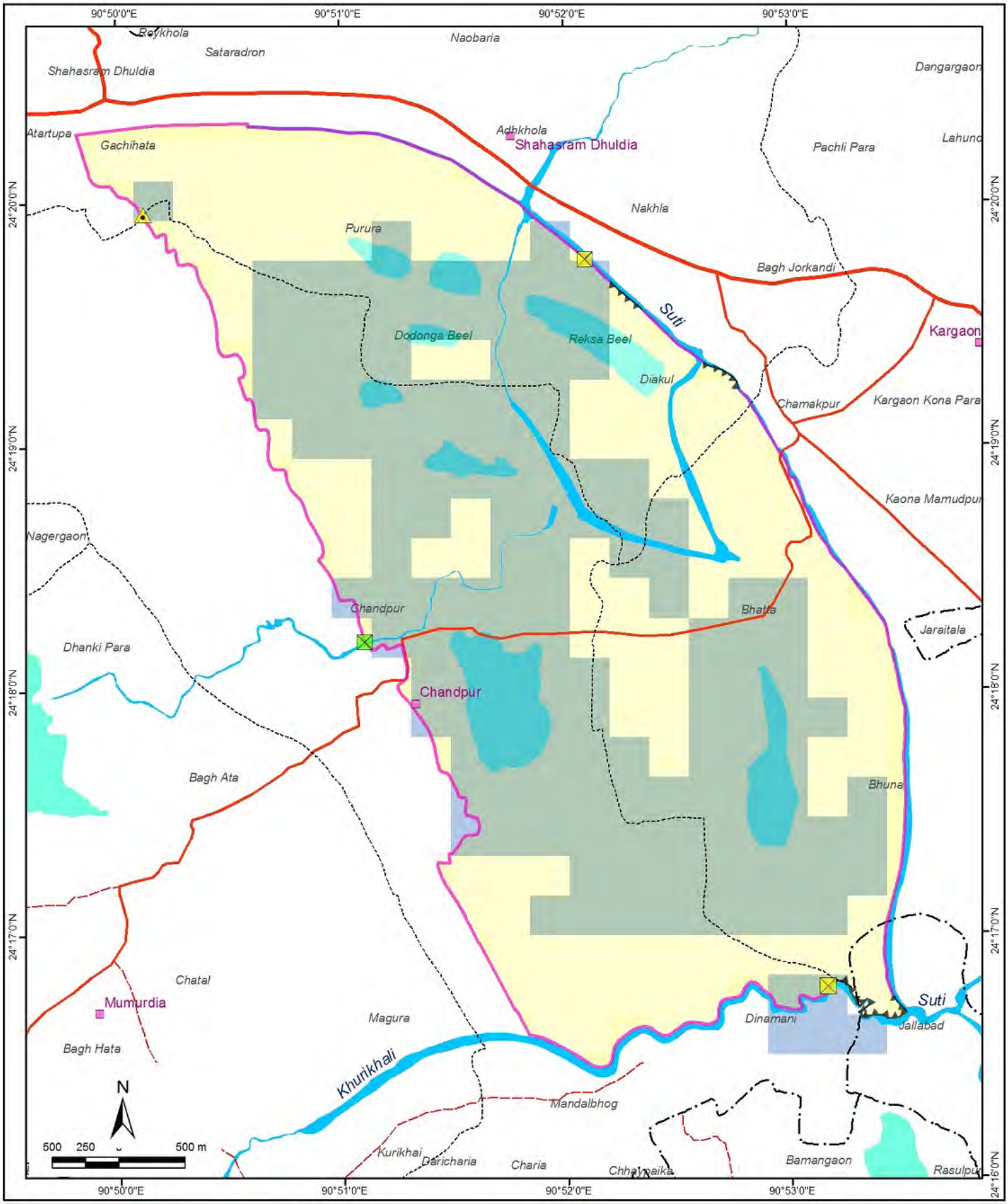
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Dharmapasha Rui Beel Project

Legend

- Division Boundary
- District Boundary
- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Upazila H/Q
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 6.1 m+PWD)

Index Map



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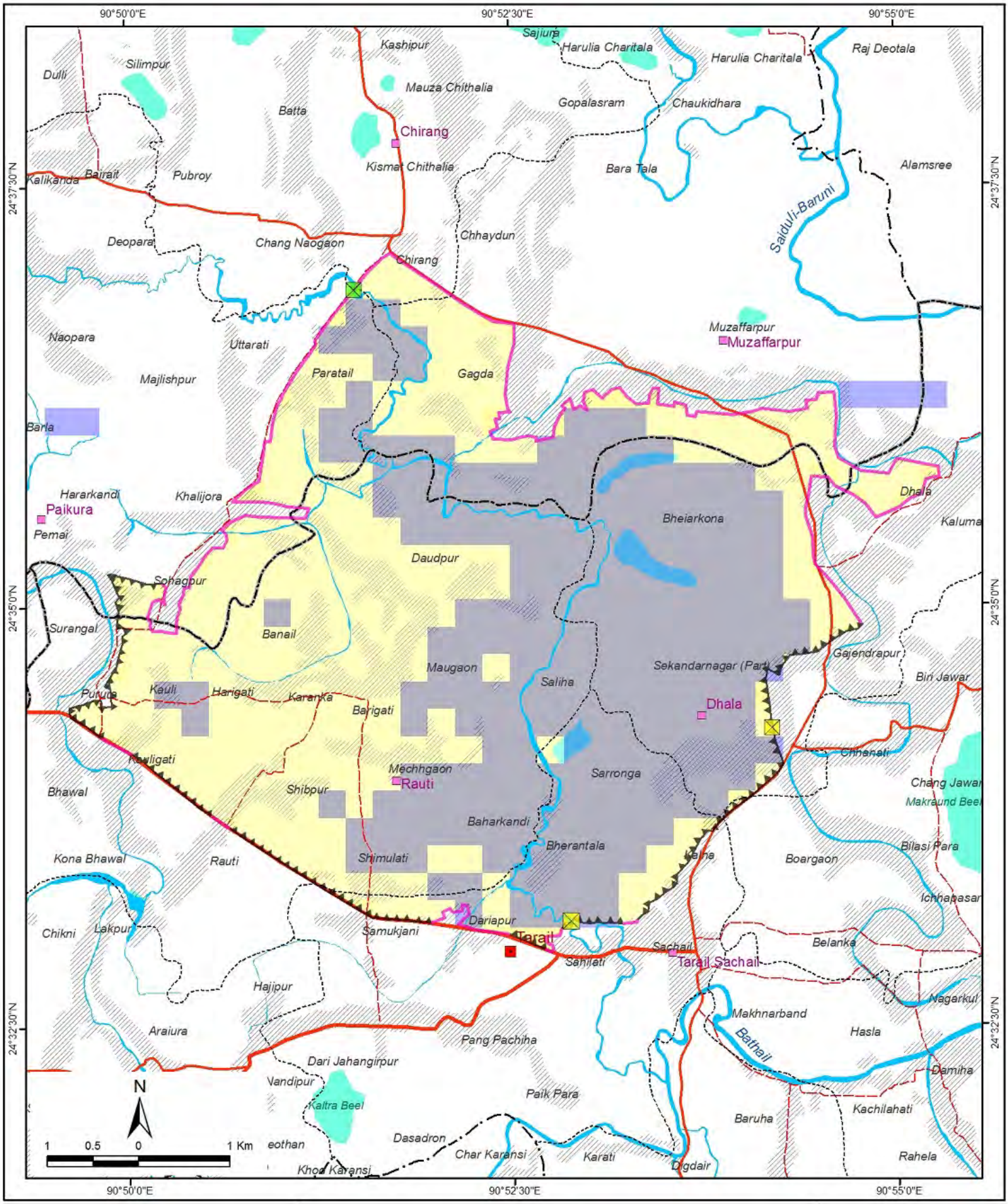
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Chandpur Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Flushing Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.9 m+PWD)

Index Map



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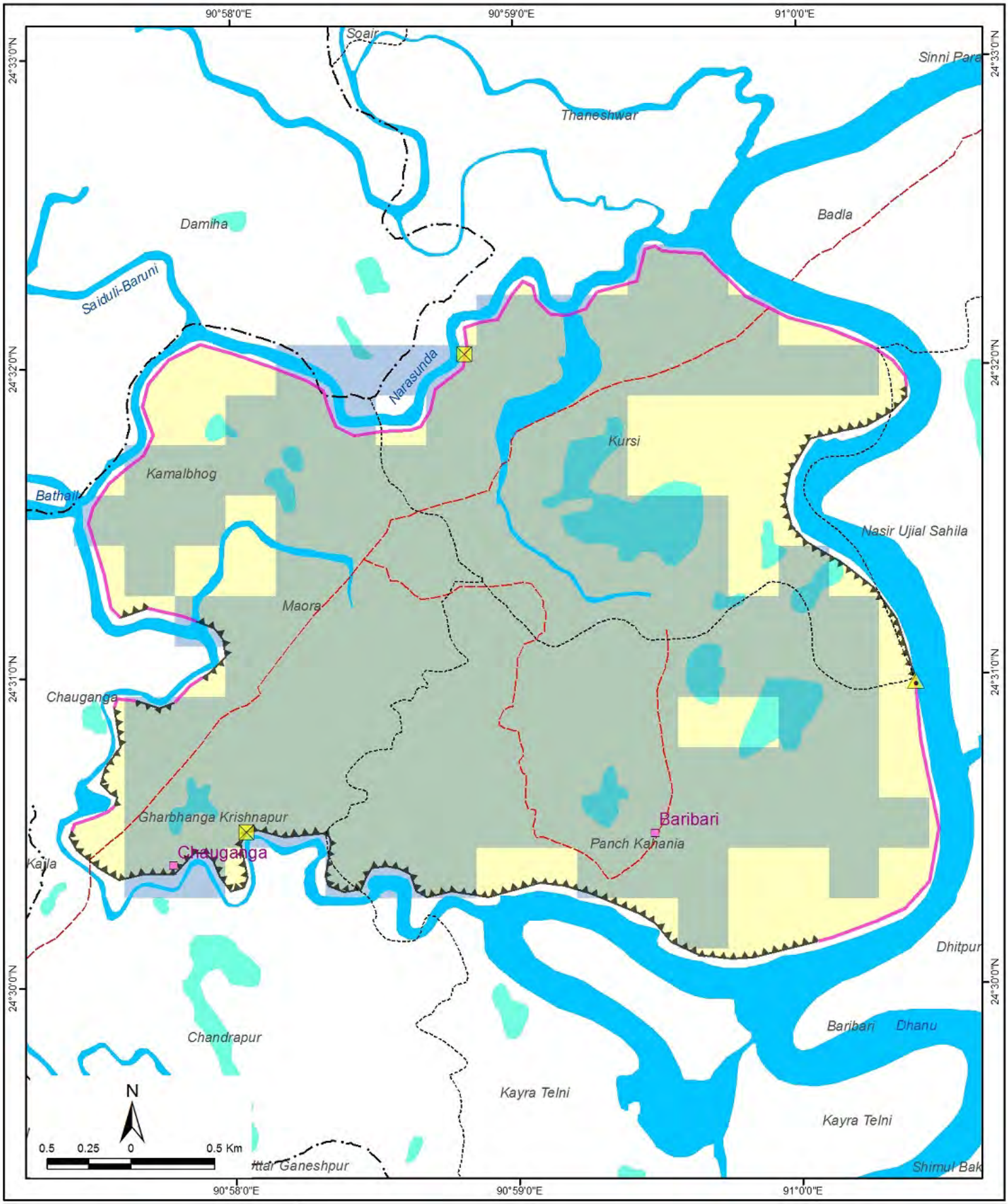
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Sunair Haor Project

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Upazila H/Q
- Union H/Q
- Drainage Regulator
- Flushing Regulator
- Settlement
- River / Khal
- Water body
- Inundated area (DWL = 5.7 m+PWD)

Index Map



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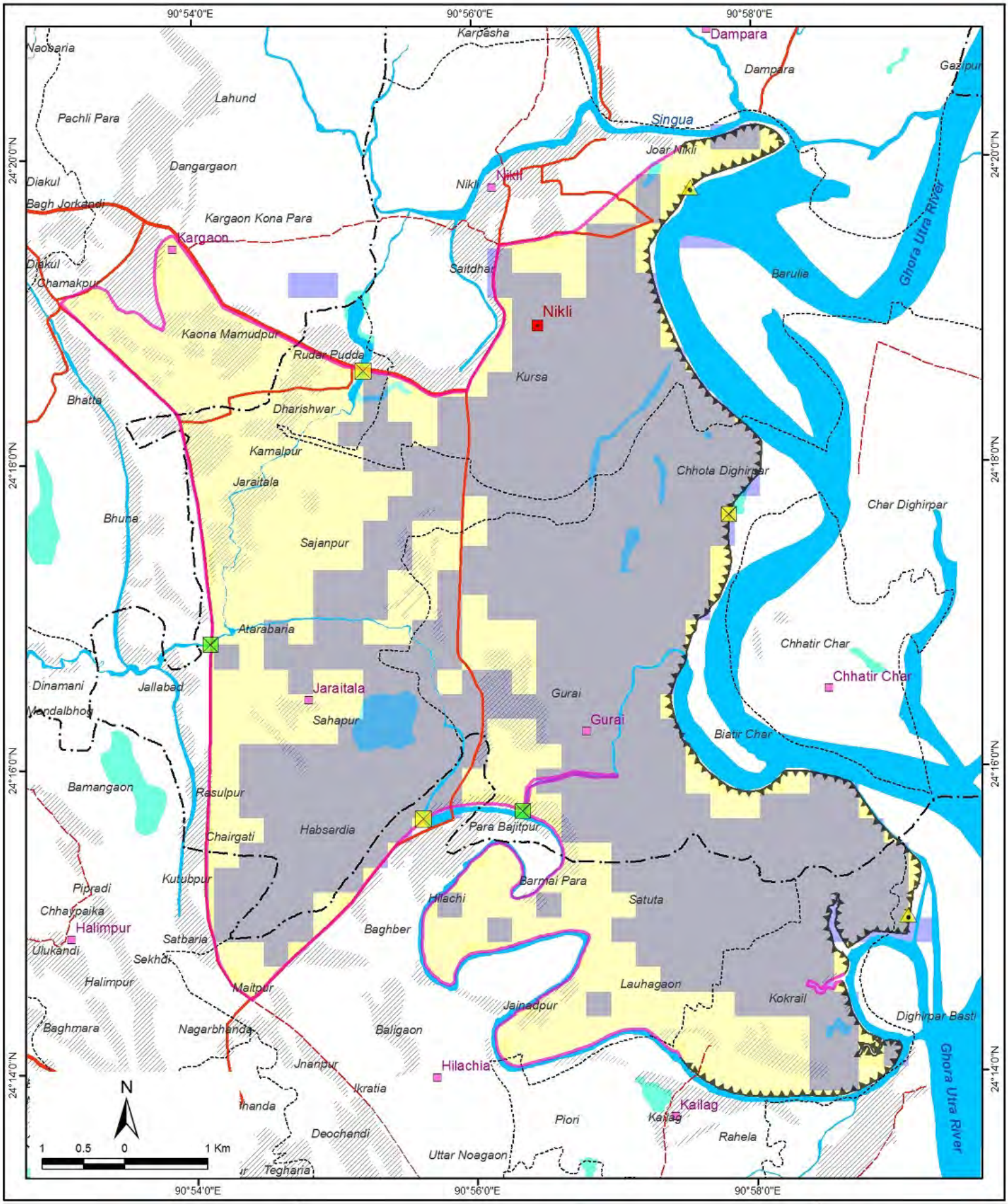
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Badla Scheme

Legend

- Upazila Boundary
- Union Boundary
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.9 m+PWD)

Index Map



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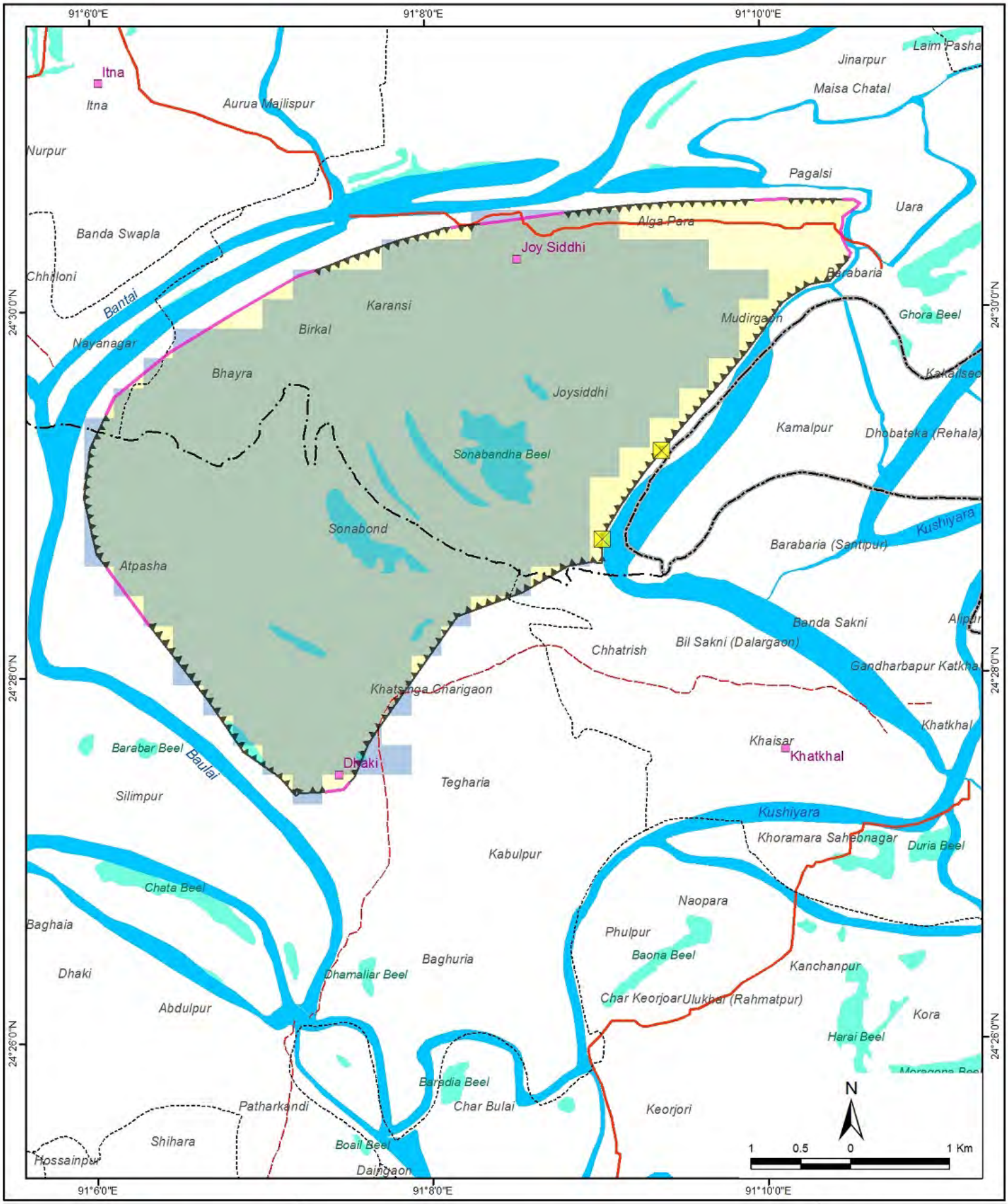
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Nunnir Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Settlement
- Upazila H/Q
- Union H/Q
- Drainage Regulator
- Flushing Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.4 m+PWD)

Index Map



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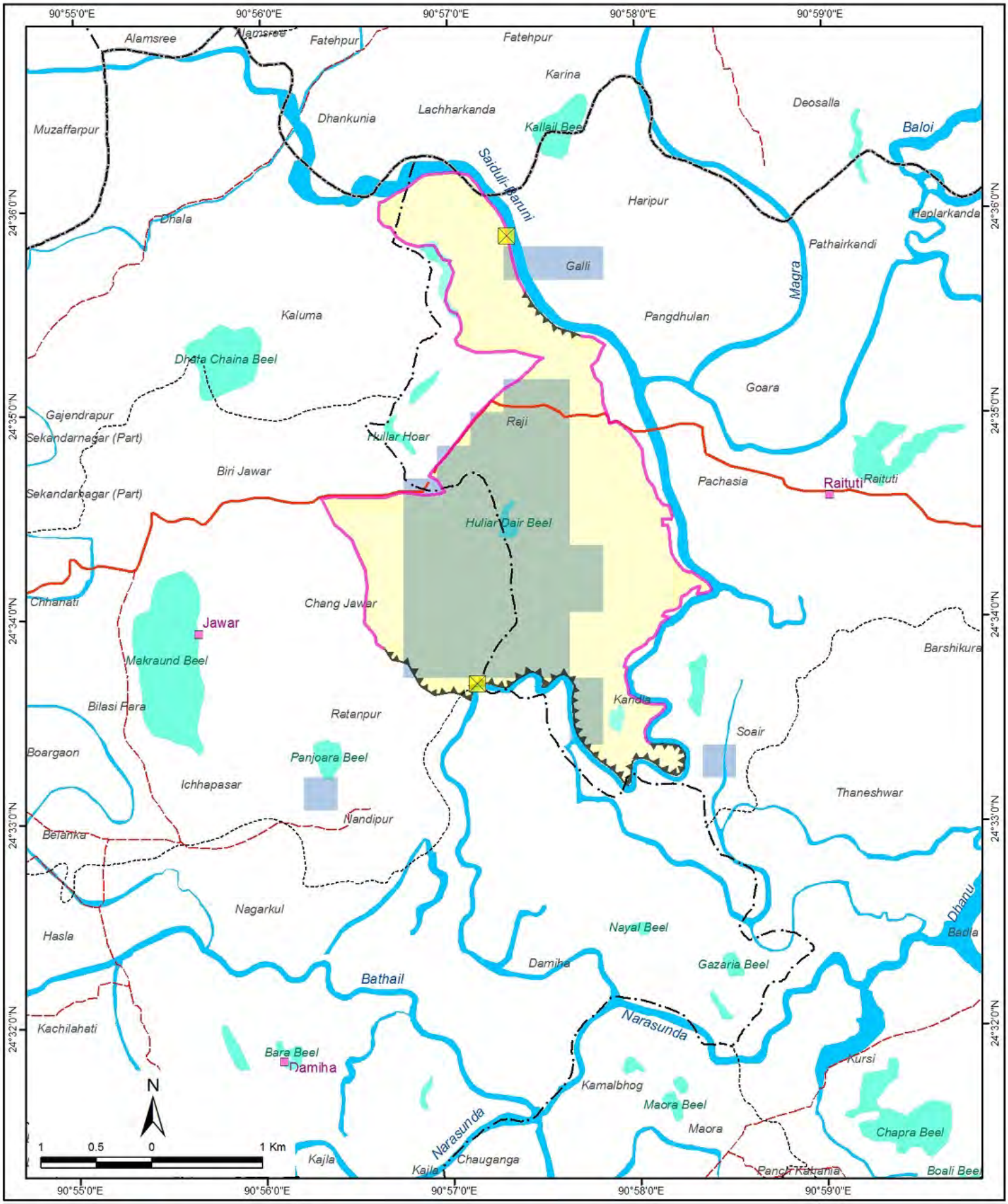
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Dakhshiner Haor Project

Legend

- Division Boundary
- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- River / Khal
- Water body
- Inundated area (DWL = 4.8 m+PWD)

Index Map



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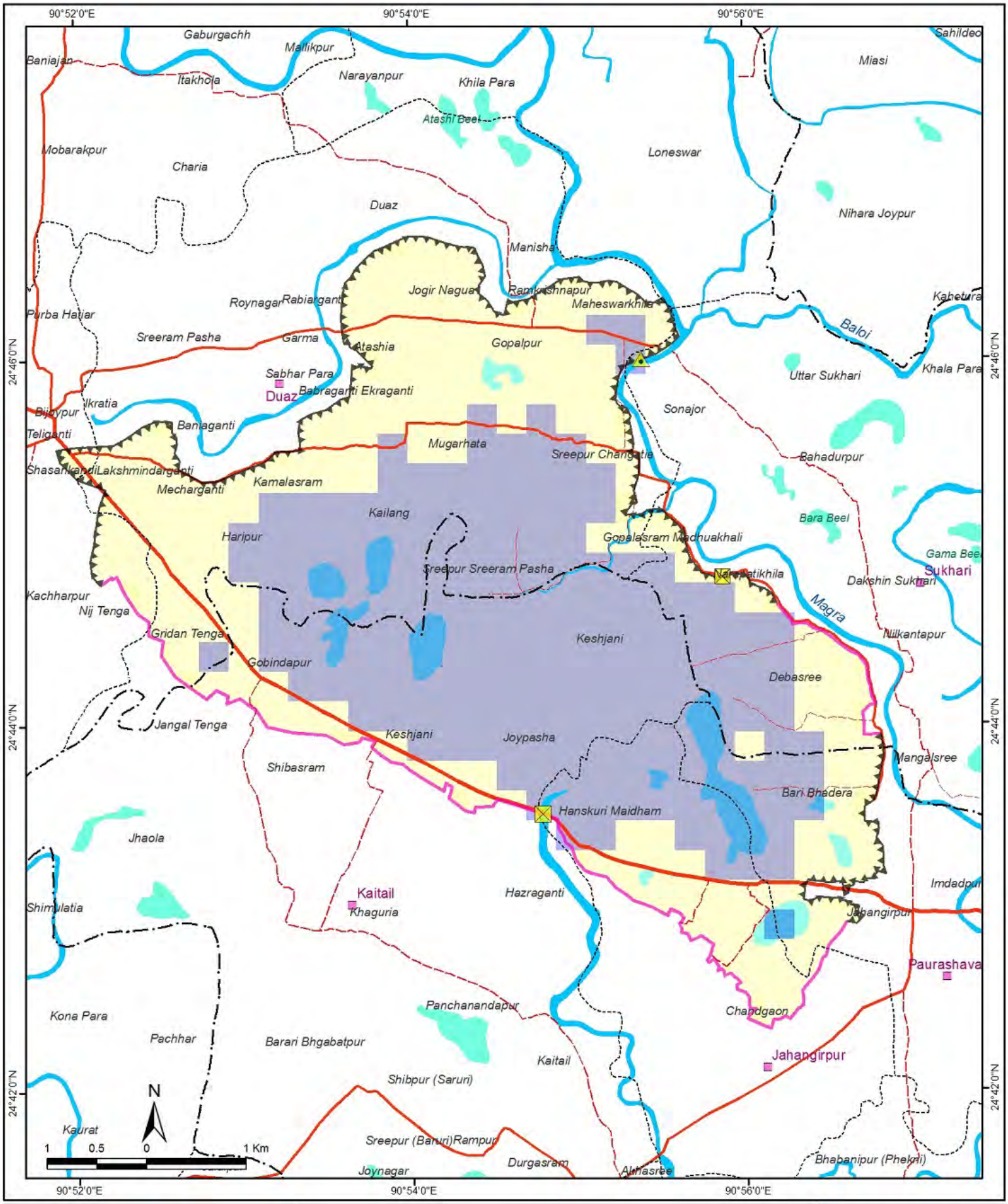
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Chatal Haor Project

