the open discussion, Mr.Kazi Saidur Rahman, SSO told that the probable water scarce area maps can be prepared from the data taken from FGD meetings. Dr. Md. Aminul Haque PSO added that the selection criteria for water scarce areas should also be included in the Final Report.

Mr. Md Jahid Hossain, Project Director suggested to include an information summary of the data for each upazila in the final report. The chairperson is concerned about the formatting errors and spelling mistakes of the report. So, he suggested a thorough review is required to eliminate those common errors.

The following decisions have been taken in the meeting:

i) Probable water scarce area map should be prepared for each upazila.
ii) The criteria for selecting probable water scarce areas should be included in the final report.
iii) An information summary of the data for each upazila should be included in the final report.
iv) The final report should be reviewed thoroughly to eliminate formatting errors and spelling mistakes of the report.

As there were no other issue for discussion, the Chairperson of the meeting thanked all the participants and concluded the meeting.

02/6/22

(Md. Delwar Hossain)
Director General (Additional Secretary),
WARPO

The list of attendees at the Discussion meeting is attached herewith (Annexure - I).

Government of the People's Republic of Bangladesh
Ministry of Water Resources
Water Resources Planning Organization
www.warpo.gov.bd

Memo No. – 42.02.0000.005.06.001.21- 1329 Date: 09-06-2022

Subject: Minutes on Draft final PRA report under "Operationalizing Integrated Water Resources Management (IWRM) in compliance with the Bangladesh Water Rules, 2018" project.

A technical committee meeting on Draft Final Report (DFR) in connection with the Consultancy Services for the project 'Participatory Rural Appraisal (PRA) / Baseline Study of Water Resources in Rajshahi, Chapai Nawabganj and Naogaon Districts' under Operationalizing Integrated Water Resources Management (IWRM) in Compliance with the Bangladesh Water Rules, 2018 was held on 25 April, 2022 at the conference room of WARPO. The meeting was chaired by Mr. Md. Delwar Hossain, Director General (Additional Secretary), WARPO. The list of participants is attached as annexure A.

Discussions and Observations:

1. The Chairperson of the meeting opened the session by welcoming the participants, participated both physically and virtually in the meeting. He allowed to proceed the meeting. Mr. Md Jahid Hossain, Project Director of the Project delivered welcome address. He mentioned that this meeting has been arranged to disseminate the study findings and to seek comments and suggestion for further improvement of the study findings. Professor Chowdhury Sarwar Jahan, Deptt. Of Geology and Mining, University of Rajshahi and Member, Technical Committee of the PRA Study proposed one minute of silence as a condolence to the departed soul of the former Project Director. It was accepted by the Chairperson, and at the same time he also congratulated the newly appointed Project Director.

2. Mr. Md Salim Bhuiyan, Team Leader of the PRA study of the project, gave a presentation on the salient findings of the study. In his presentation Mr. Bhuiyan mainly focused on field activities, analytical works, brief findings, and recommendations of the study. Afterwards, the Chairperson requested the participants to give their valuable comments and suggestions on the study. Comments and suggestions of the participants are presented below:

3. Mr. Professor Chowdhury Sarwar Jahan, Deptt. of Geology and Mining, University of Rajshahi first thanked WARPO to initiate such a nice study, which is very much essential for the Barind region. He informed that he had an opportunity to visit one of the FGD event and their quality of works was admirable. Poverty map of 2016/2020 has been available, which should be consulted rather than 2010 map, used in the report. He also expected maintaining gender balance during data collection from indigenous group. It is difficult to know the exact groundwater abstraction in the Barind region, since huge numbers of tube-wells are being installed through private initiatives. He informed that groundwater is being used in fish farming for 2/3 months in the dry season in the Barind

region. He told that in order to reduce water stress, shifting of crop calendar should be considered. He also raised that there are no industrial establishments in the project area except its municipal areas and peripheries as well. However, in this regard he added that five high capacities water pumps are used for rice processing mills in Nachol upazila, which is the water use in industries. He congratulated IWM for conducting this study nicely.

4. Ms. Sara Nawrin, Associate Professor, IWFM, BUET and Member, Technical Committee of PRA study, told that although most of her comments in the Mid Term Report are considered in this DFR, but some issues still need to be addressed; such as, the checklist mentions active and in-active tube-wells, which are found missing in the analysis. She emphasized on assessment of drinking water demand/water use on union based, as it vary union to union. She expected good quality maps in the report. Mr. Md. Obaed Hossain, Deputy Chief Engineer, BADC emphasized that the output of the study should be in line with field activities rather than using secondary data.