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- River / Khal
- Water body
- Inundated area (DWL = 4.5 m+PWD)

Index Map



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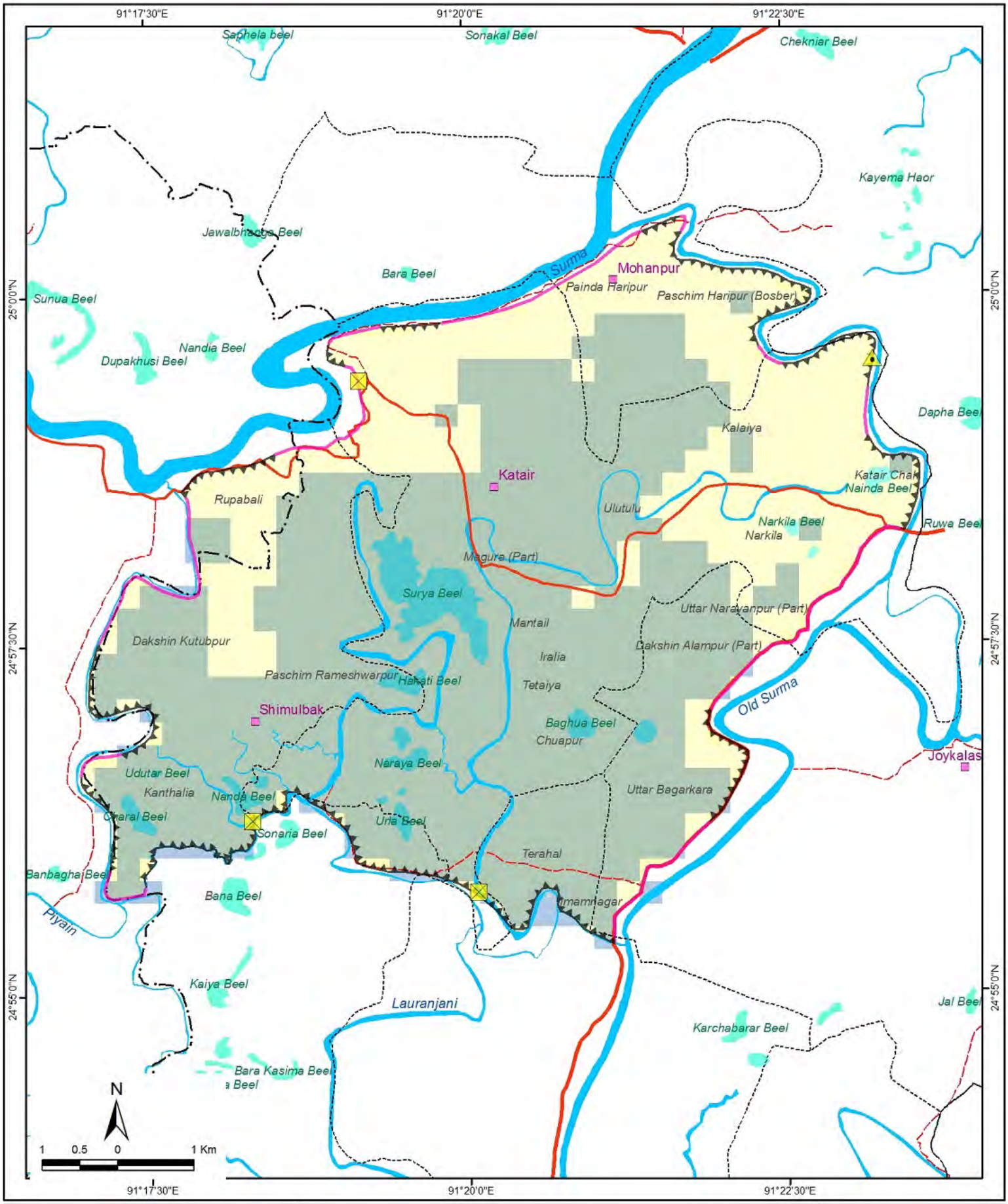
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Ganesh Haor Project

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 6.1 m+PWD)

Index Map



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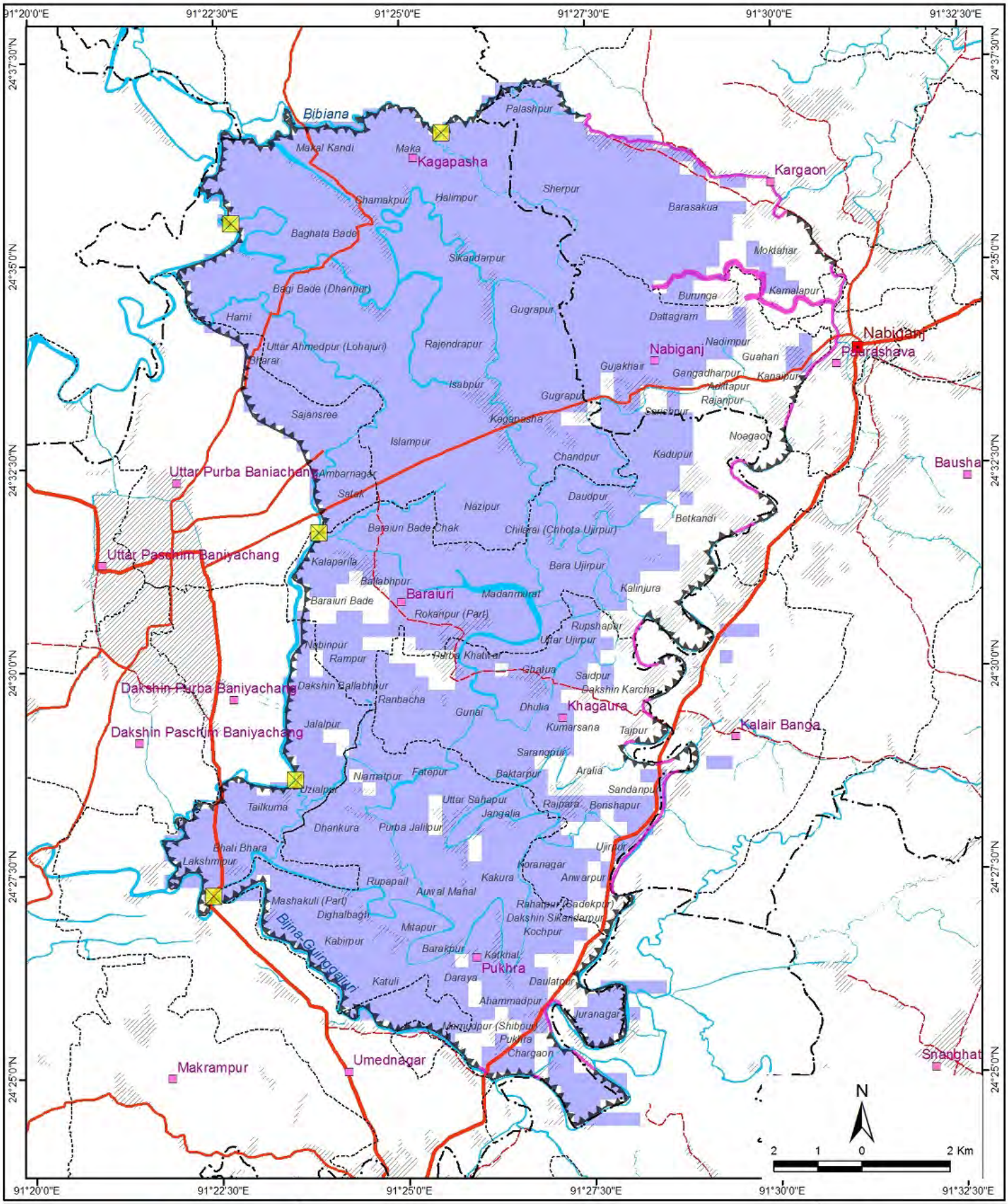
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Dhakua Haor

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 6.0 m+PWD)

Index Map



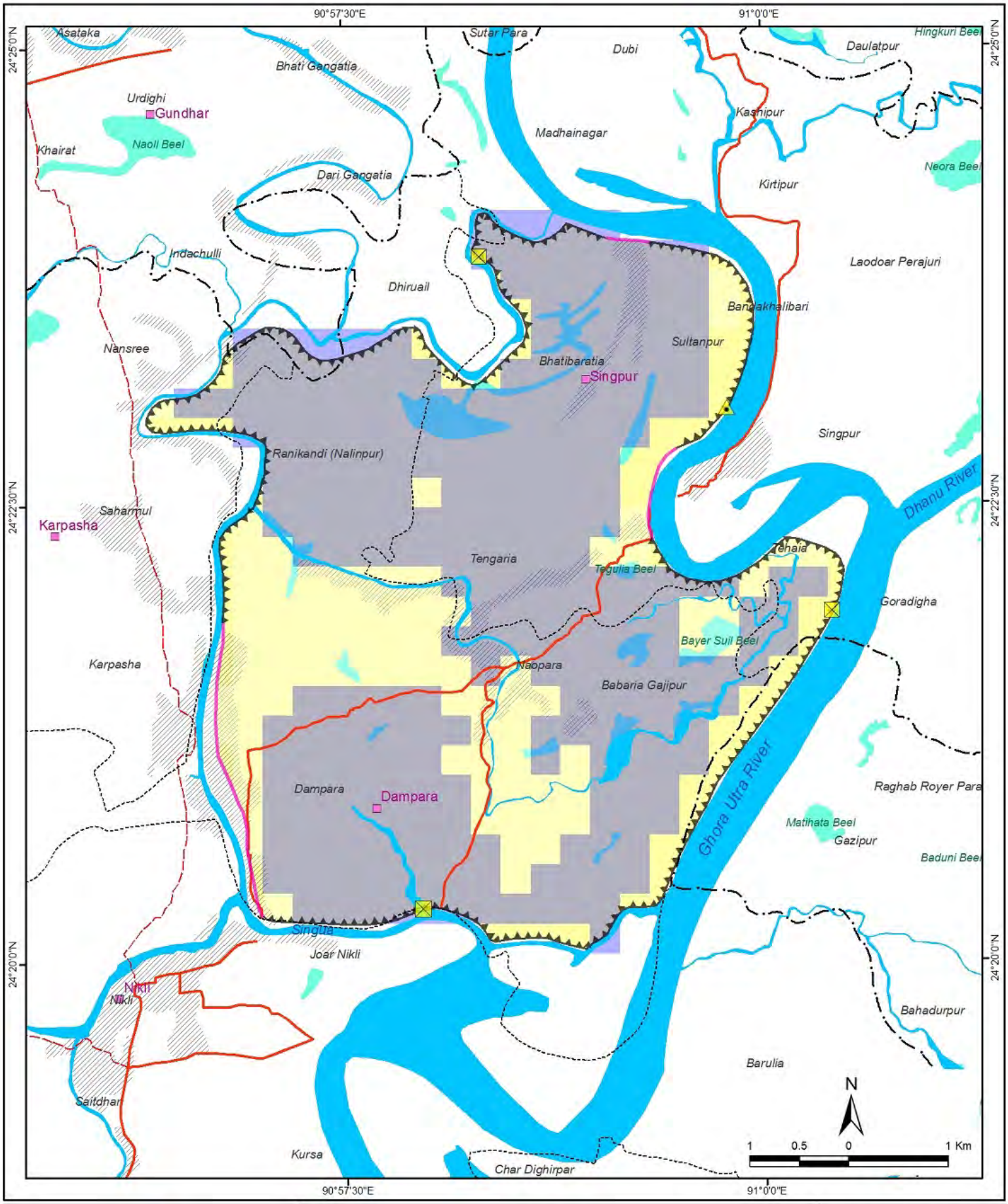
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Mokhar Haor Project

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Upazila H/Q
- Union H/Q
- Drainage Regulator
- Settlement
- River / Khal
- Inundated area (DWL = 5.55 m+PWD)

Index Map



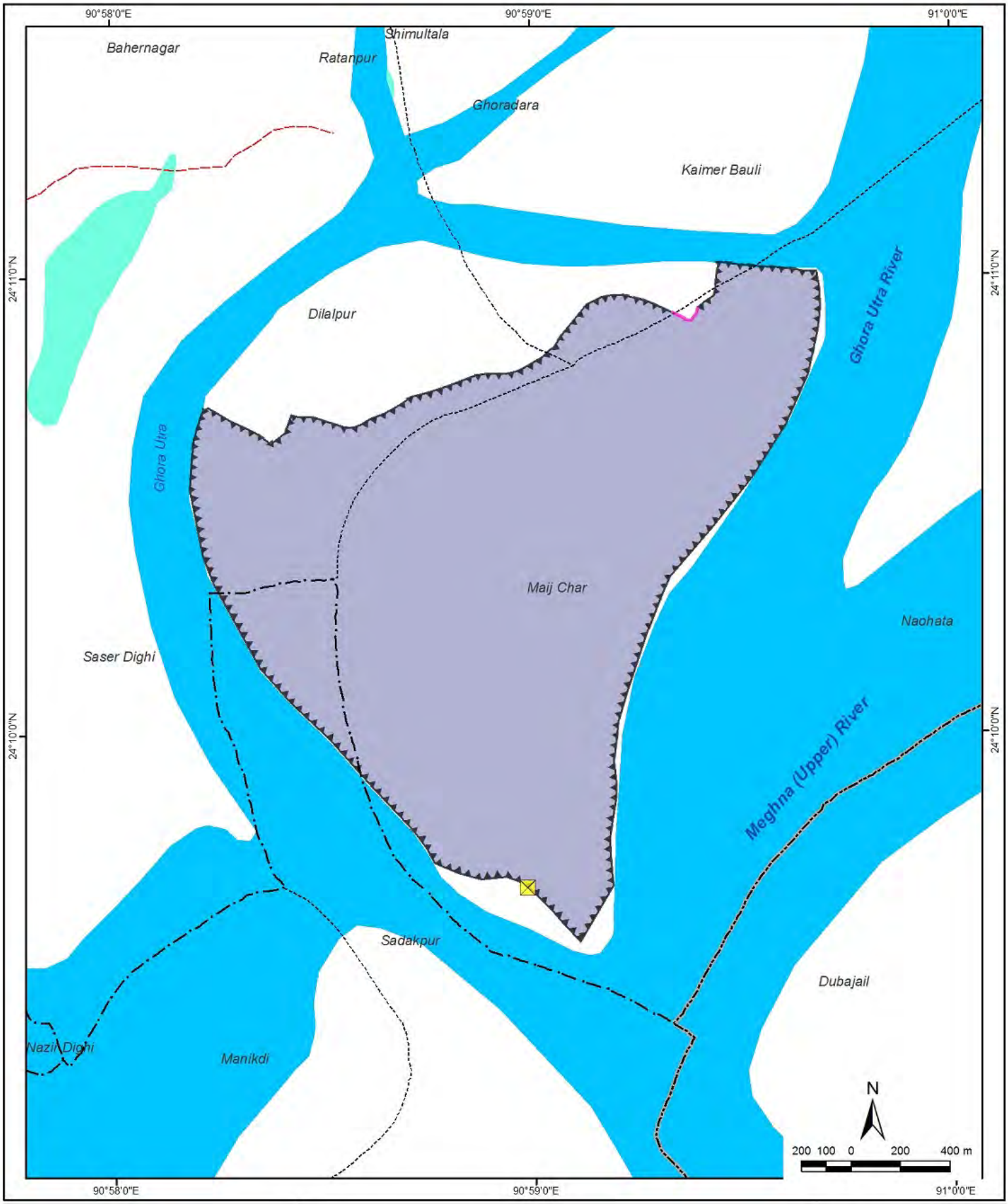
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Noapara Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- Settlement
- River / Khal
- Water body
- Inundated area (DWL = 4.6 m+PWD)

Index Map



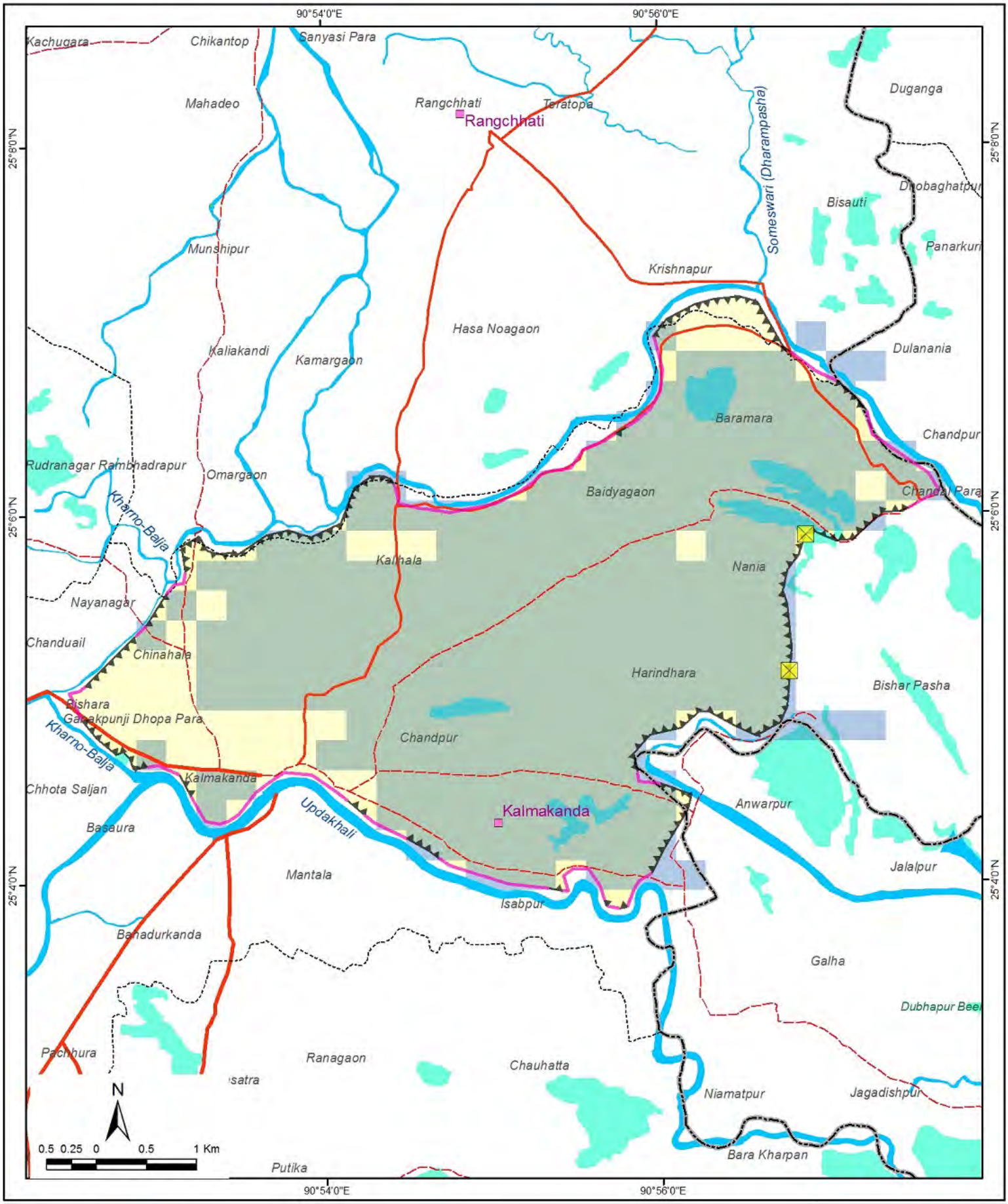
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Dulalpur Project

Legend

- Division Boundary
- Upazila Boundary
- Union Boundary
- Rural Road
- Project Boundary
- Proposed Embankment
- Drainage Regulator
- River / Khal
- Water body
- Inundated area

Index Map



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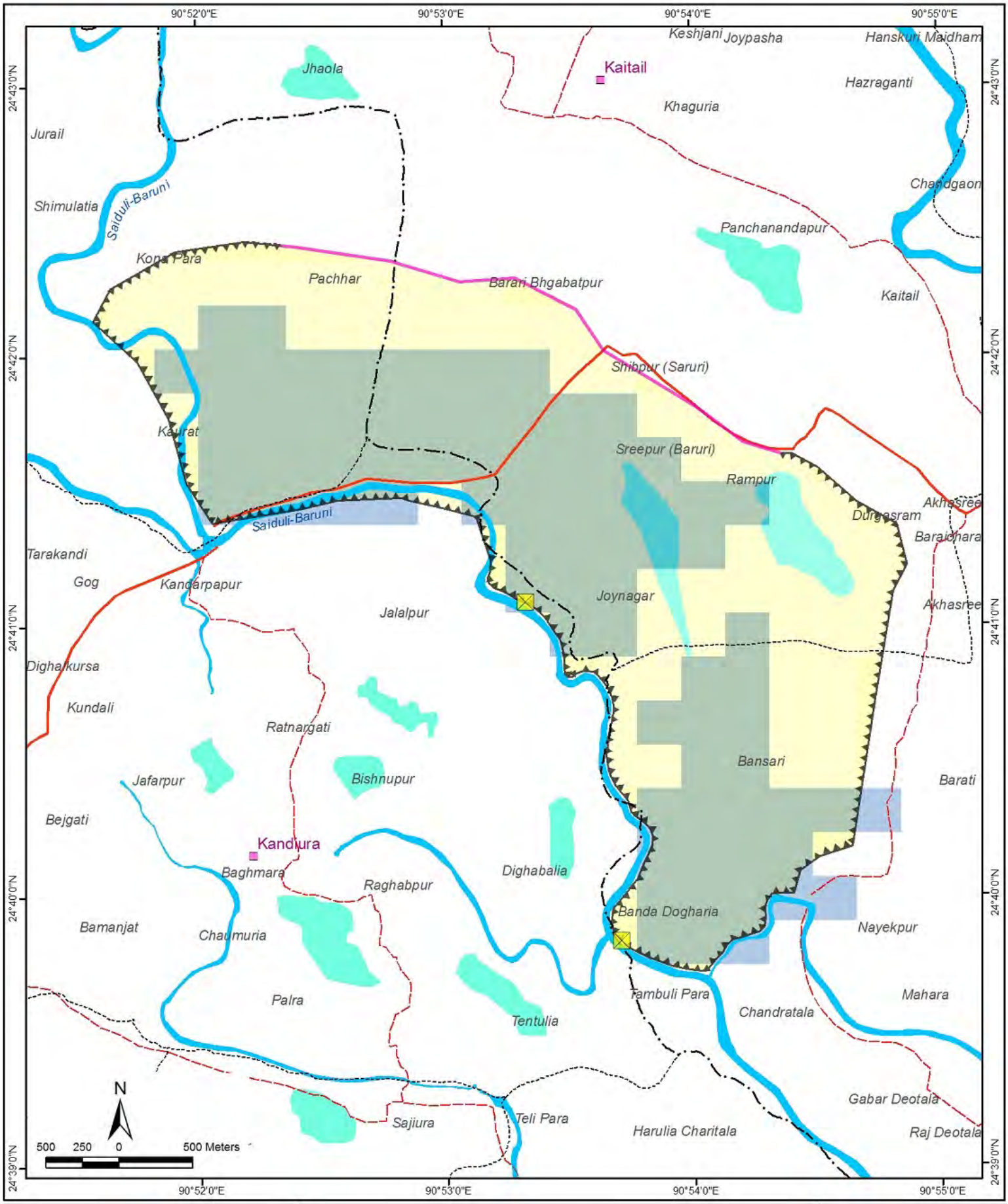
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Boro Haor Project

Legend

- Division Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- River / Khal
- Water body
- Inundated area (DWL = 6.0 m+PWD)

Index Map



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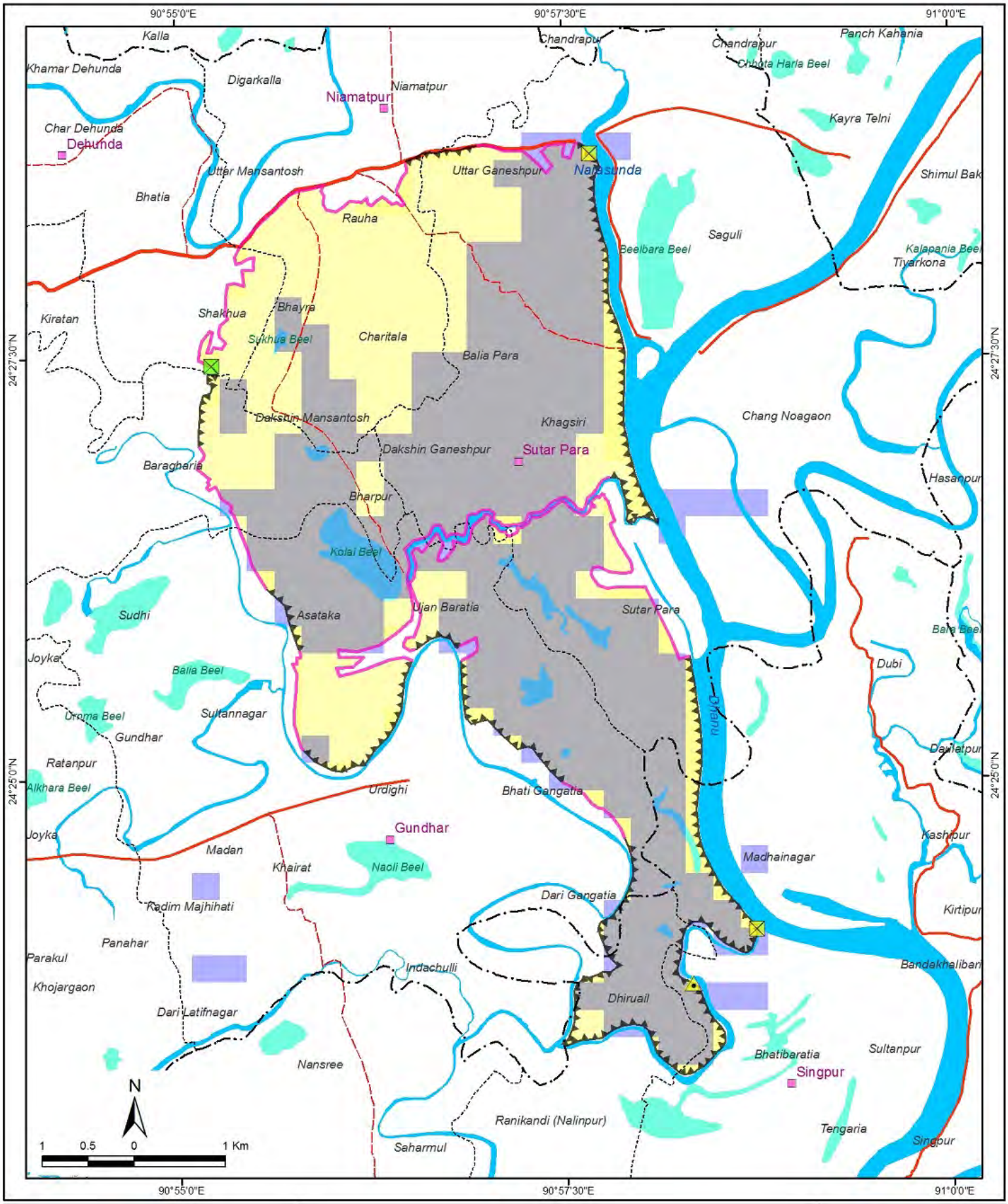
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Bansharir Haor Project

Legend

- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- River / Khal
- Water body
- Inundated area (DWL = 5.8 m+PWD)

Index Map



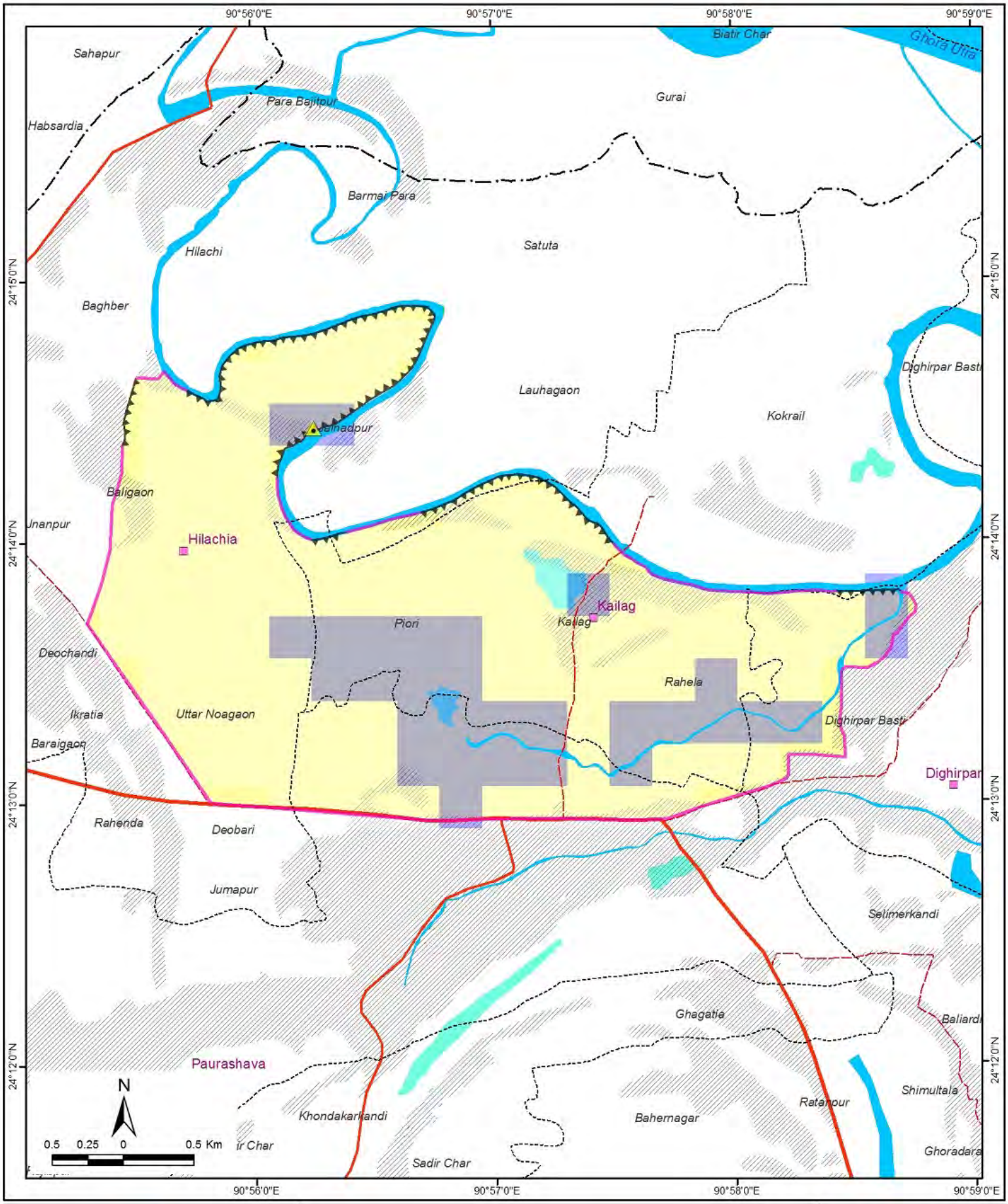
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Korati Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Flushing Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.9 m+PWD)

Index Map



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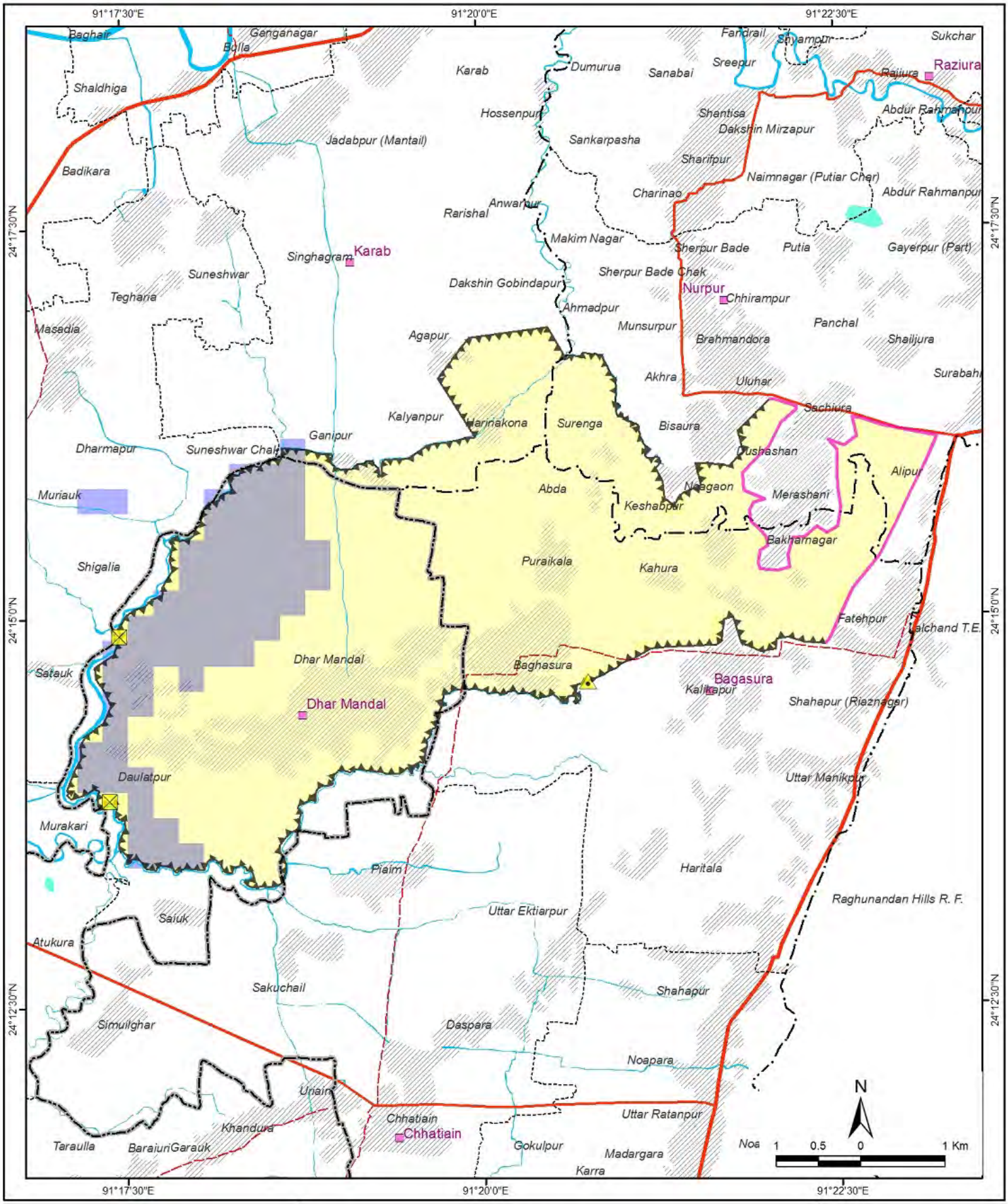
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Sarishapur Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- Settlement
- River / Khal
- Water body
- Inundated area (DWL = 4.3 m+PWD)

Index Map



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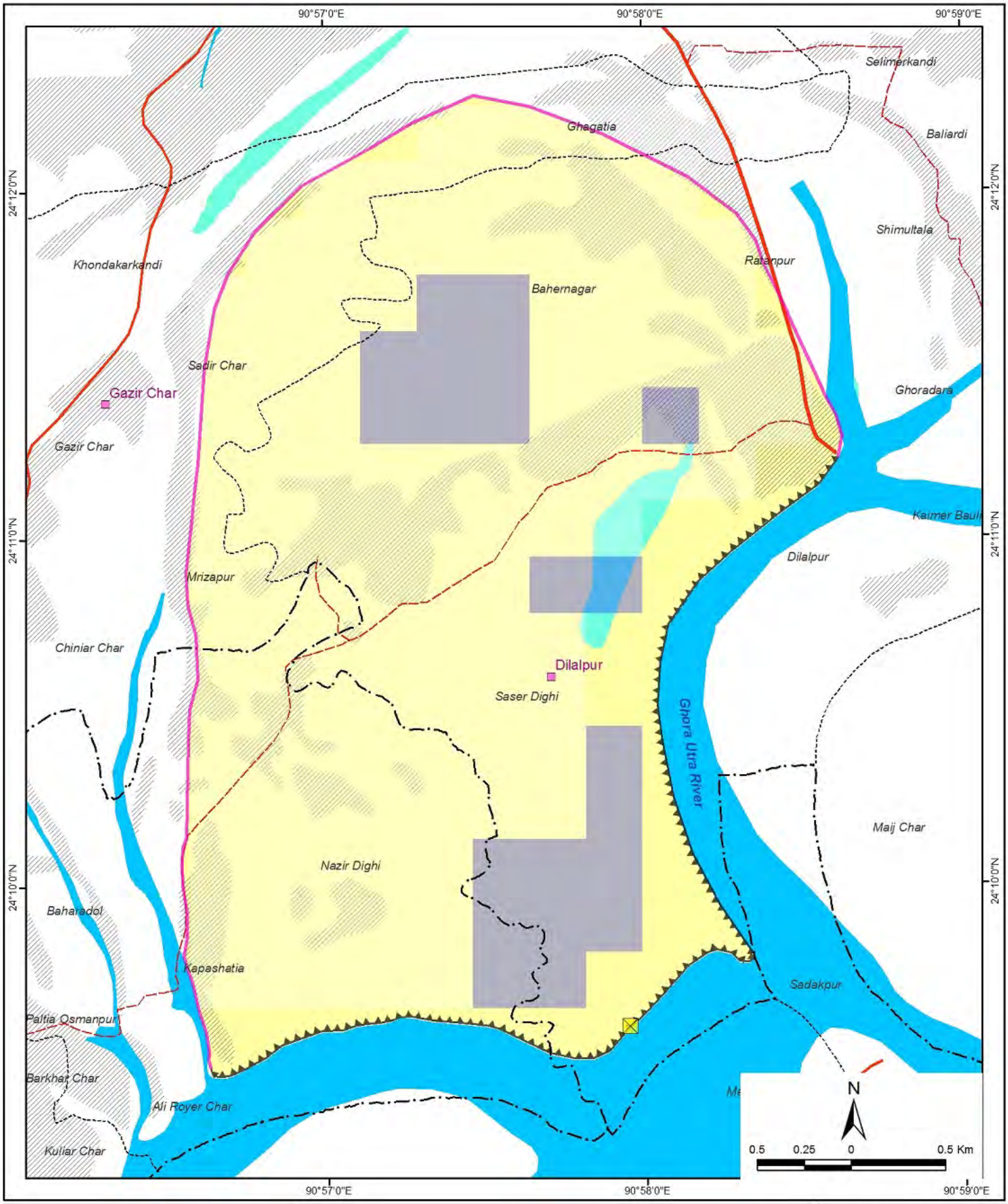
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Shelnir Haor Project

Legend

- Division Boundary
- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- Settlement
- River / Khal
- Water body
- Inundated area (DWL = 5.2 m+PWD)

Index Map



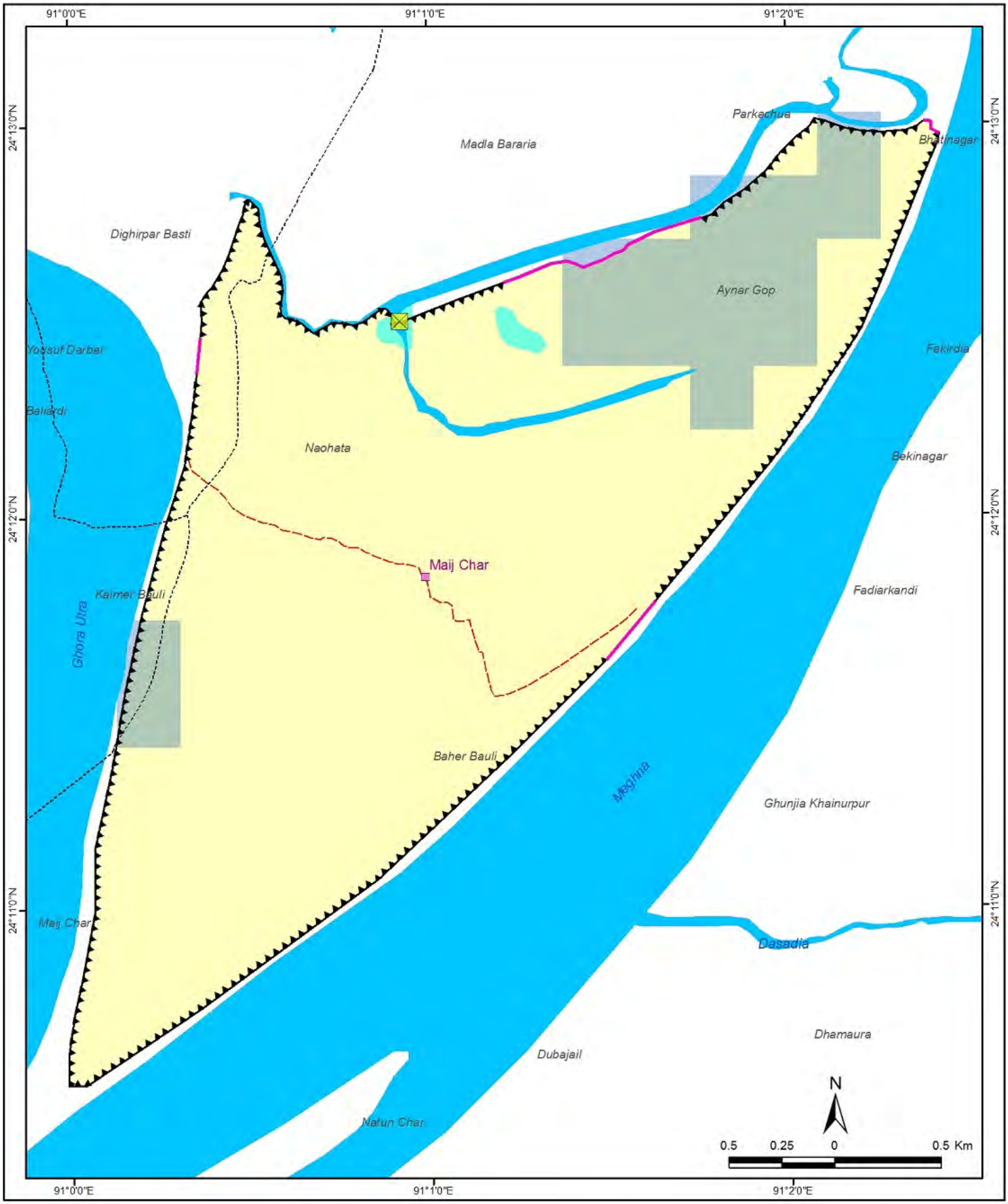
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Kuniarbandh Haor Scheme

Legend

- Upazila Boundary
- Union Boundary
- Upazila Road
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Settlement
- River / Khal
- Water body
- Inundated area (DWL = 4.0 m+PWD)

Index Map



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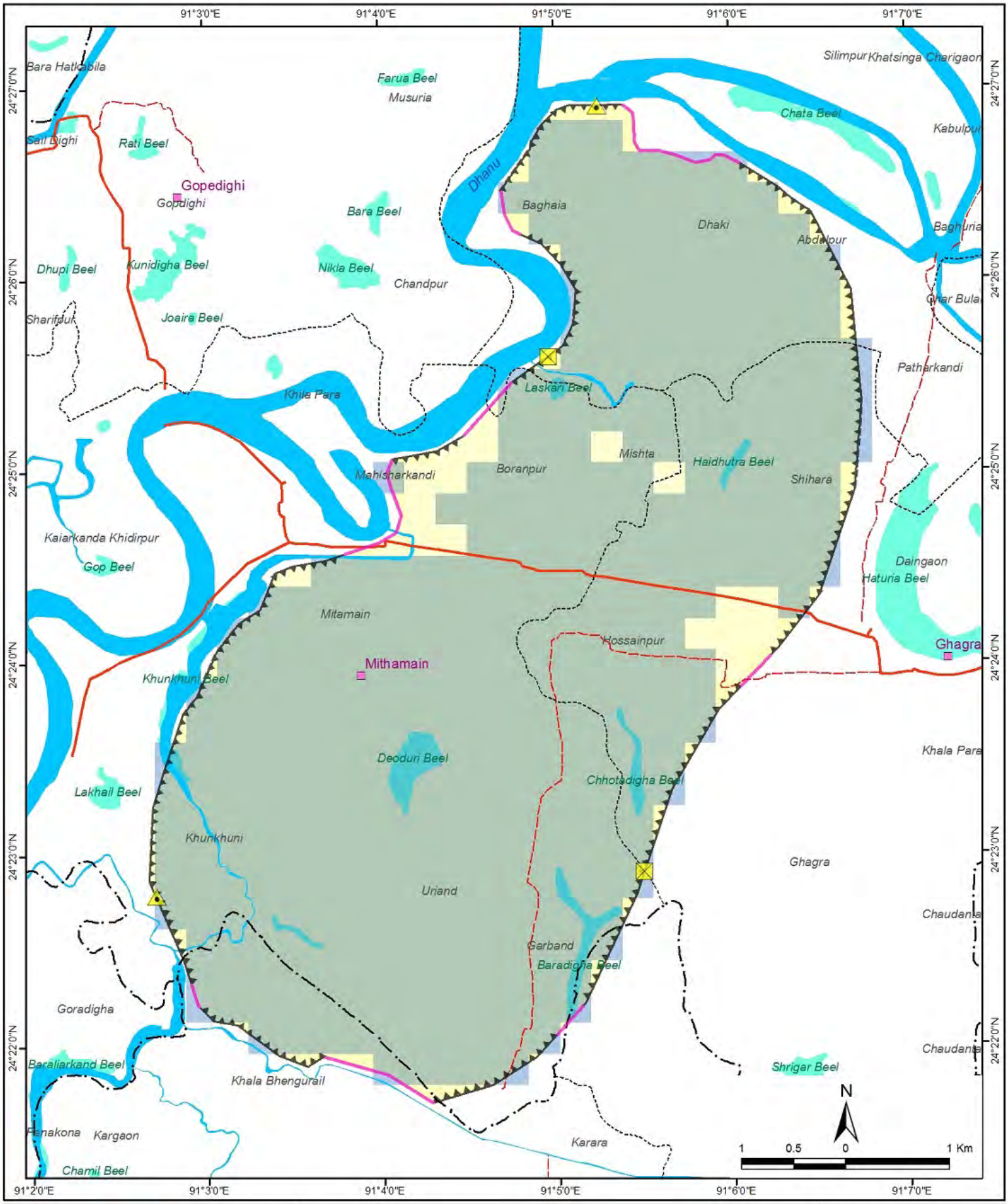
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Ayner Gupi Haor Scheme

Legend

- Union Boundary
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- River / Khal
- Water body
- Inundated area (DWL = 4.0 m+PWD)

Index Map



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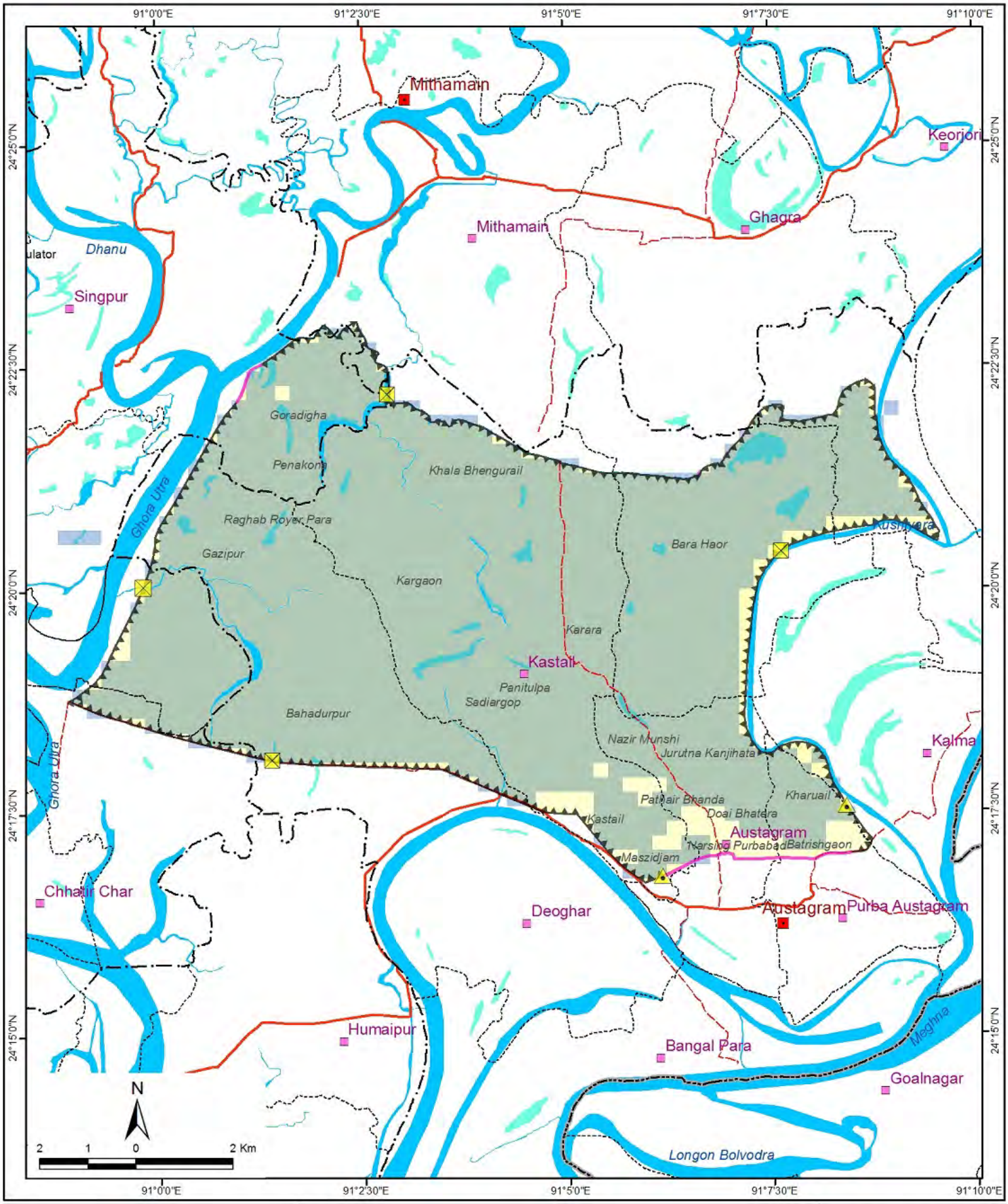
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

Charigram Project

Legend

- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.6 m+PWD)