5. Mr. Md. Shamsul Huda, Additional Chief Engineer, BMDA and Member, Technical Committee of PRA study, told that the report has been very nice. It is hoped that this will play a significant role in the implementation of the Water Act. Mr. Akram from DASCOH, thanked IWM for nice presentation. He expected WARPO's monitoring in IWRM meetings in the Barind region. He emphasized on motivation of local people in judicious use of groundwater. Mr. Jahangir of DASCOH, thanked IWM for finishing such a huge volume of works at field level under this project. He requested for demarcation of high and low Barind in the map. Nine upazilas suffer from water scarcity severely. He sharded his field experience that DTWs are dominated in Nachole, whereas number of STWs are more in Badalgachi upazila.

6. Mr. Md. Hasan Shahariar, Senior Scientific Officer, WARPO told that recommendations of the study are given in the report narratively, which is expected in specific way. Sectoral water demand such as, agricultural, fisheries and industrial sectors can be assessed. Table presentation in the report needs to be improved. Mr. Md. Masud Alam, Principal Scientific Officer, WARPO quoted an information in the ministerial meeting that about 52 tube wells are being installed in each union every year. It is very alarming.

7. Mr. Sharafat Hossain, Individual Water Expert Consultant of the project told that the Draft-Final Report prepared by IWM is comparatively elaborated and informative. He emphasized on the content of the report, how to improve it and make it functional, required for operationalizing the Bangladesh Water Rules, 2018. Dr. Md. Aminul Haque, Principal Scientific Officer, WARPO emphasized on specific recommendations in the report. The findings of the present study should reflect people's perception in water usage.

8. Mr. Mohammad Alamgir, Principal Scientific Officer, WARPO emphasized on specific recommendations in the report. Ms. Fahmida Akhtar, Principal Scientific Officer, WARPO suggested to make arrangement for transferring the data generated from this study to WARPO for inclusion in the National Water Resources Database. Mr. S.M. Tanvir Hassan, Programme Coordinator-IWRM, SRC requested for the assessment of water stress at union level. Mr. Kazi Saidur Rahman, Senior Scientific Officer, WARPO requested for the assessment of waterbodies at upazila level in tabular form in the report.

Decisions:

After the above discussion following decisions were taken:

1. Sectoral water demand such as agricultural, domestic, fisheries and industrial sectors should be assessed on Upzilla level.
2. Water scarcity areas should be identifies on union level and should be shown on the map.
3. Demarcation of high Barind and low Barind should be represented on the map.
4. The poverty map 2016/2020 should be used instead of 2010 poverty map.
5. The recommendation for PRA component should be based both quantitative as well as qualitative analysis.
6. The list of potential water bodies need to be preserved should be included in the report.

The Chairperson of the meeting thanked all participants for their active participation in the meeting. He specially thanked the participants making their valuable comments, opinion and suggestions. He suggested that the Draft Final Report should be prepared subject to the compliance, inclusion and update the DFR on the basis of comments made in the meeting and those received earlier from different officials and experts in written.

The session was concluded with vote of thanks from the Chairperson.

9/6/22

(Md. Delwar Hossain)
Director General (Additional Secretary),
WARPO

Annex-C: Compliance on Draft Final Report

The compliance on the decisions taken in the Discussion Meeting on the Revised Draft Final Report for PRA Study chaired by Mr. Md. Delwar Hossain, Director General (Additional Secretary), WARPO.

Sl No	Comments	Compliance	Response from Project Director
01	Probable groundwater scarce area map should be prepared for each Upazila	The groundwater scarce area map of each Upazila is prepared and is incorporated in Chapter 5.	Agreed.
02	The criteria for selecting probable groundwater scarce areas should be included in the Final Report	Given in the Section 5.1 of Chapter 5.	Accepted.
03	An information summary of the data for each Upazila should be included in the Final Report	An information summary of the data for each Upazila in tabular form under Chapter is incorporated in the Section 5.5 of Chapter 5.	Accepted.
04	The Final Report should be reviewed thoroughly to eliminate formatting errors and spelling mistakes of the report.	The whole report has been reviewed thoroughly and editorial mistakes have been removed.	Done and accepted.

The Final Report has been accepted by the Project Director and recommended for the approval of the competent authority of WARPO.