Index Map



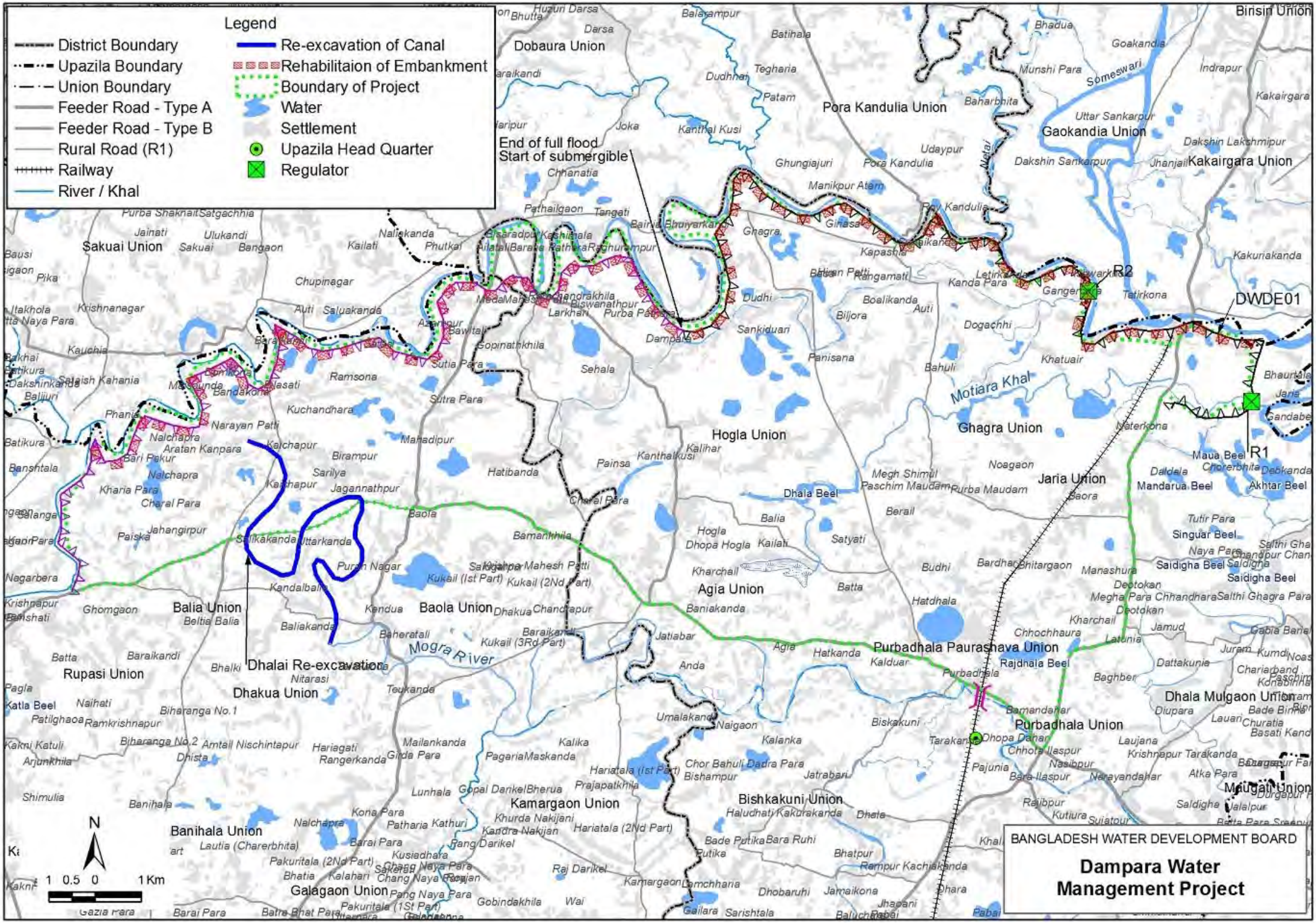
Data Collection Survey
On
Water Resources Management
in Haor Area of Bangladesh

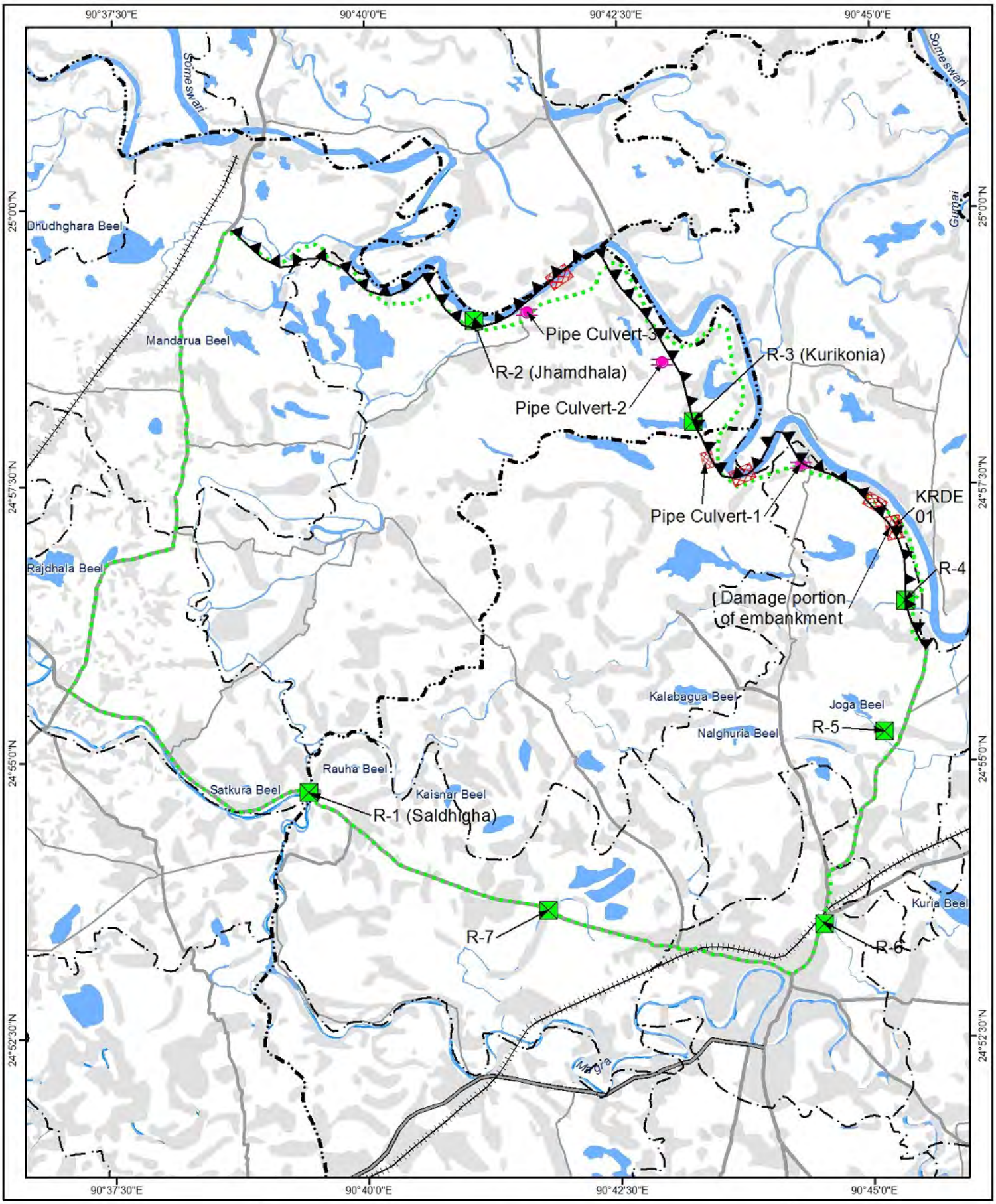
Boro Haor(Austagram) Scheme

Legend

- Division Boundary
- Upazila Boundary
- Union Boundary
- Union Road
- Rural Road
- Project Boundary
- Proposed Embankment
- Upazila H/Q
- Union H/Q
- Drainage Regulator
- Pipe Sluice
- River / Khal
- Water body
- Inundated area (DWL = 4.5 m+PWD)

Index Map


Legend
District Boundary
Upazila Boundary
Union Boundary
Feeder Road - Type A
Feeder Road - Type B
Rural Road (R1)
Railway
River / Khal
Re-excavation of Canal
Rehabilitaion of Embankment
Boundary of Project
Water
Settlement
Upazila Head Quarter
Regulator
End of full flood
Start of submergible
Dhalai Re-excavation
R2
DWDE01
R1
Motiara Khal
Mogra River
Dobaura Union
Pora Kandulia Union
Gaokandia Union
Kakairgara Union
Birisin Union
Sakuai Union
Hogla Union
Ghagra Union
Jaria Union
Agia Union
Balia Union
Baola Union
Dhakua Union
Rupasi Union
Purbadhala Paurashava Union
Purbadhala Union
Dhala Mulgaon Union
Mougati Union
Bishkakuni Union
Kamargaon Union
Galagaon Union
Banihala Union
N
1 0.5 0 1 Km
BANGLADESH WATER DEVELOPMENT BOARD
Dampara Water Management Project



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

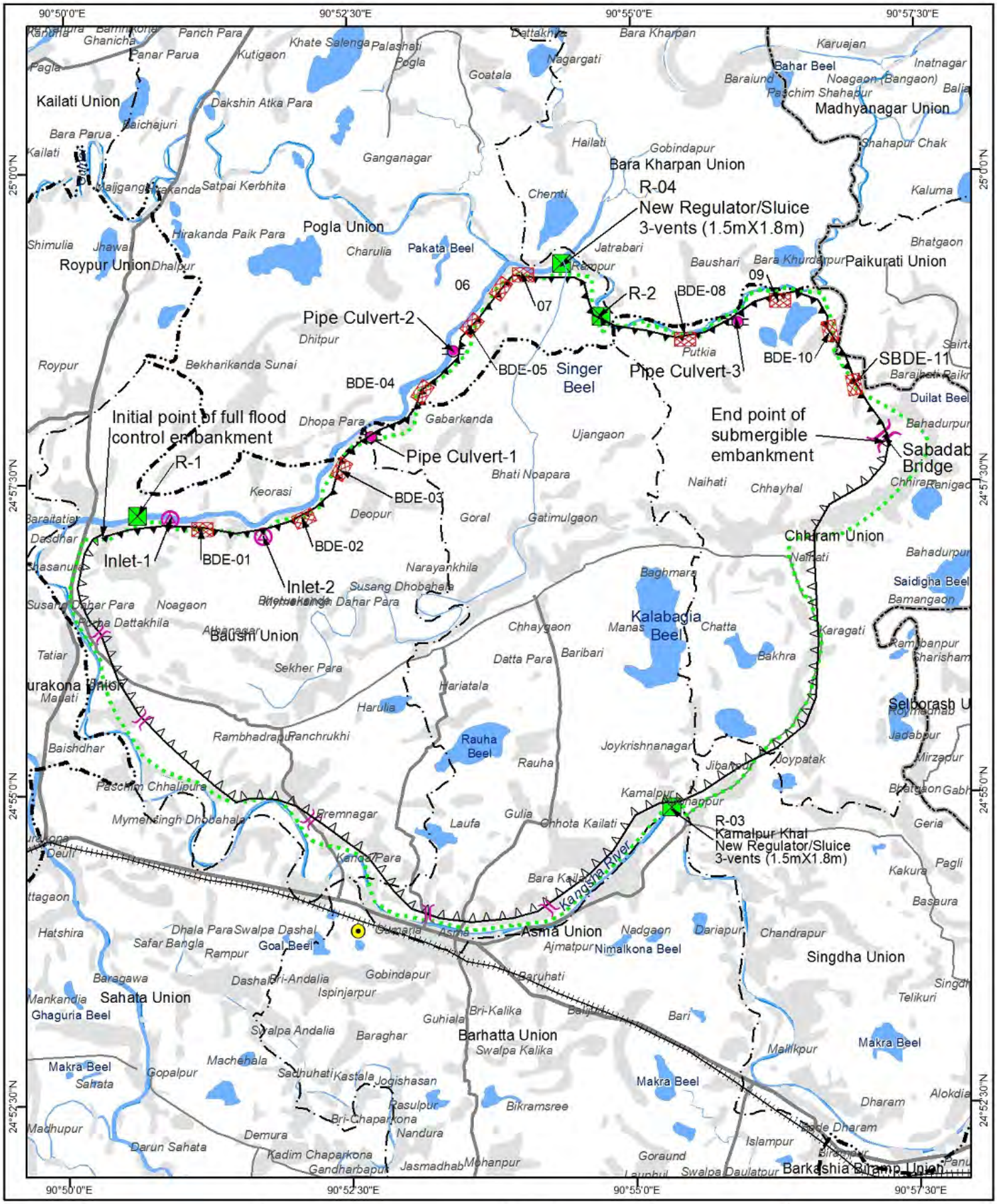
Kangsha River Scheme

Legend

- Upazila Boundary
- Union Boundary
- Boundary of Project
- Regional Road
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- Railway
- River / Khal
- Water
- Settlement
- Rehabilitation of Embankment
- Regulator
- Pipe Culvert

N

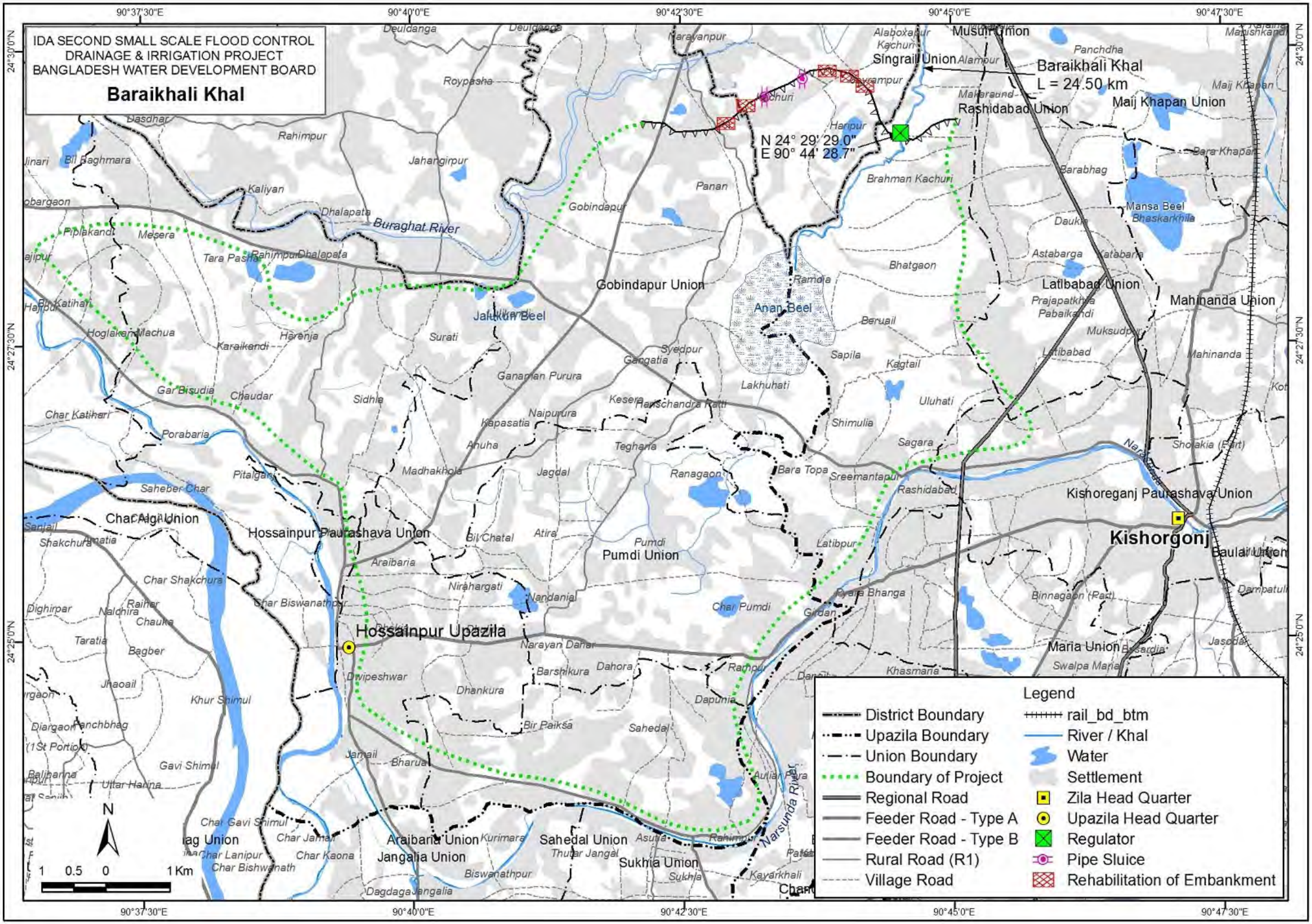
1 0.5 0 1 Km

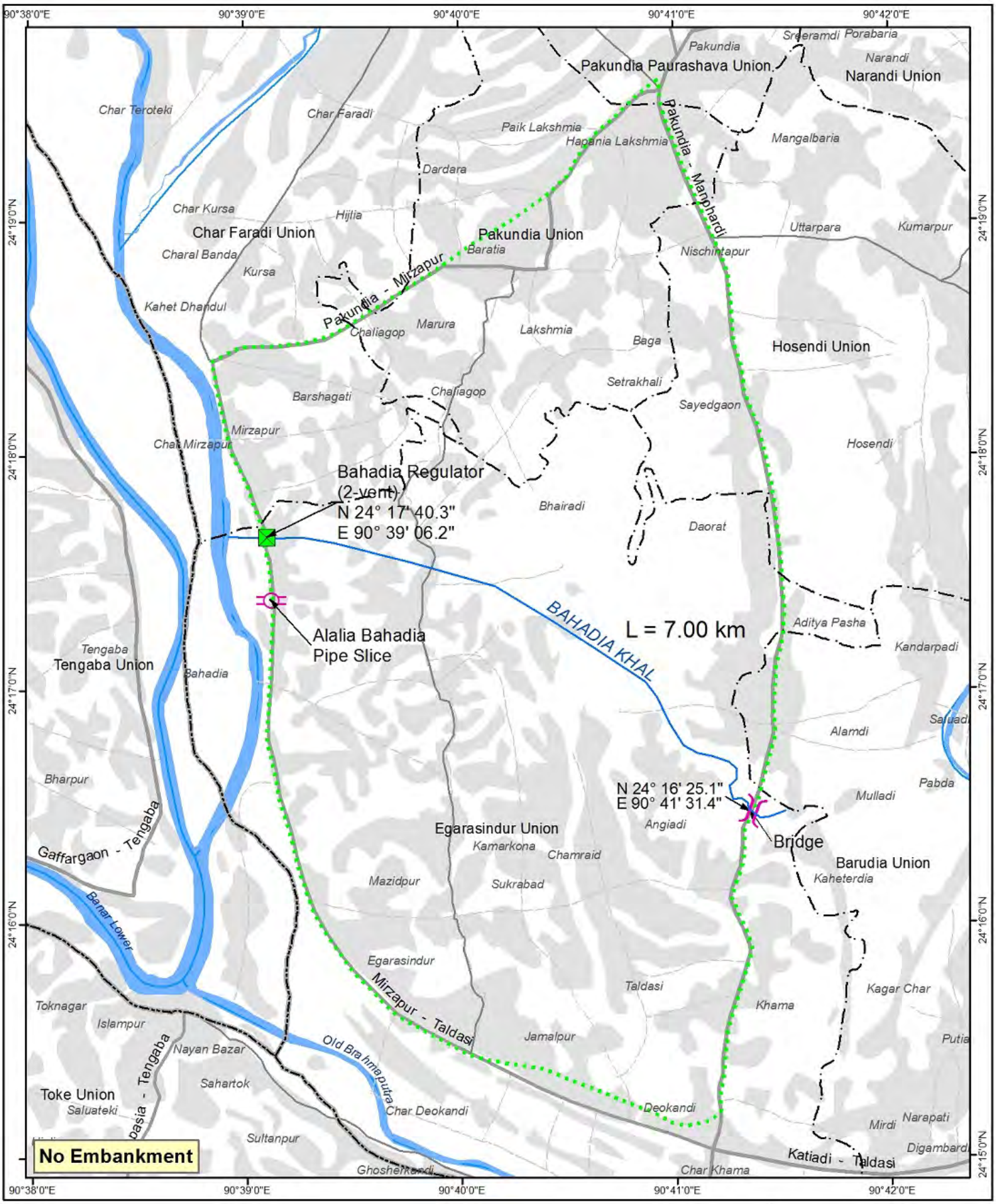


IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

Singer Beel Project


IDA SECOND SMALL SCALE FLOOD CONTROL
DRAINAGE & IRRIGATION PROJECT
BANGLADESH WATER DEVELOPMENT BOARD
Baraikhali Khal
Baraikhali Khal
L = 24.50 km
N 24° 29' 29.0"
E 90° 44' 28.7"
Singrail Union
Musuri Union
Rashidabad Union
Maij Khapan Union
Gobindapur Union
Latibabad Union
Mahinanda Union
Kishoreganj Paurashava Union
Kishorgonj
Hossainpur Paurashava Union
Hossainpur Upazila
Char Algi Union
Pumdi Union
Araibaria Union
Jangalia Union
Sahedal Union
Sukhia Union
Maria Union
Baulai Union
Anan Beel
Jalukuri Beel
Buraghat River
Narsunda River
Legend
District Boundary
Upazila Boundary
Union Boundary
Boundary of Project
Regional Road
Feeder Road - Type A
Feeder Road - Type B
Rural Road (R1)
Village Road
rail_bd_btm
River / Khal
Water
Settlement
Zila Head Quarter
Upazila Head Quarter
Regulator
Pipe Sluice
Rehabilitation of Embankment
N
1 0.5 0 1 Km
90°37'30"E
90°40'0"E
90°42'30"E
90°45'0"E
90°47'30"E
24°30'0"N
24°27'30"N
24°25'0"N



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

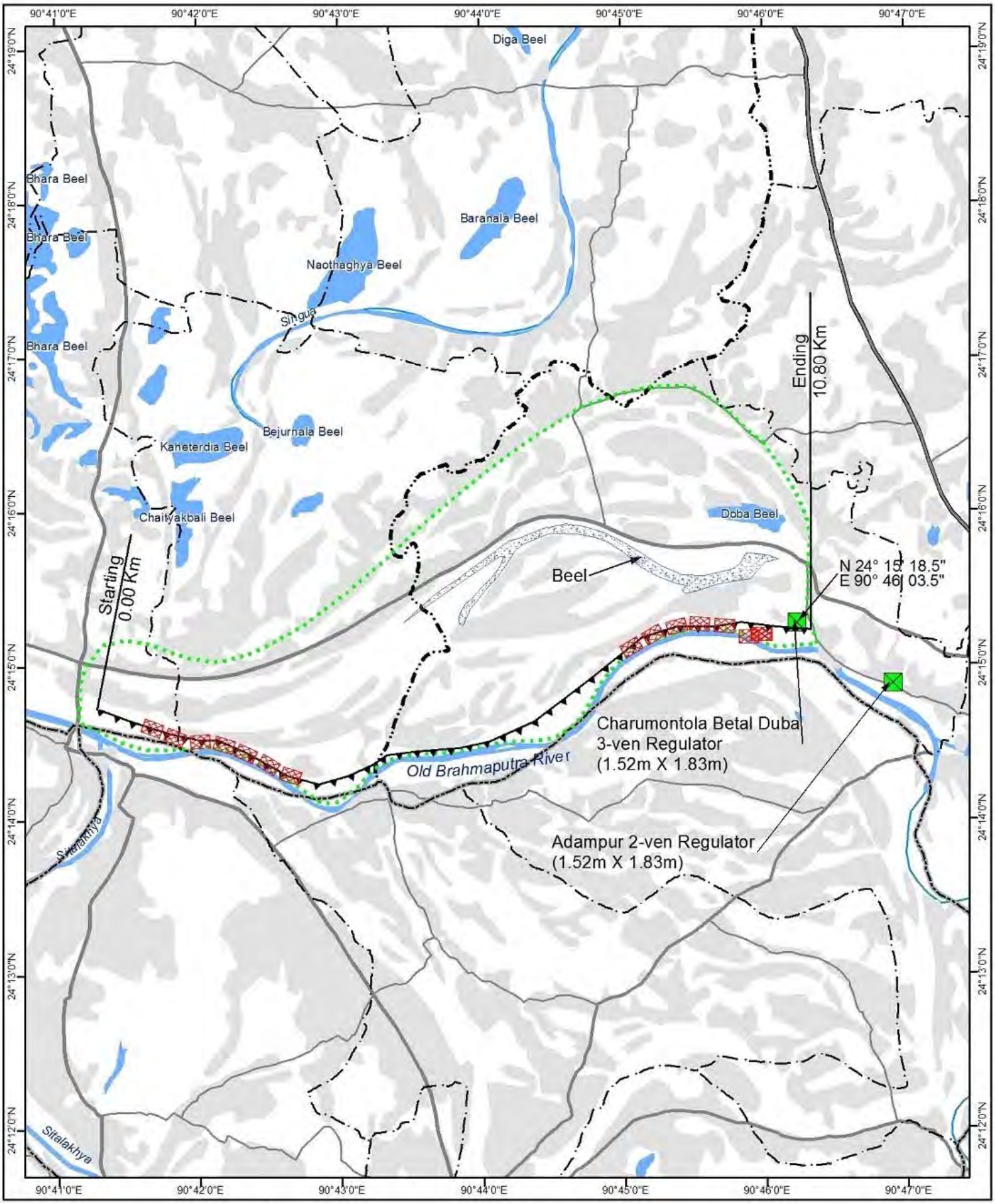
Aladia Bahadia Sub-Project

Legend

- District Boundary
- Union Boundary
- Boundary of Project
- Regional Road
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- Khal / canal
- River
- Settlement
- Regulator
- Bridge
- Pipe Sluice

N

0.5 0.25 0 0.5 Km



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

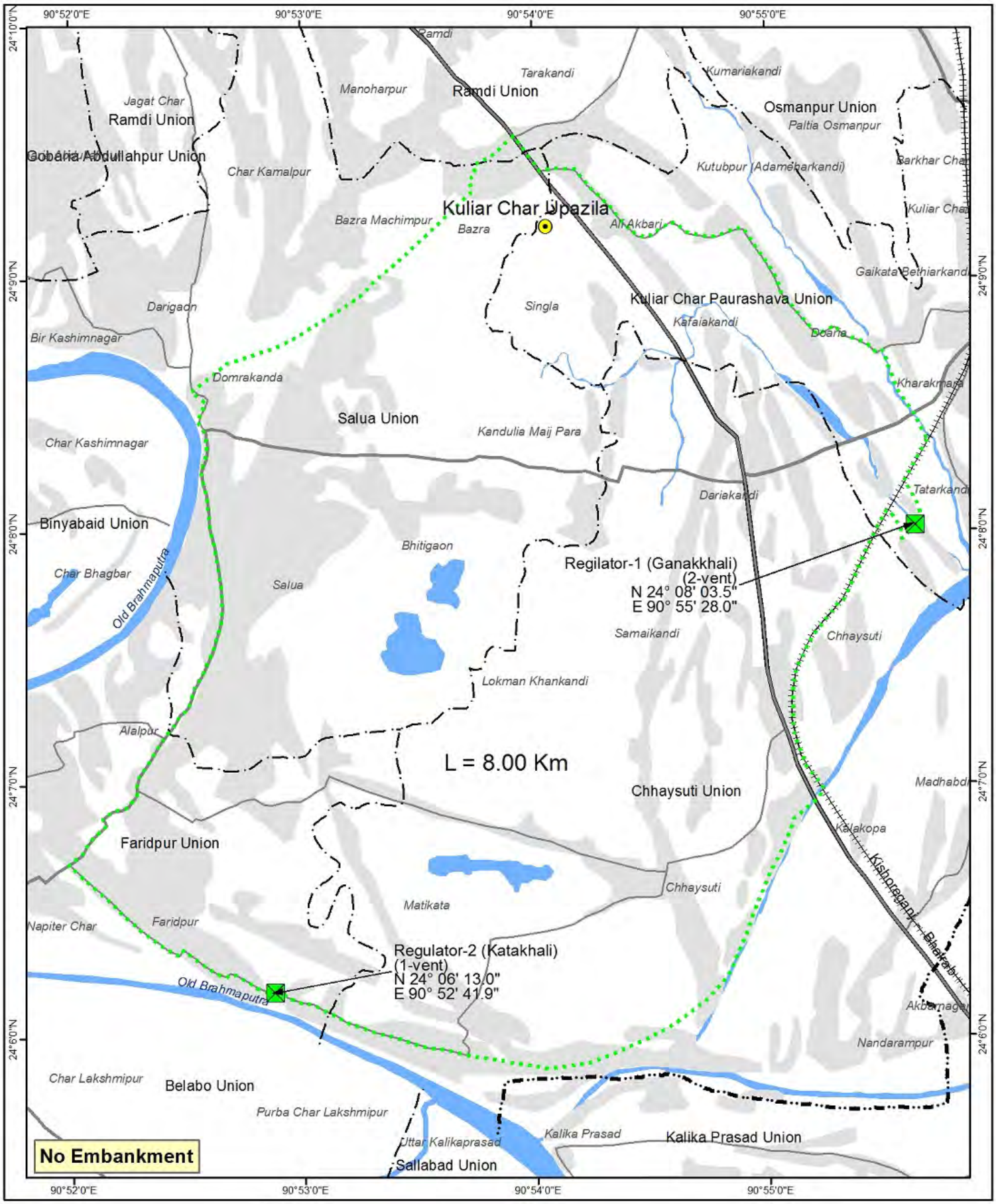
Modkhola Bhairagirchar Scheme

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Boundary of Project
- Regional Road
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- River / Khal
- Water
- Settlement
- Upazila Head Quarter
- Regulator
- Rehabilitaion of Embankment

N

0.50.25 0 0.5 1 Km



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

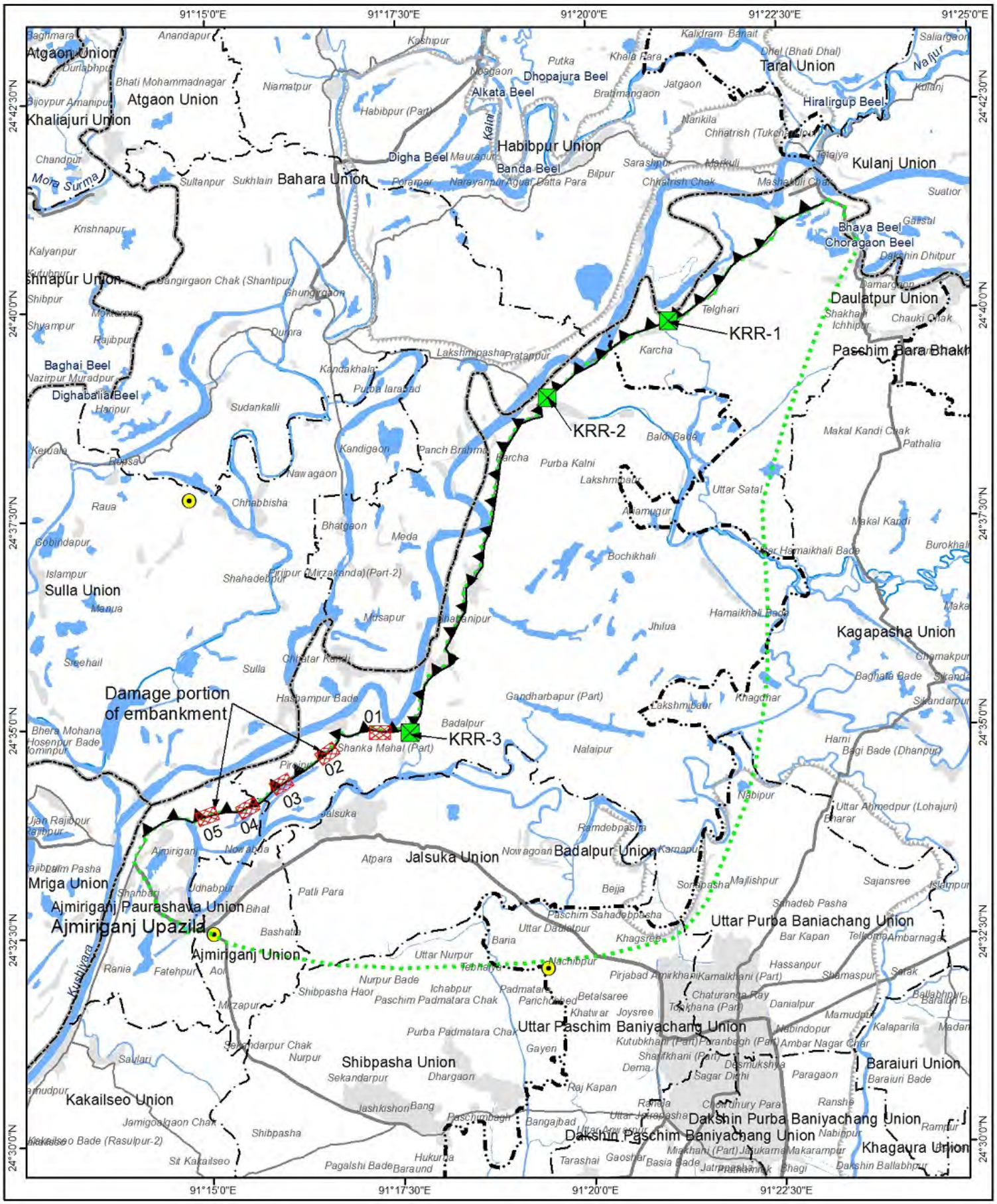
Ganakkhali Sub-Project

Legend

- Upazila Boundary
- Union Boundary
- Boundary of Project
- Regional Road
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- Railway
- River / Khal
- Water
- Settlement
- Upazila Head Quarter
- Regulator

N

500 250 0 500 m



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

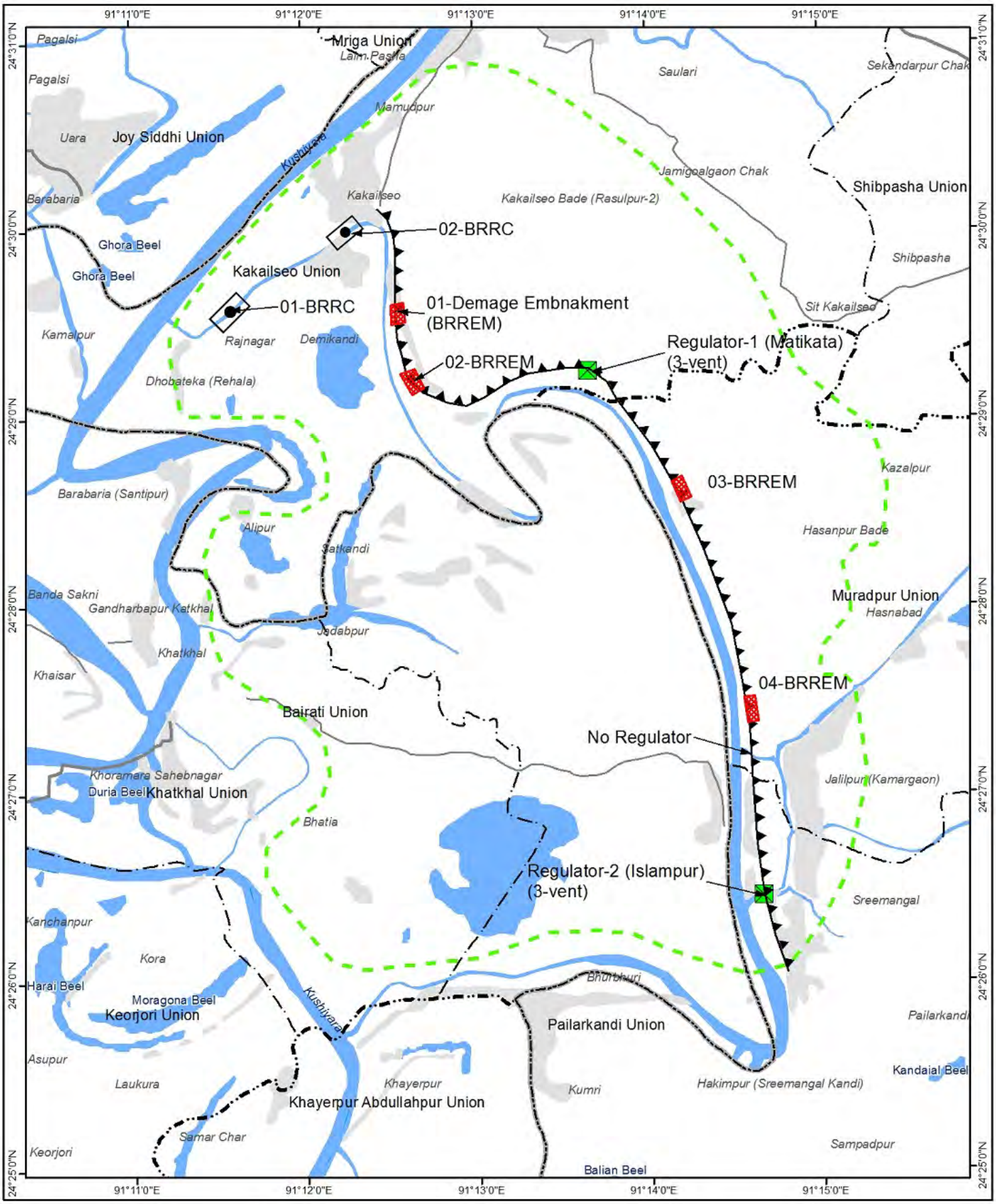
Kairdhala-Ratna Scheme

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- Railway
- Embankment
- River / Khal
- Water
- Settlement
- Upazila Head Quarter
- Regulator
- Rehabilitation of Embankment

N

1 0.5 0 1 2Km



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

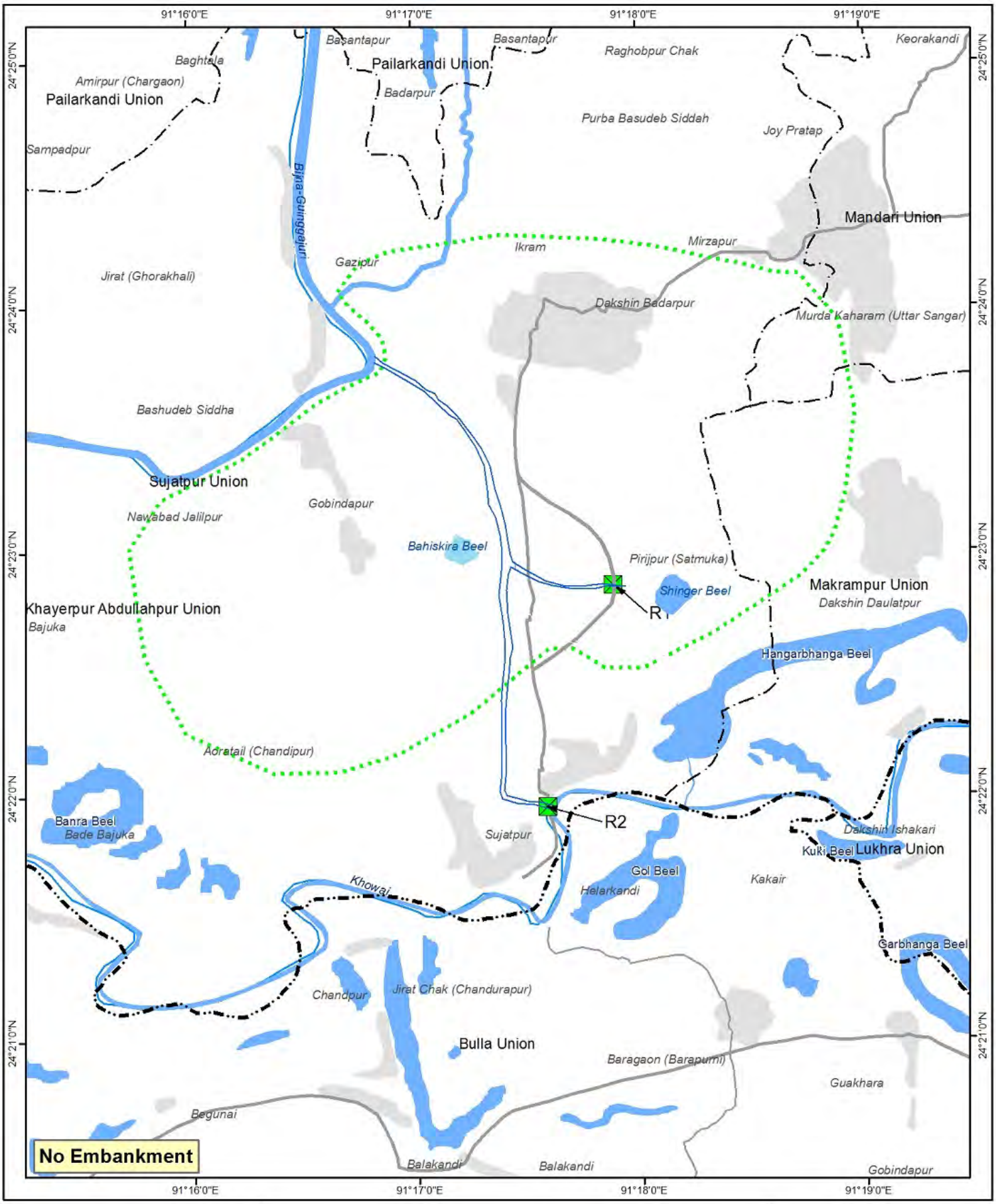
Bashira River Re-excavation

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type B
- Rural Road (R1)
- Embankment
- River / Khal
- Water
- Settlement
- <all other values>
- Regulator
- Rehabilitation of Embankment

N

500 250 0 500 m



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

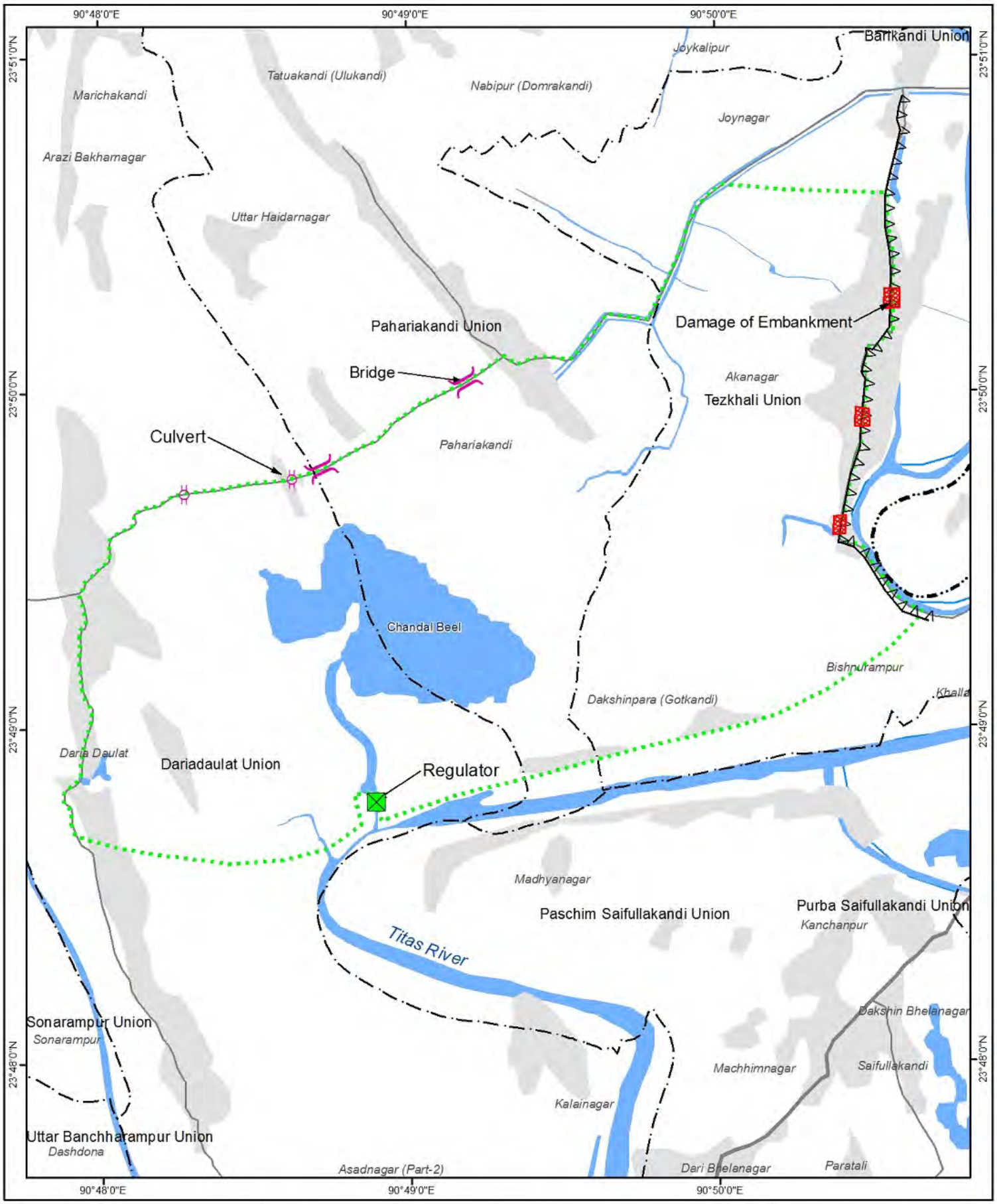
Aralia Khal Scheme

Legend

- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- River / Khal
- Water
- Settlement
- Regulator

N

500 250 0 500 m



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

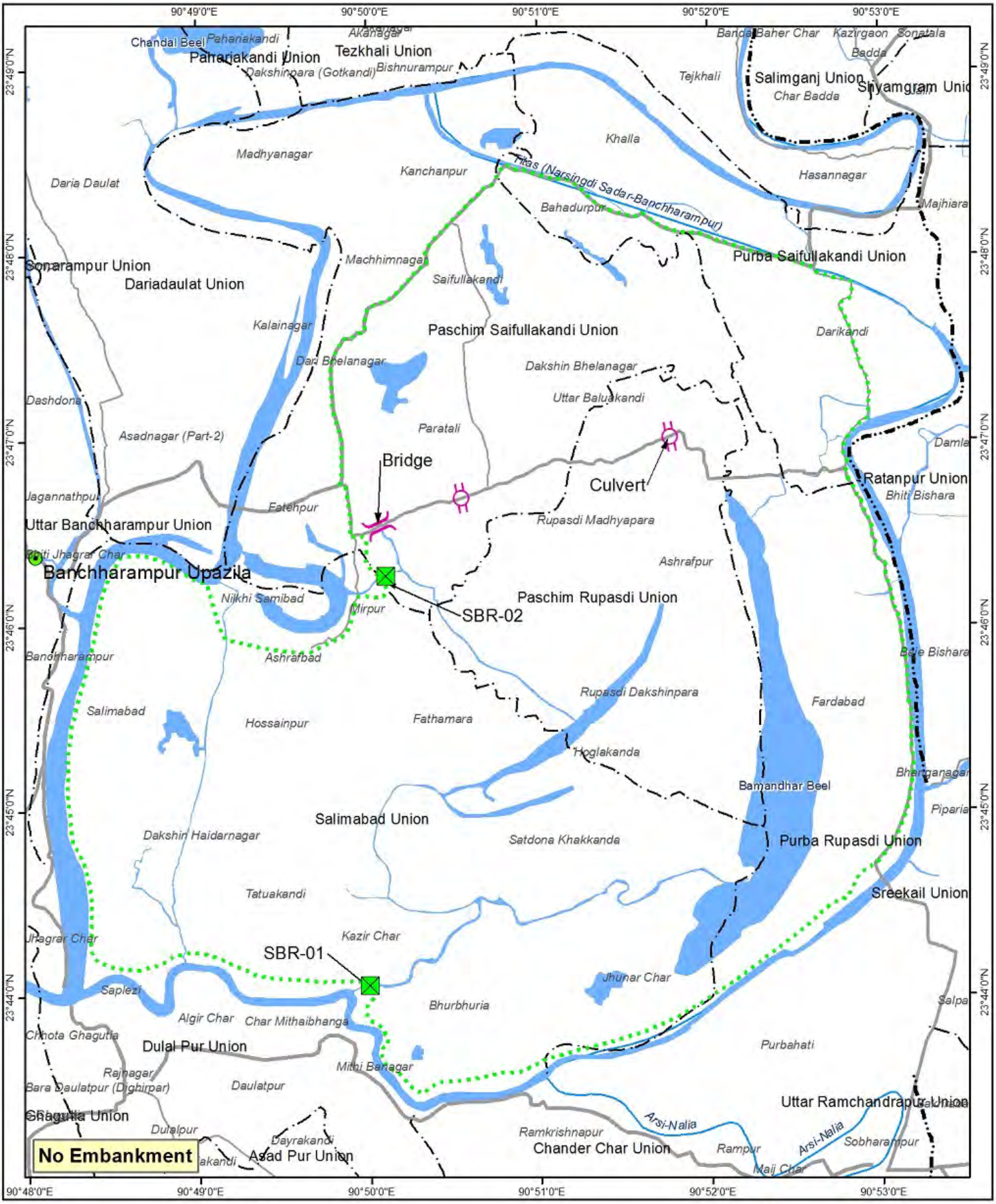
Chandal Beel Scheme

Legend

- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- River / Khal
- Water
- Settlement
- Rehabilitation of Embankment
- Regulator
- Bridge
- Culvert

N

400 200 0 400 m



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

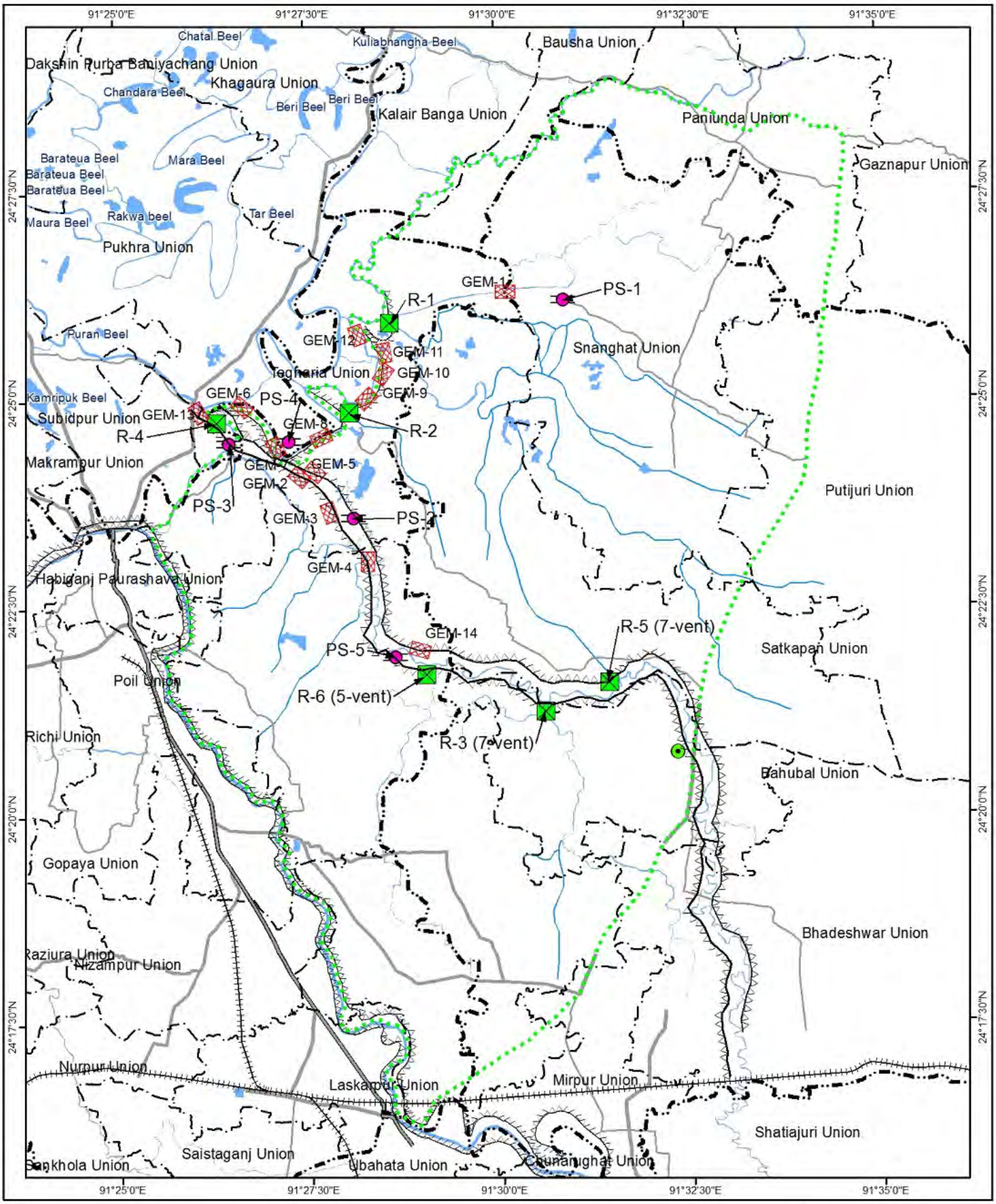
Satdona Beel Scheme

Legend

- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- River / Khal
- Water
- Settlement
- Upazila Head Quarter
- Regulator
- Bridge
- Culvert