Hossain
09/02/22

(Md. Jahid Hossain)

Project Director

Sl No	Comments	Compliance
01	Professor Chowdhury Sarwar Jahan Deptt. of Geology and Mining, University of Rajshahi He mentioned that poverty map of 2016/2020 has been available, which should be consulted rather than 2010 map, used in the report. He thanked WARPO to initiate such a nice study, which is very much essential for the Barind region. He informed that he had an opportunity to visit one of the FGD event and their quality of works was admirable. He also congratulated IWM for conducting this study nicely.	Revised with recent poverty data.
02	Ms. Sara Nawrin Associate Professor, IWFM, BUET a) The checklist provides active and in-active tube-wells, which are found missing in the analysis. Requested for clarification. b) She emphasized on assessment of drinking water demand/water use on union based, as it varies union to union. c) She expected good quality maps in the report.	a) Respondents in FGDs could not provide any accurate information about Inactive Shallow Tubewell (IASTW) and Required Tubewell (RSTW) except Active Shallow Tubewell (ASTW), during the PRA study, because they are getting water from only ASTW. b) Incorporated in each Upazila PRA report. c) Done.
03	Mr. Md. Obaed Hossain Deputy Chief Engineer, BADC The output of the study should be in line with field activities rather than using secondary data.	As a PRA study, the outputs are based on qualitative data gathered at field level.
04	Mr. Md. Shamsul Huda Additional Chief Engineer, BMDA The report has been very nice. It is hoped that this will play a significant role in the implementation of the Water Act 2013.	Thanks for comments.
05	Mr. Akram CEO, DASCOH a) He expected WARPO's monitoring in IWRM meetings in the Barind region. b) He emphasized on motivation of local people in judicious use of groundwater.	a) WARPO may look into it. b) The comment is appreciated and noted.

Sl No	Comments	Compliance
	He thanked IWM for nice presentation.	
06	Mr. Jahangir DASCOH He requested for demarcation of high and low Barind in the map. Nine upazilas suffer from water scarcity severely. He sharded his field experience that DTWs are dominated in Nachole, whereas number of STWs are more in Badalgachi upazila. He thanked IWM for finishing such a huge volume of works at field level.	Reflected in the report.
07	Mr. Md. Hasan Shahariar Senior Scientific Officer, WARPO a) He told that recommendations of the study are given narratively, which is expected in specific way. b) Sectoral water demand such as, agricultural, fisheries and industrial sectors can be assessed. c) Table presentation in the report needs to be improved.	a) Specific recommendations are made for each Upazila. b) Given for each upazila under Volume-II to Volume-IV. c) Done.
08	Mr. Md. Masud Alam Principal Scientific Officer, WARPO He quoted an information in the ministerial meeting that about 52 tubewells are being installed in each union every year. It is very alarming	Remarks is appreciated.
09	Mr. Sharafat Hossain Individual Water Expert Consultant of the Project He emphasized on the content of the report, how to improve it and make it functional, required for operationalizing the Bangladesh Water Rules, 2018.	The whole report is thoroughly reviewed and revised as per his suggestions.
10	Dr. Md. Aminul Haque Principal Scientific Officer, WARPO a) He emphasized on specific recommendations in the report. b) The findings of the present study should reflect people's perception in water usage.	a) Specific recommendations are made for each Upazila. b) People's perception in water usage for each upazila is given in Volume-II to Volume-IV.
11	Mr. Mohammad Alamgir Principal Scientific Officer, WARPO He emphasized on specific recommendations in the report.	Given in section 2.9 in volume II, section 2.5 in Volume-III and section 2.11 in Volume-IV

Sl No	Comments	Compliance
12	Mr. S.M. Tanvir Hassan Programme Coordinator -IWRM, SRC He requested for the assessment of water stress at union level in the study.	Assessment of water scarce at union level is presented in Volume-II to Volume-IV.
13	Mr. Kazi Saidur Rahman Senior Scientific Officer, WARPO He requested for the assessment of waterbodies at upazila level in tabular form in the report.	The assessment of waterbodies at upazila level is given in tabular form in volume-II to volume-IV.
14	Dr. Badal Mahalder WRE, BUET (provided in written) I really appreciate the efforts being made by the consultants. They did a good job. However, I have some minor issues as follows: ➢ Page x, Acronym spelling is not correct and please check the elaboration of BBS. ➢ Section 2.6, please check line 6 (grammatical error) ➢ Table 3-1, in two places year is missing. ➢ Section 4.3.8, The Venn Diagram is misleading. I think they should represent it in different way. The logic of Venn Diagram is not followed here. ➢ Section 4.3.9 I don't see any figure 3.2 and 3.3 ➢ Section 4.3.10, I don't see Figure 3-4 ➢ In each PRA map, DTW, STW, SW sizes are not uniform. Is it spatially varying or something else. ➢ I do appreciate the use of same legend for all the PRA maps. However, I think if any attribute is not present in a map, we can just remove that legend from the map.	➢ Corrected. ➢ There is no Section 2.6. However, the chapter 2 was reviewed thoroughly to remove editorial mistakes. ➢ Done. ➢ Done. ➢ Mistakenly mentioned in this section, however given in Annex-B. ➢ Mistakenly mentioned in this section, however given in Annex-B. ➢ Bigger size indicates more dominance in the union. It also is given in tabular form. ➢ Thanks, and corrected.