N

500 250 0 500 m



IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT

BANGLADESH WATER DEVELOPMENT BOARD

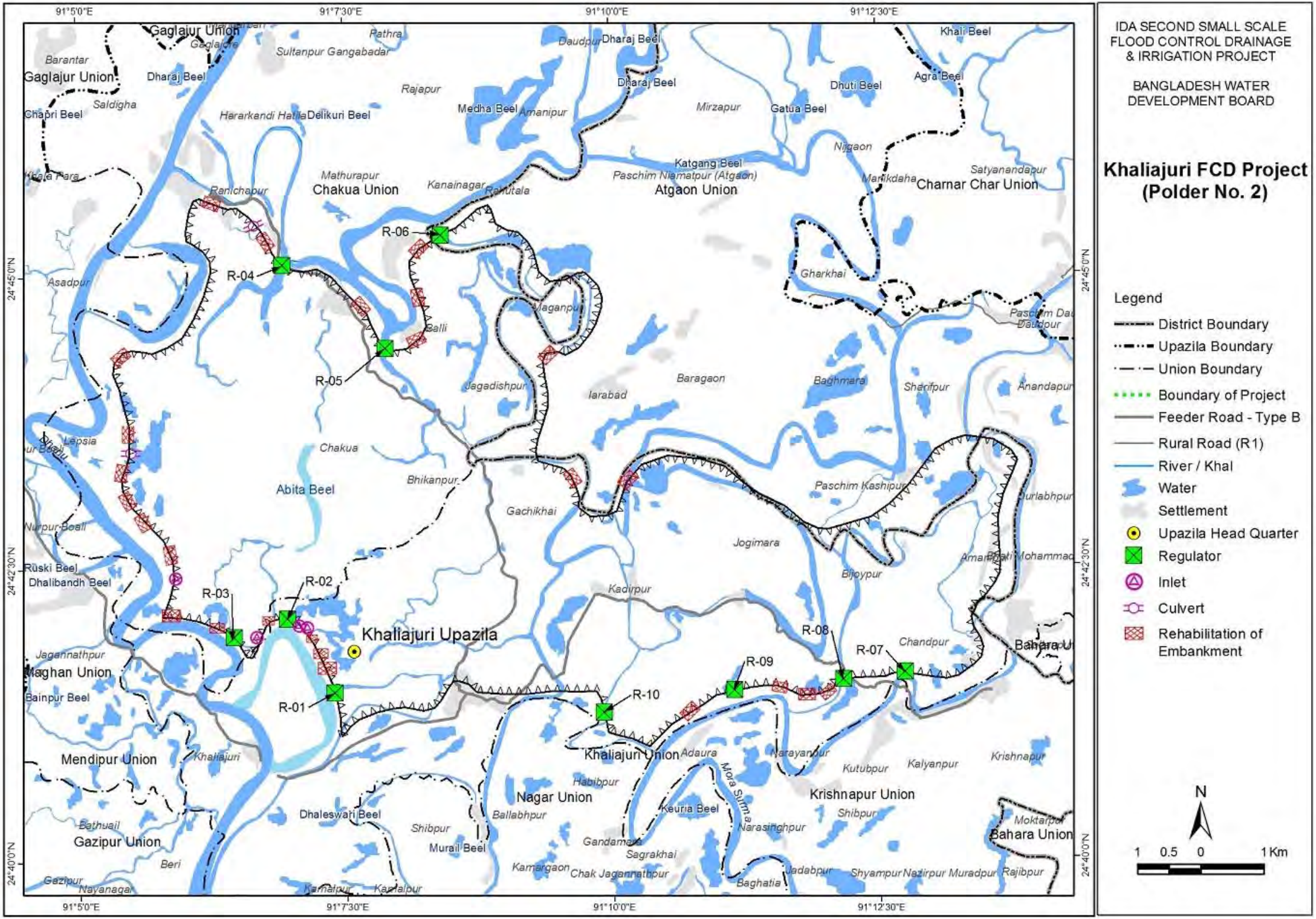
Gangajuri FCD Sub-Project

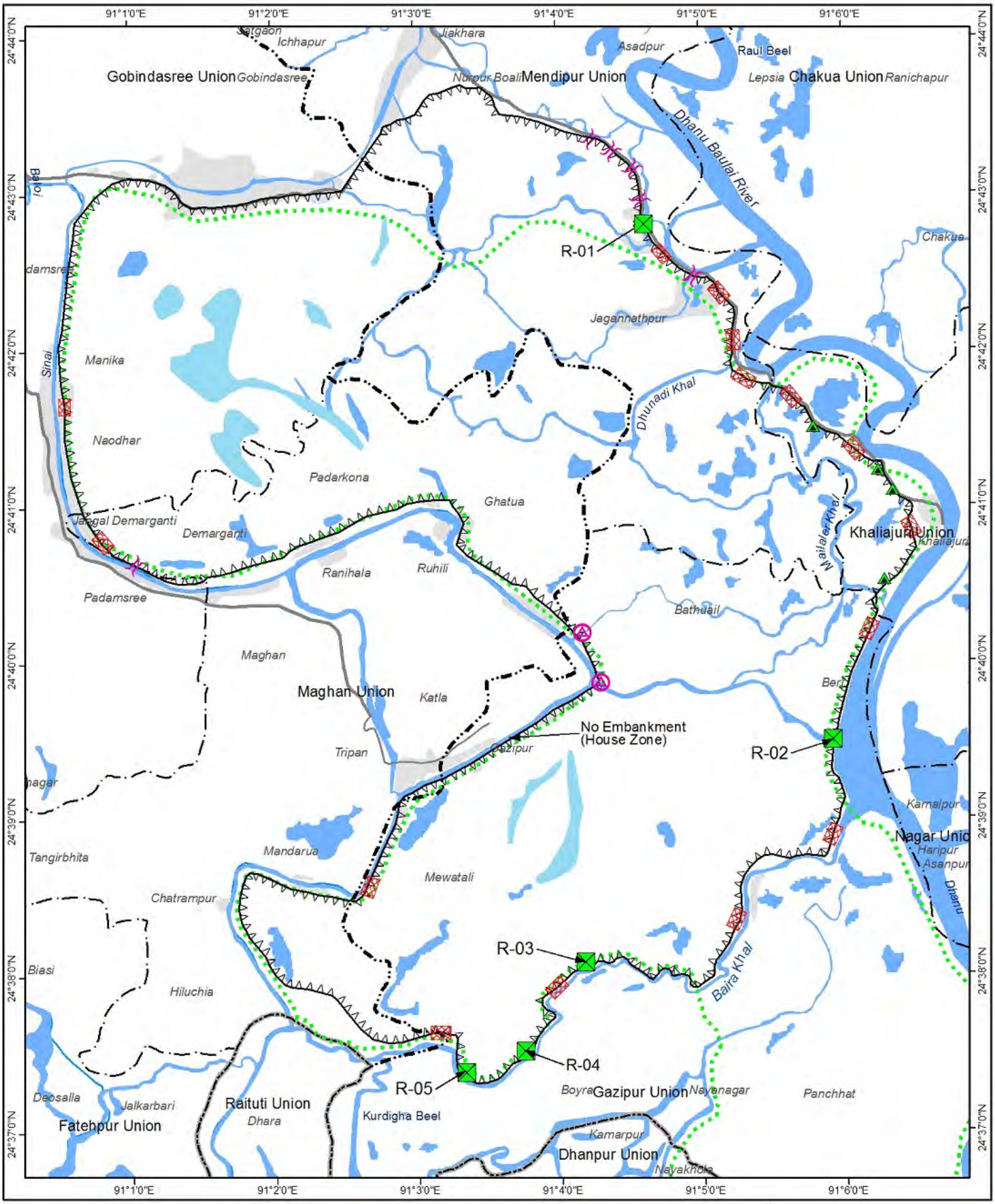
Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Boundary of Project
- Regional Road
- Feeder Road - Type A
- Feeder Road - Type B
- Rural Road (R1)
- Railway
- Embankment
- Khal / Canal
- Rehabilitation of Embankment
- Water
- Upazila Head Quarter
- Regulator
- Pipe Sluice

N

1 0.5 0 1 Km


IDA SECOND SMALL SCALE FLOOD CONTROL DRAINAGE & IRRIGATION PROJECT
BANGLADESH WATER DEVELOPMENT BOARD
Khaliajuri FCD Project (Polder No. 2)
Legend
District Boundary
Upazila Boundary
Union Boundary
Boundary of Project
Feeder Road - Type B
Rural Road (R1)
River / Khal
Water
Settlement
Upazila Head Quarter
Regulator
Inlet
Culvert
Rehabilitation of Embankment
N
1 0.5 0 1 Km
R-01
R-02
R-03
R-04
R-05
R-06
R-07
R-08
R-09
R-10
Khaliajuri Upazila
Gaglajur Union
Chakua Union
Atgaon Union
Charnar Char Union
Maghan Union
Mendipur Union
Khaliajuri Union
Nagar Union
Krishnapur Union
Gazipur Union
Bahara Union
Abita Beel
Dhaleswari Beel
Murail Beel
Keuria Beel
Mora Sutma
91°5'0"E
91°7'30"E
91°10'0"E
91°12'30"E
24°45'0"N
24°42'30"N
24°40'0"N



IDA SECOND SMALL SCALE
FLOOD CONTROL DRAINAGE
& IRRIGATION PROJECT

BANGLADESH WATER
DEVELOPMENT BOARD

Khaliajuri FCD Project
(Polder-4)

Legend

- District Boundary
- Upazila Boundary
- Union Boundary
- Boundary of Project
- Feeder Road - Type B
- Rural Road (R1)
- River / Khal
- Water
- Settlement
- Upazila Head Quarter
- Regulator
- Inlet
- Causeway
- Culvert
- Rehabilitation of Embankment

N

1 0.5 0 1 Km

附録 7-3

被害率の算定

被害率については、「バングラデシュ国メグナ川上流域水資源管理事業準備調査」にて、Kalni-Kushiyara　River Management Project における算定方法を準拠しており、本調査においても、被害率の算定方法は同じものを採用している。

「バングラデシュ国メグナ川上流域水資源管理事業準備調査」の”Appendix 13.14 Calculation of Damage Rate of Rice”を示す。

Damage rate was calculated from the estimated rice production influenced by probable floods which was calculated in the feasibility study report of the Kalni-Kushiyara River Management Project (KKRPMP, 1998). The same flooded rice production was applied in this survey, since the study area of the KKRMP had been also extended in the haor area. The F/S of KKRMP determined the yield of rice in the damage free land (inundation depth > 0.3 m) and flood damaged land (inundation depth > 0.3 m), referring to past surveys such as NERP Farm Household Survey (1996), NERP Land Use Survey (1995 – 1996), K-K Farm Monitoring Survey (1995 – 1996), Kalni-Kushiyara Pre-F/S (1994), National Minor Development Project (1994) and information of Bangladesh Bureau of Statistics published in 1991 and 1993. The rice production was calculated from these yields of rice and inundation areas for the floods of 2, 5 and 10-year probabilities as shown in the table below.

Damage Rate for 2-year flood

Crop		Flood Year (2-year)				No Flood Year		
		Cultivated area (ha)	Yield (ton/ha)	Production (ton)		Cultivated area (ha)	Yield (ton/ha)	Production (ton)
HYV Boro	Damage Free	169,239	4.69	793,731		193,752	4.69	908,697
	Damaged	24,513	2.9	71,088				
Local Boro	Damage Free	25,710	3.11	79,958		43,010	3.11	133,761
	Damaged	17,300	1.6	27,680				
B. Aus	Damage Free	7,384	1.1	8,122		7,446	1.10	8,191
	Damaged	62	1.04	64				
DW Aman	Damage Free	21,245	1.93	41,003		25,297	1.93	48,823
	Damaged	4,052	1.5	6,078				
Loc T. Aman	Damage Free	36	2.15	77		36	2.15	77
	Damaged	0	1.75	0				
HYV T. Aman	Damage Free	7,430	3.2	23,776		7,518	3.20	24,058
	Damaged	88	2.24	197				
Total Production				**1,051,774**				**1,123,607**

Loss due to Flood 1,123,607 - 1,051,774 = 71,833 ton
Damage Rate 71,833 / 1,051,774.0 = **6.4 %**

Damage Rate for 5-year flood

Crop		Flood Year (5-year)				No Flood Year		
		Cultivated area (ha)	Yield (ton/ha)	Production (ton)		Cultivated area (ha)	Yield (ton/ha)	Production (ton)
HYV Boro	Damage Free	61,411	4.69	288,018		193,752	4.69	908,697
	Damaged	132,341	2.9	387,759				
Local Boro	Damage Free	9,329	3.11	29,013		43,010	3.11	133,761
	Damaged	33,681	1.6	53,890				
B. Aus	Damage Free	2,679	1.1	2,947		7,446	1.10	8,191
	Damaged	4,767	1.04	4,958				
DW Aman	Damage Free	7,709	1.93	14,878		25,297	1.93	48,823
	Damaged	17,588	1.5	26,382				
Loc T. Aman	Damage Free	13	2.15	28		36	2.15	77
	Damaged	23	1.75	40				
HYV T. Aman	Damage Free	2,696	3.2	8,627		7,518	3.20	24,058
	Damaged	4,822	2.24	10,801				
Total Production				**827,341**				**1,123,607**

Loss due to Flood 1,123,607 - 827,341 = 296,266 ton
Damage Rate 296,266 / 827,341.0 = **26.4 %**

Damage Rate for 10-year flood

Crop		Flood Year (10-year)				No Flood Year		
		Cultivated area (ha)	Yield (ton/ha)	Production (ton)		Cultivated area (ha)	Yield (ton/ha)	Production (ton)
HYV Boro	Damage Free	9,217	4.69	43,228		193,752	4.69	908,697
	Damaged	184,535	2.9	540,688				
Local Boro	Damage Free	1,400	3.11	4,354		43,010	3.11	133,761
	Damaged	41,610	1.6	66,576				
B. Aus	Damage Free	402	1.1	442		7,446	1.10	8,191
	Damaged	7,044	1.04	7,326				
DW Aman	Damage Free	1,157	1.93	2,233		25,297	1.93	48,823
	Damaged	24,140	1.5	36,210				
Loc T. Aman	Damage Free	2	2.15	4		36	2.15	77
	Damaged	34	1.75	60				
HYV T. Aman	Damage Free	405	3.2	1,296		7,518	3.20	24,058
	Damaged	7,113	2.24	15,933				
Total Production				**718,350**				**1,123,607**

Loss due to Flood 1,123,607 - 718,350 = 405,257 ton
Damage Rate 405,257 / 718,350.0 = **36.1 %**

附録 9-1

Assessment of Present Situation and Appropriateness regarding Existing Non-structural Flood Measures

Table of Contents

1.0 Introduction

The haor area in the north-eastern region of Bangladesh is subject to very peculiar hydrological and hydraulic conditions and suffers from extensive annual flooding. This makes the livelihood in the area extremely vulnerable and limits the potential for agriculture production and general economic growth. For 6 to 7 months of the year, the cropped land is completely inundated. Strong wave action adds to the vulnerability as it can potentially wash away the land and poses a major threat to many villages in the haor area. Although the lifestyle of the haor people is well adapted to flood phenomena, damage due to drainage related inundation, pre-monsoon flash floods, severe monsoon floods, river bank erosion, failure of river structures, etc. still occurs. Due to monsoon inundation, in most haor areas, only simple harvesting of rice is possible. Boro rice and other winter crops cultivation is the major agricultural activity in this area.

Overwhelming majority of the population is dependent upon rice for food and other basic necessities of life. The harvest time varies with the rice/ crop types but is encompassed within late April to mid May.

Sometimes flash flood occurs in the pre-monsoon period, during April and May, before the harvesting. As a result, once in 3 or 4 years, the crops have been damaged due to pre-monsoon flash floods.

Among many natural hazards, flash floods or pre-monsoon floods are particularly challenging for the communities of the haor area. Flash floods are severe flood events that occur with little or no warning. They can be triggered by intense local or upstream rainfalls, failure of dams, and outbursts of glacial lakes from upstream hilly areas. Flash floods tend to carry with them much higher amounts of sands and debris compared to monsoon floods and, as a result, cause more damage to roads, culverts, embankments, bridges and other water management infrastructure, silt up the canals and rivers, and cause sand carpeting over the cultivable land. Though the main tools of the damage reduction revolve around structural measures like embankment, river dredging, etc., non-structural flood measures are also considered as useful means of damage reduction. This study paper tends to assess the present non-structural measures practiced in the haor area and to evaluate their appropriateness.

2.0 Relevance of Flood Damage Pattern with Non-structural Measures

2.1 Relevance

Analysis of area specific flood damage pattern is relevant as not all types of non-structural measures are effective for all types of flood damage. For example, where the flash flood can cause a life threatening situation, early warning and evacuation is most important. On the other hand, where major threat is crop damage, crop diversification and alternate livelihood can be also effective measures.

2.2 Flood Damage Type in the haor Area

The major damage experienced in the Haor area include:

- Crop damage,
- Sediment deposition in the rivers and canals, thus reducing their conveyance capacities,
- Sediment deposition in haors (sand carpeting), which may adversely affect the fertility,

- Sediment deposition in beels (the lowest part of haor), which may adversely affect fisheries,
- Water logging and drainage congestion,
- Damage of embankment,
- Damage of social infrastructure like schools, roads, markets, etc.,
- Damage of houses, and
- River bank erosion.

Threat to human life is not common in the haor area, because there is no habitat in the low lying areas and most habitats are raised above normal monsoon flood levels. However, in some extreme flood events, there are some incidences of life loss. On the other hand, among the various types of flood damage experienced in the haor area, crop damage is the main issue of concern. In some years, the extent of crop damage may exceed more than 75%. Thus, more focus is given on asset loss reduction by government and non-government organizations.

2.3 Impact of Flood Damage and Importance of Non-structural Measures

Since the pre-monsoon cultivation is the only major economic activity for the vast majority of the people in the haor area, any damage can have serious consequences. Damage of standing crops can push people in hunger, indebtedness, distress sale of property and seasonal migration.

During the period from 1993 to 2010, about 2.44 million tons of rice, 64,000 tons of jute, 40,000 tons of other crops could not be harvested because of flood damage (Haor MP, CEGIS, 2012, Annex 2 – Agricultural Sector Report).

Though within the haor area, there are perennial and seasonal water bodies which are the abodes of fishes, and though monsoon inundation provides a favorable ground for fish spawning and growth, the common people in the area have no access to the huge aquatic resources. Rather it is controlled by a small powerful group of people through fishing right lease obtained from the local government. Therefore, pre-monsoon crop failure has serious implication on livelihood of poor and extreme poor people.

To ensure flood damage reduction, thus, non-structural measures should also be considered in addition to and in parallel with structural measures.

3.0 Typical Non-structural Flood Measures

Non-structural flood measures refer to any measure that does not involve physical construction (like retention basins, embankment, dredging river channel, diversions, etc.) but instead uses knowledge, practices, and/or agreements to reduce the potential impacts of floods. Non-structural approaches can be cost-effective alternatives to traditional engineering and ecological solutions. Typical approaches include policies and laws, raising public awareness, and training and education. Such measures offer a variety of possibilities including the installation of early warning systems, soil and land use management, insurance, awareness building and public information actions, emergency systems, and post-catastrophe recovery, all of which can help mitigate flood related damage. Nonetheless, not all

non-structural measures are effective in all situations and it is always better to adopt multiple non-structural measures along with some structural measures for better flood risk management. Non-structural measures are generally less expensive than structural measures, easy to roll out and they are more sustainable because they include active involvement of the community.

The need for non-structural measures becomes very important for the haor area for several reasons, which are:

- high cost of structural measures,
- lack of capacity to build and operate structural measures,
- low involvement of local community into structural measures,
- lack of feeling of ownership toward structural measures, and
- adverse environmental impacts of structural measures.

The various types of typical non-structural measures can be grouped as flows:

Table 3.1 Groups of Non-structural Flood Measures

Risk Acceptance	Tolerance strategy	Toleration (flood proofing)
		Emergency response system
		Insurance
Risk Reduction	Prevention strategy	Watershed management
		Delimitation of flood areas and securing flood plains (development control)
		Implementation of flood area regulations
		Application of financial measures (an economic contribution or the waiver of a financial burden such as: taxes, loan interest, or the liquidation of a loan)
	Mitigation strategy	Reduction of discharge through natural retention
		Forecasting and early warning
		Emergency action based on monitoring, warning, and response system (MWRS)
		Public information and education

Source: Modified by JICA Study Team, adapted from "Resource Manual on Flash Flood Risk Management, Icimod, 2008, originally based on "Colombo, A.G.; Hevas, J.; Arllam, A.L.V. (2002), Guidelines on Flash Floods Prevention and Mitigations. Ipsra (Italy): NEIDES

Different types of non-structural measures are practiced in the haor area. In the following sections, each measure is analyzed briefly covering present situation, on-going and planned activities, and potential for further interventions.

4.0 Regulation of Development in River Areas

Through field visit, physical verification and consultation with different stakeholders and local communalities, it is known that development in river bank sides of the haors is not regulated in the study area. Part of the river side areas are relatively high land compared to the low lying haors, and thus these areas are less prone to flooding. People use those lands for housing, shops, duck farming, etc.

There are two main reasons for not having any development control in the river side establishments. First, the people usually construct these establishments at relatively flood free areas, so these are less susceptible to flood loss; and second, the local administration has no legal framework and resources to ensure any development control.

It may be proposed that local authorities can be given legal authorities for development

control in consultation with all stakeholders concerned including BWDB. However, considering the effectiveness and necessity, this has a low priority.

The local residents, farmers, fishermen and development workers claimed that some groups of people sometimes had made cross dams over the rivers for fish culture/capture, which are barriers for smooth flow of water and navigation. The JICA Study Team found that local BWDB has no such record regarding activities in either the side of the river bank or within the river itself.

It is also important to mention that, unplanned rural road development, often supported by the Food for Work Programme, has resulted in blockage to flood waters and fish movements on floodplains. To reduce the adverse impacts of rural road construction, there is a need for institutional changes in the form of inter-sectoral planning process and a practical change to ensure greater provision of fish-friendly culverts through roads wherever they cross existing canals and also traverse extensive areas of open floodplains.

The process of installing culverts requires the consideration of several important issues, including fish passage requirements and the hydrological and physical characteristics of the sites. The various fish species present in the haor area have different swimming and climbing abilities. It is therefore possible to “custom build” in-stream structures to cater for the fish species present in a particular catchment, although it is important to ensure that there are suitable habitats for the species upstream of the culverts.

Watershed management can also reduce flood hazards by controlling the quantity and velocity of flash floods. Proper uses of land, forest, and water resources are primary acts of watershed management. However, since the major watershed of the haor area lies outside the boundary of the country, integrated watershed management is difficult to achieve.

5.0 Flood Forecasting and Warning System

Flood forecasting and warning, as one of significant non-structural measures, can reduce the flood damage by enabling and persuading people and organizations to be prepared for the flood and take actions to increase safety and reduce damage. Its goal is to alert the agencies/departments to enhance their preparedness and to motivate vulnerable communities to undertake protective measures.

5.1 Model Based Forecast

(1) Flood Forecasting and Warning Center (FFWC)

As stated in the BWDB Act-2000, Flood Forecasting in Bangladesh is the mandate and responsibility of Bangladesh Water Development Board (BWDB) and Flood Forecasting and Warning Center (FFWC) of the BWDB has been carrying out this activity. FFWC was established in 1972 and is functioning as directed by the Standing Orders for Disaster (SOD) of the Government of Bangladesh. FFWC is acting as the focal point in co-ordination with other ministries and agencies like BMD, DMB, DAE, etc. during the monsoon season for flood disaster mitigation and management. The center is fully operative working in the flood season, from April to October every year.

The forecasting analysis system of FFWC has been developed and improved through the technical and financial assistance of DANIDA (Danish International Development Agency).

However, since the hydro-meteorological records utilized for the forecasting analysis are obtained by manual operation, transmitted through wireless voice communication, and manual input to the model, problems related to reliability, accuracy and immediacy of the input data have occurred. Further, one of the main struggle and demand is to increase the warning lead time.

An ADB project is about to start as a pilot study on satellite based weather forecast incorporating flood forecast. This will be implemented by JAXA.

Data Collection

According to interview with the executive engineer (FFWC) by the JICA Study Team, the FFWC model incorporates 86 representative water level stations and 56 rainfall stations distributed throughout the country. Out of those, 20 water level stations and 15 rainfall stations are in the NE region. (The total numbers of BWDB water level and rainfall stations are 343 and 269, respectively). The real time hydrological data is collected by the single sideband (SSB) wireless, fixed & mobile telephone system through the BWDB hydrological network. WLs for non-tidal stations are collected daily five times at 3 hour intervals during the day time from 6:00 AM to 6:00 PM, and for tidal stations collected hourly. Rainfall is collected daily at 9 AM. Some limited WLs, rainfalls and forecasts of upper catchments from Indian stations are also collected through Internet, e-mail and BMD.

In 2012, 3 automated WL stations were established; one of them is in the NE region, at Bhairab. However, these are not incorporated in the FFWC model yet. It may be mentioned here that, JICA established 14 automated telemetric stations in 1996. However, now all of them are broken.

For the rainfall estimation, satellite images from National Oceanic and Atmospheric Administration (NOAA, USA) and India Meteorological Department (IMD) are used. For the flow data from the Indian territory, they are using the Weather Research and Forecasting (WRF) weather model developed by NOAA, which can convert the rainfall data into flow data.

The JICA funded Maulvibazar Doppler radar data, never used by FFWC as the station is not calibrated yet. A separate JICA project is now doing the calibration and it is expected to be completed in 2013. That project will also establish a link with FFWC for smooth incorporation of radar data into the model. The radar has a 200 km coverage in diameter. This radar gives information on rainfall intensity, cloud height, wind, etc. A cloud height is very important to estimate rainfall amount.

Currently, multi donor funded CDMP II (Comprehensive Disaster Management Project, 2nd Phase) is working with FFWC to improve the lead time, to install new gauging stations, to improve the warning dissemination and to set up new local FF model.

Info Box --- CDMP II

CDMP is an umbrella program executed by United Nations Development Program (UNDP) together with Department of Disaster Management and Relief (DDMR). It is funded jointly by UKAid, EU, Norad, SIDA, AusAID and UNDP. CDMP I was carried out from 2004 to 2009, while CDMP II started in 2010 and is expected to continue till 2014. CDMP II covers 1,780 unions in 200 Upazillas in 40 districts.

Data Processing

FFWC uses the simulation model MIKE11 developed by Danish Hydraulic Institute (DHI) and a special version of MIKE11 FF (flood forecasting) conceptual hydrodynamic model is in operation for forecast formulation.

FFWC developed 'General Model (GM)' in cooperation with DHI and IWM by adopting MIKE11 to real time operation in which the boundary is extended near the Indian borders on all main rivers. This covers the entire flood affected area of Bangladesh, except the coastal southern part (Annual Flood Report, FFWC, 2012). However, the model cannot run in a dry season if the water level is below a certain level, hence, it is not possible to operate this model during the flash flood period.

Output

The principal outputs of FFWC are the daily statistical bulletin of floods, river situation, a descriptive flood bulletin, forecast for 24, 48 & 72 hours at 52 monitoring points, production of Upazilla/Thana Status Map, Satellite Imageries, special flood report along with different graphical and statistical presentation during the monsoon season. Under the CDMP II, there is a plan to increase the lead time from current 3 days to 5 days.

(2) Local Flash Flood Forecasting for NE region

Until recently, FFWC could not forecast for the pre monsoon period because the GM cannot operate in a dry season. In CDMP II, a local FF model for the Northeast (NE) region is under preparation through IWM. The new NE FF model is now operated as a trial basis and experimental flash flood warning has started since 2013 for 8 stations, namely, 3 on Kushiyara, 3 on Surma, 1 on Kalni and 1 on Kangsha. The lead time is 48 hours.

In addition, CDMP II has a plan to increase the number of water gage stations to 400 and to 600 in 2013 and 2014, respectively (Early Warning System: A Briefing for the DER Meeting, 11 February 2013). CDMP II also has a plan of installing 40 automatic water level gauging stations. The locations are not finalized yet, but some of them will be in the NE region. Automatic gauging stations with telemetry will certainly improve the warning reliability.

5.2 Warning Dissemination System

Under the present institutional mandate, the warning is provided by FFWC to all BWDB divisional offices and relevant government and non government organizations, and also posted on FFWC's website (http://www.ffwc.gov.bd). In addition, the bulletins are disseminated to more than 600 recipients including different ministries, offices (central & district levels), individuals, print & electronic news media, development partners, research organizations, NGOs, etc. as well as President's & Prime Minister's Secretariats. Whenever

the forecasted river stage crosses the Danger Level, the concerned field offices and limited key officials are informed through the mobile SMS. Warning dissemination to the people is the responsibility of local government.

With support from the Department of Disaster Management and Relief (DDMR) under CDMP II, mobile phone Cell Broadcasting (CB) has been started from July-2011 for flood warning message dissemination. Instant Voice Response (IVR) method is also introduced, and anyone can call 10941 from a 'Teletalk' mobile (a government owned service provider) and hear a recorded Bangla Voice Message regarding the day's flood situation. As a normal call charge is applicable, the voice message is given within one minute duration.

Below the district level, the responsibility of forecast dissemination and response action belongs to Disaster Management Committees (DMC) set up at district, upazilla and union levels. BWDB divisional officials are the members of the District DMC.

Dissemination of flood forecasts and warnings is weak because one organization does not have overall responsibility for disseminating flood forecasts and warnings to potential users. Also, there is no monitoring to confirm whether recipients can understand or use the flood warnings provided. (Bangladesh: Early Warning Systems Study, ADB TA 4562, December 2006).

Currently, FFWC issues warnings on water level at some fixed river locations, which local people cannot correlate with their local areas. As a trial basis, FFWC has been currently producing a national level inundation map. But local level inundation maps cannot be produced unless the new DEM data are available to FFWC. It is recommended that new DEM data for the NE region now being prepared by a JICA project should be incorporated into the FFWC model so that local inundation maps can be produced.

5.3 Simplified Warning System

Simplified flood warning denotes the system that does not use a computational mathematical model. There can be various types of simplified warning systems:

(a) By using historical data employing statistical calculation

(b) Co-relating upstream water gauge levels and downstream floods

(c) Simple visual inspection of upstream river, either physically or through CCTV

Some NGOs tried to apply such system in the haor area, but without much success. A systematic formal arrangements are highly recommended.

Example of Type (a): In 2009, CNRS, an NGO, developed a simplified warning system called "People-centered flood early warning systems" based on rainfall-runoff relationship (Adopting Early Warning System to Address Flash Flood in the Deeply Flooded Haor (Wetland) Basin in Northeast Bangladesh, Center for Natural Resources Studies (CNRS), December 2009). The target area covered the haors in Tahirpur Upazila. However, it was not successful because of lack of availability of rainfall information in the Meghalaya catchment.

Example of Type (b): Another NGO (Oxfam) had some activities on early warning based on upstream water level information. But the flood damage reduction was not achieved well. Though they could issue an early warning, the lead time was short. That could not reduce the damage as enough labor force was not available for harvesting at short notice. It is generally

considered that a 7 day lead time is required for effective crop damage reduction (ADB, 2006).

Example of Type (c): A simple visual tower method used in Nepal is shown below. A red flag is hoisted to warn the local people.

<Photo of Simple Visual Observation based Flood Warning in Nepal>

Photo 5.1 Community based early warning system in Nepal

Photo 5.2 Automated simplified warning system in Nepal

Source: Resource Manual on Flash Flood Risk Management, Module 2: Non-structural Measures, ICIMOD-USAID, July, 2008

6.0 Local Disaster Management Planning

6.1 Response System/ Evacuation Planning

The response aspects of flood warning are much neglected. This can be attributed to lack of proper warning and dissemination. Also, no response system can function properly as no single organization is responsible for ensuring flood response. (Bangladesh: Early Warning Systems Study, ADB TA 4562, December 2006). One of the reasons for such weak situation could be linked to the fact that the life loss is not a concern in the haor area.

Info Box --- Main lessons learnt from ADB TA of 2006

- A 2-day lead time for flood warning is sufficient to save household assets and small livestock, but a 7-day lead time is required for saving agriculture and properties;
- More infrastructures such as flood or cyclone shelters are required so that villagers may have more choices about the actions they can take in response to warnings;
- Infrastructures such as roads, water supplies, and sanitation facilities need to be designed and maintained in such a way that they may continue to function properly during floods; and
- A systematic way for assessing flood damage needs to be developed.

In 2012, Bangladesh enacted the Disaster Management Act 2012 from a draft that was developed by CDMP I in 2006, and later reviewed by CDMP II. Under the Act, Department of Disaster Management and Relief (DDMR) has been established, and establishment of National Disaster Management Training and Research Centre and National Disaster Management Volunteer Corps is underway. Disaster Management in Bangladesh is guided by National Disaster Management Council headed by the Prime Minister. Similarly, each district has a District Disaster management Committee (DMC) and each Upazilla has a Upazilla DMC.

CDMP II utilizes a simplified Community Risk Assessment (CRA) tool as a bottom-up method to identify risks at the community level and a newly innovated Fast Tracked Risk Assessment (FTRA) as the complementary top-down coordination at the local administration level to produce the Risk Reduction Action Plans (RRAPs). Most of the measures are long term interventions and community-led initiatives, while some agreed priorities for community level, small scale, and quick yielding interventions are to be financed by the Local Disaster Risk Reduction Fund (LDRRF, see the next Info Box).

Info Box --- Local Disaster Risk Reduction Fund (LDRRF)

The Local Disaster Risk Reduction Fund (LDRRF) is a funding mechanism established jointly by Government and the donors in the Comprehensive Disaster Management Programme (CDMP) to provide resources and financial supports for the most vulnerable communities in the form of grants to broaden and strengthen their coping capacities against disaster and climate change.

Governed by a Technical Committee and the Approval Committee, the grant is awarded to small/medium projects that are developed based on the Risk Reduction Action Plans (RRAPs) developed through Community Risk Assessment (CRA) methodology; aligned with other community needs; and being endorsed by the Union Disaster Management Committees (DMCs).

During 2005-2009 LDRRF supported more than 560 small / medium scale projects in more than 380 Unions in 11 districts benefitting over 600,000 vulnerable people.

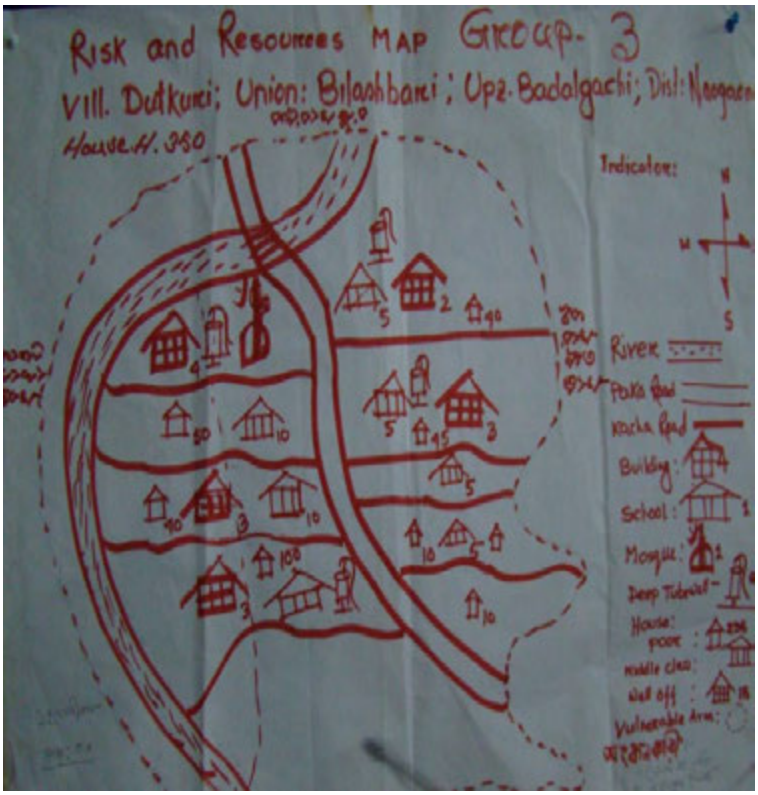
Source: CDMP Leaflet on LDRRF

In 2012, a total of 242 unions have gone through the FTRA/Review of RRAP process facilitated by CDMP II. Moreover during this period, 23 CRAs were conducted to develop RRAPs, bringing a total of 900 unions so far (including 644 CRAs completed during the CDMP Phase I). Among the recommended risk reduction and adaptation measures, some of the community level /small scale interventions are financed by the LDRRF's 1,088 schemes under 206 contracts at a value of around USD 14.4 million. (Annual Progress Report, CDMP II, 2012)

6.2 Hazard Mapping

The local communities in the haor area have no clear understanding about existing flash flood management programs. Even with the current flood warning which gives the expected river water levels at some specific locations, the community cannot correlate that information with their localities.

Many organizations are now working with the local communities to prepare local hazard maps. CDMP II is also doing this on a country wide basis. Some of NGOs are working exclusively in the haor area like POPI. Under their 'Participatory Capacity and Vulnerability Assessment Program', they are preparing local hazard maps as exemplified below.



Source: POPI

Fig. 6.1 Simple Local Level Hazard Map

Asian Disaster Preparedness Center (ADPC) is now implementing a project named “Multi-Hazard Risk and Vulnerability Assessments, Modeling and Mapping in Bangladesh”. It is a 30 month project started from Jan 2011 and expected to end in May 2014. This project is under DDMR and funded by Norway. It looks into 7 types of hazards, namely, flood, cyclone, earthquake, drought, tsunami, landslide and industrial disaster. Its final target is to prepare union level multi hazard maps considering exposure of people, infrastructures, roads, etc.

6.3 Flood Shelter

There are few flood shelters in the haor area. They have been used for multi purposes. In normal times, these are used as schools or hospitals. Since human loss is not a serious issue in the haor area flooding, the government and NGOs pay less importance on the flood shelter. DDMR is the government agency which is in charge of construction of the flood shelter. Sometimes they implement this through LGED.

Since there is no formal evacuation plan, the people use their common sense to evacuate. Some NGOs like POPI, CONCERN and Polli Bikas Kendro have been working with the local communities for evacuation planning.

It was learned from the community that they do not prefer to evacuate until it becomes impossible to stay in their houses during floods. The common reasons not to evacuete to the flood shelter are,

- They have to accept the risk of looting of valuable assets and resources from their houses,

- The shelters are not suitable for women as in many cases separate female toilet facilities are not available, and
- The shelters lack facilities for cattle head evacuation.

6.4 Disaster Prevention Edification and Awareness Building

Many organizations are carrying out disaster prevention education and awareness building programs. Among them, CDMP is the leading peoject.

CDMP II launched several initiatives to raise awareness, and promote household preparedness to disasters by providing life jackets, solar lanterns and radio sets. In addition, disaster management education is provided during the preparation of local Community Risk Assessment (CRA). Further, CDMP II now introduces disaster management topics in school text books. Bangla and English versions of two learning modules namely, the Introduction to Disaster Management (IDM) and the Comprehensive Disaster Management (CDM) modules are now accessible at http://elearning.cdmp.org.bd. Communication materials like 1 million posters, 50 thousand leaflets and other materials were published and distributed to schools countrywide.

CDMP II is now forming flood management volunteer corps involving Ansar and VDP (Community Police). CDMP II will also provide training to them.

6.5 Seed Bank and Food Bank

A community Food Bank (CFB) is an idea where buffer stock of food grains is built up at a community level to provide food against seasonal deficits in the lean months (mid-September to mid-November) or during disaster periods. The CFB will keep deposit of food from the beneficiaries and return back it during the crisis period. The depositors may withdraw their food in terms of cash and have the provision in getting interest. Branches can be set up in villages and a central storage is required which may be set up at the upazilla level. Though some NGOs are promoting this idea, it is not widely practiced in the haor districts.

At present, the required seeds for different crops are available mostly by the public sector (BADC). Some private firms also supply some small amount of seeds. After a major flood, usually there is a scarcity of seeds. To overcome this problem, there should be some facility to maintain seed security stock. Public private partnership can be promoted in establishing seed banks, preferably at the upazilla level. Though some NGOs are promoting this idea, it is not widely practiced in the haor districts.

6.6 Flood Damage Insurance/ Crop Insurance

Small scale farmers with few resources are typically unable to insure their crops against extreme weather events and can lose their entire income every time a flood hits. Although flood damage insurance and crop insurance are widely practiced ideas in many flood prone developing countries, it is not yet adopted in the haor area. BRAC, one of the leading NGOs, once tried to introduce crop insurance but it was not very effective.

Now, a new project is going to be implemented soon to develop an ‘affordable’ crop insurance system to natural calamities for the Bangladeshy small farmers who lose crops. The project titled “Pilot Project on Weather Index-Based Crop Insurance TA - 46284” will be

implemented by Asian Development Bank (ADB) under a grant of $2 million from Japan.

The system of weather index-based crop insurance, that incorporates historical weather and crop production data, is considered to be more cost-effective and efficient than traditional agriculture insurance. It reduces farm-level monitoring and transaction costs. Several countries in Asia, including India, Indonesia, Mongolia, the Philippines, Sri Lanka, and Thailand, have begun piloting or providing these products but this is the first time it will be trialed in Bangladesh. The project will design and pilot the insurance over a three years period in selected districts, targeting to cover at least 12,000 farm households. It will collaborate with agricultural banks, multilateral financial institutions and farmer cooperatives and try various models to make the business sustainable. Along with reduced premiums and improved distribution networks, ADB says that the new insurance scheme will provide other benefits to farmers like income support during lean periods, access to credit and a buffer against loan defaults.

The project will also support developing 'a regulatory and legal framework' to accommodate the new concept. Under the project, at least 20 weather stations will be upgraded and at least 400 staff from government and meteorological agencies, insurance companies, agricultural institutions, and civil society groups will be trained up on 'weather-indexed insurance' to improve the accuracy of weather data.

7.0 Livelihood Diversification

Livelihood of the haor people is extremely vulnerable and the combined effect of flash floods, monsoon floods and strong wave action limits the potential for agriculture production. Rural poor households in the haor area have to depend upon fisheries and off-farm labor to supplement the meager farm income. The common property nature of the water bodies (Jalmohals) and the unfavorable lease arrangements inhibit the full growth potential of the fishery sector. This forces many people to opt seasonal migration to find work.

To maintain the livelihood of the vulnerable haor community, paddy variety diversification, non rice crop diversification and job diversification is essential to coping with the situation. All the haor farmers are not fully motivated to such switchover yet.

7.1 Paddy Variety Diversification

The seven haor districts comprising 39 Upazillas accounts for 13.5% of the Bangladeshy area, 12% of the population, and 11% of the agricultural households. About 5.25 million metric ton of rice is produced in the haor area, which is 18% of the total rice production in Bangladesh on an area of 1.74 million ha (16% of total rice production area). Considering Boro rice is the only rice crop in the haor area, it can be said that the production yield of the haor area is above the country average.

The haor farmers grow both local and hybrid varieties of boro rice. Most hybrid varieties are developed by Bangladesh Rice Research Institute (BRRI). The most common varieties are BR-28 and BR-29. The present status of Boro rice cultivation in seven haor districts is as follows.

Table 7.1 Distribution of Paddy Varieties (2012-2013 season)

Districts	Percent of Boro rice varieties out of total Boro rice production (%)				
	BR-28	BR-29	BR-19/ other BR	Non BR hybrid	Local/ Others
Kishoreganj	35	45	-	19	1
Netrokona	55	35	-	-	10
Sylhet	47	31	4	5	13
Moulavibazar	36	35	18	7	4
Habiganj	16	42	-	34	8
Sunamganj	23	52	5	10	10
Brahammanbaria	47	44	-	8	1

Source: Compiled by JICA Study Team through interview survey of head office and 7 district offices of Department of Agricultural Extension (DAE) during May 2013.

The haor farmers select the varieties based on soil conditions, grain yield, seed availability, cost of inputs, and maturity duration. The apparent popularity of BR-28 and BR-29 has its roots on the fact that BR-28 is a short maturation variety (140 days) and BR-29 has a rather high yield (7.5 t/ha). BR-28 can offset the risk of crop damage due to flash floods to some extent. In addition, with BR-28, farmers can produce other short life crops (garlic, onion, etc.). Following table shows the salient features of 5 popular BR rice varieties in the haor area.

Table 7.2 Salient Features of BR Rice Varieties Farmed in Haor Area

Rice variety	Seed sowing time	Harvesting time	Grain yield (Ton/ha)	Days of maturity
BR 14	15 Nov-20 Dec	1 May-31 May	6.5	160 days
BR 19	15 Nov-15 Dec	18 April-4 May	6.0	170 days
BR 28	15 Dec-7 Jan	1 May-25 May	6.0	140 days
BR 29	30 Oct-15 Nov	19 April-2 May	7.5	160 days
BR 45	15 -30 Nov	1 April-7 April	6.5	145 days

References:

1. BRRI-Bangladesh Rice Research Institute-Fact sheet (Web based Fact Sheet-Training Module)

2. Crop Production in the Haor Areas of Bangladesh: M. Shahe Alam et. al., Journal of Agriculturalist (Krishi Foundation, 2011)

3. Plant Varieties Developed by the NARS Institutes and Agricultural Universities (BARC Publication, June 2011)

From the above table, it can be seen that BR-45 is the earliest harvesting type with a reasonable yield. However, its stem is very weak against wind and also shattering (falling off the grains during harvesting) is a big problem. Thus, it is not much popular and only practiced in the most vulnerable areas. BRRI is now trying to solve these problems. Though BR-29 is very popular, it cannot withstand if temperature is less than 13 ºC, so in years of severe cold, its yield drops drastically.

The above discussion concludes that though the best scenario has not been achieved yet, paddy variety diversification is well practiced in the haor area as one of non-structural measures for flash flood damage reduction. Until now, no single rice seed has been found without any limitation. So there is a need to continue rice research / crop diversification research. Many suitable technologies have been demonstrated, however, these technologies have not been properly promoted yet. So, there is a need to enhance farmer awareness about them. Farmers are also constrained by the availability of improved seeds. There is a need to

enable farmers to use market opportunities and create linkage with markets for small holder producers.

7.2 Crop Diversification

The major problems of the haor area in an agricultural sector are associated with flood damage, drainage congestion, difficulty in timely transplantation, seedlings scarcity, land ownership and tenancy, access to inputs and credit, man power shortage and transportation during harvesting and post harvesting activities, lack of storage facilities and marketing, etc. To cope with such adverse situations, the haor farmers have been trying to diversify crops.

Some of crops are cultivated during the Robi (winter period) period, usually before the Boro cultivation; and the others are cultivated during Kharif (summer period). The cultivation areas of major crops in the study area are given in the following table.

Table 7.3 Cultivation Areas of Major crops in the Study Area

Crop Group	Crop Area ('000' ha)							
	Sunamganj	Kishoreganj	Netrokona	Sylhet	Habiganj	Moulvibazar	Brahmanbaria	Study Area
Aus	3.9	23.0	1.8	45.9	33.6	32.4	3.8	144.4
T Aman	67.8	76.7	139.2	162.9	67.2	102.5	47.5	663.6
B Aman	-	-	-	6.3	26.1	4.1	24.1	60.5
Boro	193.8	166.3	176.3	77.2	108.0	40.4	109.3	871.3
Total Rice	***265.5***	***266.0***	***317.3***	***292.2***	***234.9***	***179.4***	***184.7***	***1,739.8***
Wheat	0.6	1.7	1.0	3.2	0.7	0.1	2.3	9.6
Maize	-	2.5	-	2.0	0.0	-	0.0	4.5
Oilseeds	2.9	6.5	3.1	4.8	1.4	0.2	5.3	24.2
Pulses	0.4	1.8	0.6	3.8	0.5	0.3	4.8	12.2
Spices and Condiments	1.4	4.2	2.4	2.8	1.7	1.1	5.5	18.9
Potato	1.9	6.5	2.5	5.5	2.2	1.9	3.6	24.0
Vegetables	8.5	9.8	6.1	18.8	9.0	11.6	9.4	73.2
Jute	0.5	8.5	7.7	-	0.5	-	5.0	22.0
Sugarcane	-	-	-	-	0.3	-	-	0.3
Total Non Rice	***16.1***	***41.5***	***23.3***	***40.7***	***16.3***	***15.2***	***35.9***	***189.0***
Total Crop Area	**281.5**	**307.5**	**340.6**	**332.9**	**251.1**	**194.6**	**220.6**	**1,928.8**
Net Crop Area	**254.0**	**196.9**	**211.1**	**208.7**	**162.9**	**126.9**	**150.4**	**1,310.9**
Cropping Intensity (%)	***111***	***156***	***161***	***160***	***154***	***153***	***147***	***147***

Source: Department of Agriculture Extension (DAE), 2010

It can be seen from the above table that vegetables, potatoes and oil seeds are the major non rice crops in the study area. CONCERN is promoting cultivation of a special potato. This special potato can be planted in late November and requires only 40 days to harvest. So the people can cultivate Boro rice after harvesting the special potato.

Another important aspect is that the cropping intensity is more than 1 in all the districts. Though there is a room for improvement, it can be said that crop diversification is well practiced in the haor area as one of non-structural flood measures to reduce the flood related

damage.

The yield levels of different crops are closely associated with soil conditions, input usage (fertilizer, etc.) and cultural practices. The yields of different crops cultivated in the haor area are given in the following table.

Table 7.4 Yield Rates of Different Crops in the Study Area

Crop Name	Yield rate (ton/ha)						
	Brahmonbaria	Hobigonj	Kishoregonj	Moulovibazar	Netrakona	Sunamganj	Sylhet
Aus	1.99	2.46	2.50	2.61	2.21	2.18	2.46
T Aman	2.43	2.68	2.56	2.53	2.40	2.07	2.60
B Aman	1.18	1.39	-	1.01	-	-	1.34
Boro (all types)	3.83	3.64	4.08	3.24	3.25	3.37	4.10
Average Rice	3.09	2.95	3.51	2.67	2.87	3.02	2.95
Wheat	1.94	2.26	2.02	1.80	2.46	2.22	2.20
Maize	2.00	6.00	4.40	-	-	-	5.19
Oil seeds	1.20	1.13	1.06	0.86	0.87	1.19	1.14
Pulses	0.92	1.17	0.95	0.80	1.06	1.31	1.17
Spices and Condiments	2.23	3.66	3.00	4.15	3.72	1.99	2.25
Potato	11.11	9.05	15.85	12.05	12.83	16.49	11.66
Vegetables	14.00	15.45	5.68	14.48	19.95	16.23	15.00
Jute	1.50	1.80	1.70	-	1.50	1.29	-
Sugarcane	-	44.42	-	-	-	-	-

Source: Department of Agriculture Extension (DAE), 2010

Notes:

1. Rice yields are average of all types of hybrid and local varieties.
2. Pulses include Arhar, Gram, Kheshari, Maskhalai, Motor, Mung, Mushur, other pulses.
3. Oilseeds include Groundnut, Mustard, Till.
4. Vegetables include Beans, Brinjal, Cabbage, Cauliflower, other winter vegetables, Spinach, Pumpkin, Radish, Sweet Potato, Tomato, Water Guard, Arum, Long Beans, Brinjal_kharif, Chalkumra, Chichinga, Cucumber, Danta, Jhinga, Kakrol, Karala, Lady's Finger, Patal, Puisak, other kharif Vegetables. The yield level of vegetables has been calculated on the basis of average yield values of vegetables both in summer as well as winter.
5. Spices include Chilli_Kharif, Chilli_Rabi, Coriander, Garlic, Ginger, Onion, and Turmeric.

Other potential crops are shrubs such as bamboo and mustaq. These plants can provide vegetative protection against wave erosion, and are also raw materials for mat and basket making.

Case Studies

To tap the potential of crop diversification, many NGOs and agencies have been carrying out various activities. Three case studies are explained briefly in the following.

(1) CNRS

CNRS, NGO working in the haor area, undertook a pilot project with the assistance from Bangladesh Agriculture Research Institute (BARI) and Bangladesh Rice Research Institute

(BRRI): the two are national research institutions. The main target was to assist the farmers to adjust with their improved cropping patterns.

The pilot project, funded by Oxfam Hong Kong, tested 126 demonstration plots with 18 different crops together with local farmers from ten villages in Sunamganj District. Several techniques were tested to shorten crop maturity (by varying transplanting of seedlings), change in seedling and harvesting periods, and find optimum fertilizer use. Results of the pilot project are given below. Out of 18 crops, only tomato and Bate shak returned poor conclusion.

Table 5.5 Results of CNRS Pilot Project on 18 Crops in Sunamganj

	Observed Yield (ton/Ha)	**Optimal yield (t/Ha)**	**Conclusion**
BRRI 45 Rice	7.14	6	Recommended
BRRI 29 Rice	9.88	7.5	Recommended
Wheat	4.01	3.5 - 4.6	Recommended
Potato	29.64	25 - 30	Recommended
Garlic	9.88	10 - 12	Recommended
Onion	11.12	12 - 15	Recommended
Bitter gourd	24.70	25 -28	Recommended
Sweet gourd	69.34	60 - 70	Recommended
Bate shak	14.82	45 - 55	not recommended
China shak	25.35	25 -30	Recommended
Red amaranth	12.84	12 - 14	Recommended
Stem amaranth	12.35	13 - 15	Recommended
Garden pea	9.88	12 - 14	needs further trials
Eggplant	49.40	45 - 50	Recommended
French bean	13.59	13 - 14	Recommended
Tomato	25.94	80 - 85	not recommended
Radish	41.17	55 - 60	needs further trials
Mung bean	0.98	1.2 - 1.5	needs further trials
Black gram	1.23	1.4 - 1.6	needs further trials

Source: CNRS Publication on results of Pilot research, written by M. Anisul Islam and Mokhlesur Rahman Suman, retrived from CNRS website,

(2) Climate Change Cell

Climate Change Cell under Ministry of Environment, in collaboration with BRRI and BARI tested adaptive cropping at the farmers' fields between 2006 and 2008, which demonstrated encouraging results. The research was conducted in Sunamganj District by employing CNRS. Research findings have opened up avenues for the farmers to adapt to the risks of flashfloods. However, more social and institutional work is needed to sensitize farmers to the shift from their traditional preference over rice to other non-rice crops as well as to provide an enabling institutional mechanism that could facilitate extension of adaptive cropping to wider communities exposed to flashflood hazards.

The comparative analysis of different crops is summarized in the following table. Apart from the 3 Boro varieties, all other crops shown in the table can be harvested well before flash flood occurrence. It can also be seen that some of crops returned much more profit than

conventional Boro crop, like Radish, Sweet gourd, Bitter gourd and Garlic.

Table 7.6 Comparative Analysis of Different Crops

Name of crops	Flash Flood Impact			Economic Aspects				Type of land that can be used
	Maturation days	Harvesting time	Safe from Flash Flood?	Production cost (Taka/Ha)	Production (Ton/Ha)	Market price (Taka/Ha)	Gross profit (Taka/ Ha)	
BR-28	145	Early Apr	No	41,310	5.37	64,440	23,130	Winter rice land
BR-29	150	Mid Apr	No	40,333	6.18	80,340	40,007	Winter rice land
Habiganj Boro 6	145	Early Apr	No	41,310	4.56	52,440	11,130	Winter rice land
BR-45	140	End Mar	Yes	41,310	5.98	74,450	33,440	Winter rice land
CH 45	140	End Mar	Yes	41,310	5.55	66,600	25,290	Winter rice land
French bean	70	Early Jan	Yes	63,726	7.41	74,100	10,374	Fallow land, adjacent homestead and front yard
Radish	65	Early Feb	Yes	69,024	37.05	370,500	301,476	Adjacent homestead and front yard
Spinach	40	Early Jan	Yes	34,083	5.56	55,600	21,517	Adjacent homestead and front yard
Garden pea	95	Early Mar	Yes	33,094	9.98	149,700	116,606	Adjacent homestead and front yard
Sweet gourd	130	Early Feb	Yes	85,026	68.13	340,650	255,624	Fallow land, adjacent homestead and front yard
Red amaranth	45	Early Jan	Yes	36,513	8.98	53,880	17,367	Adjacent homestead and front yard
Stem amaranth	65	Mid Jan	Yes	46,728	47.01	235,050	188,332	Adjacent homestead and front yard
Bitter gourd	120	End Feb	Yes	117,633	28.4	340,800	223,167	Fallow land, adjacent homestead and front yard
Potato	75	Mid Feb	Yes	156,063	19.06	285,900	129,837	Winter rice land, Fallow land, adjacent homestead and front yard
Ash gourd	85	End Jan	Yes	47,542	17.90	89,500	41,958	Adjacent homestead and front yard
Onion	120	End Mar	Yes	64,343	11.36	227,200	162,857	Winter rice land, Fallow land, adjacent homestead and front yard
Garlic	130	End Mar	Yes	120,528	9.92	496,000	375,472	Winter rice land, Fallow land, adjacent homestead and front yard

Source: Climate Change Adaptation Research: Adaptive Crop Agriculture Including Innovative Farming Practices in Haor Basin, Dec, 2008, Climate Change Cell, DoE, MoEF; Component 4B of CDMP, MoFDM

(3) CDMP II

DCRMA (Disaster and Climate Risk Management in Agriculture) is a component of CDMP-II, having been implemented since 2011 by Department of Agricultural Extension (DAE). DCRMA has project activities on crop diversification, integrated farming, adaptive farming, farmers' capacity building, etc. in 4 haor districts (Habiganj, Netrokona, Sunamganj

and Moulovibazar).

One of the DCRMA activities is Field Demonstrations in Kharif-II, 2011 and Rabi, 2011. Followings are the recommendations from the demonstration activities for the haor area: (Present Status of Established Field Demonstrations in Kharif-II 2011 and Rabi 2011, published March, 2012, Implemented By: DCRMA Project under CDMP-II/ DAE Part)

- Development of late T. Aman variety
- Introduction of submergence tolerant rice (BRRI 51, 52)
- Use of early variety of BRRI 45
- Introduction of pulse, maize, mustard, etc.
- Establishment of fruit garden
- Vegetables cultivation
- Swamp tree plantation
- Green manuring like dhaincha cultivation
- Supplementary irrigation in Aman and Aus
- Short duration variety (for Boro 120-130 days)
- Storage of surface water
- Mechanical cultivation introduction
- More use of surface water
- Increase of homestead activities
- Establishment of appropriate crop demonstration (short duration variety coconut, dhaincha, betel nut, orhor, drum stick, quickly growing vegetable and fruits, mushroom)
- Motivational and Training program for farmers

In another activity of DCRMA, it has demonstrated the effectiveness of floating garden on hyacinth beds (for aroid, okra, red amaranth, stem amaranth, cucumber, Indian spinach, turmeric and seedlings production in floating beds), boro seed production in dry bed, community based cultivation and community based seed storage for higher viability in the haor area (Report on Floating Vegetable Cultivation, February, 2013, by DCRMA/ DAE).

During the monsoon season when otherwise agriculture is not possible, the floating agriculture has several advantages: (1) the waterlogged area can be cultivated and the total cultivable area can be increased, (2) an area under floating cultivation is more fertile compared with the traditional land, (3) no additional fertilize and manure is required unlike the conventional agricultural system, (4) after cultivation, the biomass generated could be used as organic fertilizer in the field, (5) it conserves the environment, (6) during the floods it can be used as a shelter for the poultry and cattle, and (7) a farmer can harvest crops and fish at the same time. All the activities of the practice are environmentally friendly and can prove to be an alternative livelihood option.

7.3 Job Diversification

Flash flood damage is directly associated with agricultural activities. To reduce the damage of flash floods, nonagricultural income generation activities are promoted. There are scope and opportunities for undertaking some innovative income earning initiatives such as floating cage fish culture, beel nursery, pen culture, etc. Some of these are well known technologies in the country although they may not be well known in the haor area.

To improve livelihood of the haor community, there are many NGOs working on fish and fisheries resources management and conservation in Bangladesh. Their main activities include but not limited to (i) Mono- and poly-culture of different species; (ii) Nursery management programme; (iii) Baor fisheries development and management; (iv) Credit programs; and (v) Extension Programmes. NGOs working on a fishery sector includes Bangladesh Rural Advancement Committee (BARC), Proshika Mannobik Unnayan Kendra, Rangpur Dinajpur Rural Service (RDRS), Care International Bangladesh (CARE), Caritas Bangladesh, Association for Social Advancement (ASA), Gano Shahajya Sangstha (GSS), Association of Development Agencies in Bangladesh (ADAB), World Fish Bangladesh, IUCN, Christian Commission for Development in Bangladesh (CCDB), Friends in Village Development, Manabik Sahajaya Sangstha, Technical Assistance for Rural Development (TARD), POPI, CNRS, Chetona, etc.

It can be said that though there is further room for improvement, job diversification is currently used widely as a tool of non-structural flood measures to reduce flood related damages.

(1) Capture Fisheries

The contribution of haor capture fisheries to the livelihood of rural poor in the haor area is historically very significant. Many of the people, particularly the poor, often depend on fishing in the floodplain for living. Although 2.59% of the study area population are full-time fishermen, over 65% of the households engage in fishing as part-time or as subsistence fishing. Rapid population growth has caused increased fishing leading to reduction of fish stocks, which in turn has adversely impacted on the livelihood of those directly dependent on the capture fisheries.

(2) Beel Nursery

Beel is generally defined as the deepest parts of a haor, where water remains even in the dry season. Beel nursery is a good and fruitful way of increasing biodiversity and production of pure strain and native fish species. In this scheme, government owned beels are made available to fishery groups through lease agreement. The groups then maintain sustainable fishing after getting proper training. This activity ensured higher production of fish and improved the livelihood of the local fishermen community.

To boost up haor fisheries production and increase fish biodiversity and thus, in turn to improve livelihood of the haor fishermen community, beel nursery activities were undertaken by LGED under financial assistance from a UN agency International Fund for Agricultural Development (IFAD) (See Case Study below).

Some of successful examples of job diversification are the two IFAD financed LGED projects. First, Sunamganj Community Based Resource Management Project (SCBRMP) implemented promotion of beel nursery development in one haor district (Sunamganj) and based on its very positive results it is replicated in Haor Infrastructure and Livelihood Improvement Project (HILIP).

Info Box --- two IFAD funded LGED projects

SCBRMP started from 2002 and is expected to end in 2014. The estimated cost is US$ 50 million and the target beneficiaries are 90,000 farmers (SCBRMP leaflet, 2010). The HILIP started from 2012 and is expected to run until 2019. The estimated cost is US$ 118 million and the target beneficiaries are 688,000 households (HILIP leaflet, undated).

Case Study

Under the Community Resource Management component of these two Projects, a total of 500 beels are to be brought under Beel User Groups (BUG). The BUG is a community management institutional arrangement for the Beel re-excavation to improve their productivity and biodiversity. The objective of this component is to improve the livelihood of poor rural households engaged in fishing by improving their access to fish resources, increase in fish production and the fish species in the beels of the haor area.

With agreement from the Ministry of Land (as owner of the beels), the BUG is to gain access to public water bodies. The combined impact of beel development and improved management of this resource has helped to increase fish production and fish species in the Beels. It is estimated that around 20,000 members of the BUGs will benefit from this component of which at least 20% will be women. (HILIP Project Design Report, May 2011). HILIP project thus opens up new income source of the people to compensate agricultural flood damage.

Water of some beels is drained out and may become dry. As a result, beel fisheries cannot be practiced. To address this issue, establishment of a spillway on a drainage canal is considered. The spillway can retain water in the beels at a certain height during the flood recession period.

The Department of Fisheries (DoF) has also conducted beel nursery activities through Second Aquaculture Development Project. DoF had implemented around 75 beel nursery in the haor area from 2009-10.

Because of the success of these projects, now IFAD is forming a new project called CALIP to expand the coverage. The scope of CALIP is expected to be finalized within 2013.

(3) Pen Culture

The pen culture of fish farming is a method of growing fish by holding them captive within an enclosed space in rivers, floodplains or lakes whilst maintaining a free exchange of water. This pen culture is an alternative open system of commercial breeding that allows interaction with the immediate environment, yet prevents the entry of undesirable animals and fish that may harm the cultured stock. This kind of practice is highly suitable for the community based approach and its popularity has been increasing.

(4) Floating Cage Culture

Cage culture is an aquaculture system where fishes are held in floating net pens. Cages are widely used in overseas commercial aquaculture and individual cage units come in all shapes

and sizes and can be tailored to suit individual farmer's needs. One popular size of the cage is 20´X10´X6´. Cage units can be purchased through commercial outlets, but can also be made from readily available construction materials such as poly pipe, bamboo or wood or/and steel. Cages are mostly used in open freshwater bodies where gentle current of water prevails. In the study area, such examples are found in South Sunamganj (22 nos.), Mithamain (12 nos.) and Jamalganj (10 nos.), (Source: Upazila Fisheries Officer). However, it is not suitable where the wave actions are high. The main problems of cage fishing are cage dislocation and fish food washing away due to wave action. Thus, further trial is recommended.

(5) Poultry/ Livestock

In the case of poultry/ livestock, the principal threat is from disease. There limited is the access to vaccination and improved feed preparation technologies which can help to build the resistance against disease as well as improve animal productivity. There also limited is the knowledge about preventive disease measures. The strategies required are to build linkage with private sector service providers, ensure market access, enhance capacity of local para-vets, and access to improved inputs such as day-old chicks and improved feed.

For livestock and poultry, the focus should be on developing the linked elements within a value chain. One of the keys for improvement is access to health services and breed upgrading. To do this, it requires establishment of sustainable support services. Similarly the introduction of improved breeds of chicken and duck through breeding services (mini hatcheries) are important.

(6) Agro Industry

For the synchronization effect, cottage industries based on agro-products are most recommendable. For example, fish processing (dried fish) can be improved through updating processing and packaging techniques and establishing linkage with buyers. Another practice can be value addition to bamboo and mustaq (local aquatic plants). These plants can provide vegetative protection against wave erosion, and also raw materials for mat and basket making.

Quality improvement of handicrafts and access to new markets can be an important initiative. The IFAD funded HILIP proposed to provide training and capital support for such income generating activities mainly for women. The project will closely work with the smallholder producers and other market actors along the value chain.

It is also possible to establish alternate use of agro product and by-product. For example, it is possible to make ethanol (bio-fuel) from straw of paddy. Japan's Kawasaki Heavy Industries installed such plants in Japan. The largest plant can produce 22,500 l/year of ethanol at a cost of JPY 40/liter. The US market price of ethanol in May 2013 was about JPY 55/ liter. It is a viable option but needs further investigation on availability of straw, transportation to plant, plant location and marketing strategy.

7.4 Improved Market Access

The agricultural production system is closely linked with storage and marketing facilities. The storage facilities for crops in the haor area are very poor. The inaccessibility of the haor

area makes it difficult for farmers to get the reasonable prices for their produce. Most of the farmers sell their products in village markets immediately after harvest when prices are typically low. The reason for farmers' inability to store their crops are (i) need of cash, (ii) lack of proper storage facilities, (iii) crop loan obligations, and (iv) tenure crop division arrangements. The producers are then frequently obliged to replace this food grain at higher prices to meet daily consumption requirements during the off-season. The marketing system is traditional. In order to improve the socio-economic conditions, the marketing system needs to be strengthened through establishment of regulated markets, construction of warehouses, provision for grading of crop quality, standardization of produce, standardization of weight and measures, daily broadcasting of market prices of agricultural crops on Radio, TV, daily news paper, and improvement of transport facilities, etc. The agriculture marketing system should be developed for improvement of the haor area. Producers should be linked with markets and may be organized into market-based farmer's associations, with interventions aimed to improve links with buyers and input suppliers.

Case Study

Under the Livelihood Protection Component of HILIP, the livelihood is to be improved by adopting a value chain approach for crop cultivation particularly rice, horticulture and livestock such as ducks, poultry, etc. The broad objective of this component is to enhance production, diversification and marketing of crop and livestock produce. This component will develop the capacity of smallholder producers to participate in selected market-based value chains and establish and support market-based institutions. A total of 94,000 persons are expected to directly benefit from this component in the 26 project Upazilas. (HILIP Project Design Report, May, 2011)

8.0 Flood Proofing of Living Environment

This includes raising of houses, tube-wells, latrines, stock yards, and construction of new platforms above the flood levels to be used for housing purpose (new villages) and markets.

Though it involves physical construction, flood proofing is widely recognized as one of non-structural measures. According to UNESCO Guideline, (Guidelines on Non-Structural Measures in Urban Flood Management, International Hydrological Programme -V | Technical Documents in Hydrology | No. 50, UNESCO, Paris, 2001), "Flood proofing is the use of permanent, contingent or emergency techniques to either prevent flood waters from reaching buildings and infrastructure facilities, or to minimize the damage from water that does get in.

8.1 Raising of Habitat Area

People are living for many generations in the haor area and thus, they adopted their living style with the normal monsoon flood. In most cases, their houses, tube wells, stock yards, cattle houses, latrines, etc. are constructed above a normal flooding level. In this way, they can reduce the flood damage. However, in some years of extreme flooding events, their habitats go under water.

Many NGOs help poor people in raising habitats, either by providing materials or by cash. Some NGOs integrate these activities with their micro-credit scheme or health safety

scheme.

8.2 Raising of Villages and New Platform Construction

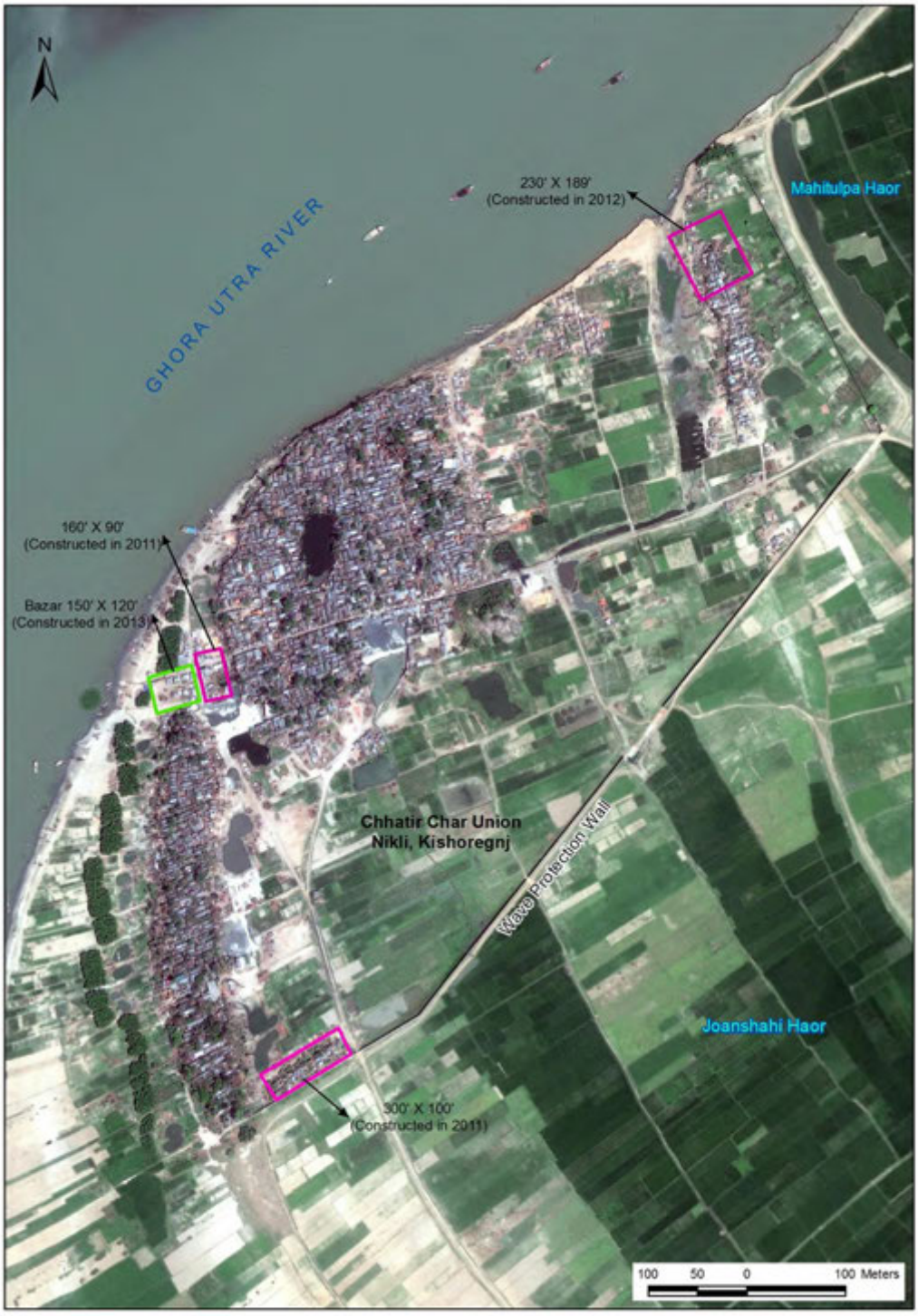
In this approach, part or an entire area of a village is raised above a normal flood level or a new platform is constructed above a normal flood level to be used as a village or market area. POPI is leading in this approach and constructed 4 platforms from 2011 to 2013. All four platforms are constructed in Chatirchar Union, Nikli Upazilla in Kishoreganj District. The layout and photos are as shown in the following. The layout photo shows their sizes and construction years. One of them is used as a market area and the rest are used as living villages. The height of the platforms was 11 feet.

The land is given under a lease agreement to the homeless people for 10 years without any ownership right. The Union Council and local community together decide who gets the land lease.

The priority was given to those who had lost their home due to erosion, female headed family, family with no agricultural land, and very poor. In the 3 living villages, a total of 250 families have get land. Each family got a land parcel of 25 ft X 15 ft.

The construction was done using dredged materials extracted from the nearby river. Layers of soil was placed and then compacted manually. All cost was borne by POPI but periodic maintenance is expected to be done by the beneficiaries. The actual construction cost of one of the platform with a size of 150 feet long, 120 feet wide and 11 feet high (198,000 cu. ft) was 4.9 million BDT, which is equivalent to BDT 2.45 per cu. ft, or BDT 87 per m3 (Contract award document, POPI, 2012).

With the success of POPI, now BWDB is planning to replicate the new platform construction in their Kalni-Kushiara dredging project.



Source: JICA Study Team Field Investigation

Photo 8.1 The Locations of newly raised villages at Chatirchar, Nikli

Source: POPI

Photo 8.2 A newly raised village named Sunaulla hati, Chatirchar, Nikli where community people has manage 70 decimal land for the land owners without any interest

Photo 8.3 Constructed platform Side View

Photo 8.4 Stair to Constructed Market

Photo 8.5 The Newly Constructed Village

9.0 Participatory Water Resources Management

There are many structural water resources management facilities in the haor area: namely, submergible embankment, culverts, regulators, protective dykes, etc. In a traditional way, these are managed by public sector agencies. However, due to lack of proper O&M, sometimes these structures may not function properly and lead to flood related damage. It is now considered that stakeholders participation in operation and management of such

structural facilities can ensure proper O&M and reduce the flood damage. Thus, water resources management through a participatory approach is sometimes considered as one of non-structural measures of flood damage reduction.

Ministry of Water Resources (MoWR) prepared a Guideline for Participatory Water Management in the light of participatory water management as provided in NWP (National Water Policy). The stakeholders of such participatory water management are:

- Local stakeholders,
- Water management organizations,
- Local government institutions,
- Ngo/community level self help groups,
- Private sector service providers,
- Implementing agencies, and
- Other public sector agencies.

The guideline also stipulates the scope and function of three tier entities on the basis of size and complexity of the project/scheme (see the next Info Box), namely, Water management group, Water management associations and Water management federation.

Info Box --- Water Management Organizations

Three types of water management organizations are proposed, namely, Water Management Group (WMG), Water Management Associations (WMA) and Water Management Federation (WMF). For each project/ scheme, there will be at least one level of WMO. The number and level of WMO to be formed in any project/ scheme will be decided by the stakeholders on the basis of their preference and in consideration of the size and complexity of the project/ scheme.

- WMG at the lowest level for each smallest hydrological unit or social unit (village)
- WMA at the apex level of project/ scheme up to 1,000 ha; or at mid level of project/ scheme more than 1,000 ha
- WMF at the apex level of project/ scheme more than 5,000 ha, and sometimes at the apex level of project/ scheme between 1,000 and 5,000 ha.

Source: Guidelines for Participatory Water Management, Ministry of Water Resources

Case Studies

Four case studies are given below.

(1) WMIP Project

Water Management Improvement Project (WMIP) is an on-going project of BWDB funded by World Bank and the Netherlands government, expected to be completed by 2015. The project is basically designed to expand the role of communities in water resources management, to empower them to manage the infrastructure and to provide a framework for participation of beneficiaries and stakeholders in rehabilitation and operation of the water

management (Inception Report of Component 1 and 2, WMIP, November, 2010).

The view of participatory water management was successfully tested in a previous project called Integrated Planning for Sustainable Water Resources Management (IPSWRM) involving 9 polders. WMIP is intended to improve, modify and apply the IPSWRM model in a broader scale.

In the WMIP project, a 10 step Participatory Scheme Management (PSM) is applied, where the steps are, (1) Identification, (2) Scheme assessment, (3) Screening, (4) Mobilization, (5) Planning, (6) Design, (7) Implementation, (8) Management plan preparation, (9) One year trail operation and maintenance period and (10) Evaluation and management transfer. In this way, it is expected that the people will develop a sense of ownership of the project.

The core component of the participatory approach is formation of water management organizations. In WMIP, 2 tiers of such organizations have been considered, Water Management Group (WMG) at the lowest level and Water Management Association (WMA) by combining a number of WMGs. The WMA has at least a 30% representation of women and should consist of one male and one female representatives elected by each WMG. In addition, representatives of landless people, fishermen and destitute women are to be included in the WMA.

The O&M activities are divided into three groups under the WMIP, namely (1) preventive maintenance, (2) periodic maintenance and (3) emergency maintenance. It is proposed in WMIP that WMA will be responsible for preventive maintenance while BWDB will provide both periodic and emergency maintenance.

In the WMIP project, 67 schemes are under execution and first results of management transfer will start to emerge from 2014. However, no schemes are included in the haor area.

(2) Local Government Engineering Department (LGED) Practice

The Small Scale Water Resources Development Projects of LGED (funded by ADB and JICA) organized Water Management Cooperative Association (WMCA) for the operation and management of the facilities. The implementation started from mid 2000 and currently is expected to be continued till 2017. Under SSW-I and II, about 570 sub projects were developed and handed over to Water Management Cooperative Associations (WMCAs) for O&M, and by 2017, a further 260 and 200 sub projects will be developed under ADB and JICA assistance, respectively.

The LGED small scale project revolves around the concept of Water Management Cooperative Association (WMCA). In a typical sub project, the WMCA has to make an upfront contribution and the subproject is constructed by the LGED. After management transfer, the WMCA is responsible for operation and also for routine maintenance. The periodic maintenance is done by LGED. However, in most cases, WMCA also contributes a matching fund for the periodic maintenance.

This LGED model is generally considered to be very successful. However, there are further room for improvement. The “O&M Strategy Development for Small Scale Water Resources Subprojects” (ADB, May, 2009), mentions that “……additional targeted post handover support for maximum and sustainable benefits is required……”.

(3) “Concern” Practice

Concern, an international NGO based in Ireland, carried out 21 sub projects in the haor area for village protection from wave action with financial assistance from Irish Aid and European Commission under the project name “Haor Initiatives for Sustainable Alternative Livelihood (Hisal)”. The project was implemented between October 2006 and December 2011.

In this project, Concern organized a cooperative society in the target village and the society created a maintenance fund upfront. The beneficiaries also contributed all labor required for the construction. After the completion, the ownership was transferred to the village cooperative society and they took over responsibilities for all kinds of maintenance.

According to Concern, in the past 5 years, there were 2 cases of collapse out of the 21 sub projects; however, the villagers successfully reconstructed those without any assistance from Concern. Thus, the model is generally considered to be successful.

(4) CNRS-CARE Practice

Under the CNRS-CARE project “Flood Risk Reduction Activities in Sunamganj, FRRAS, Phase –II, December 2006 –March 2010”, a number of activities were undertaken to protect agricultural crops from flash floods by making natural barriers through planting of swamp trees, i.e. Hijol and Koroch saplings as one of non-structural flood measures. They planted 30,000 saplings of these species in the haor areas of Sunamganj District. They also develop and put in place community-based systems and mechanisms involving communities and Union Parishads to ensure regular maintenance and durability of submergible embankment and tree plantation activities.