No.

The People's Republic of Bangladesh

DATA COLLECTION SURVEY ON WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST AREA OF BANGLADESH (SUMMARY REPORT)

SEPTEMBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
OYO INTERNATIONAL CO., LTD.

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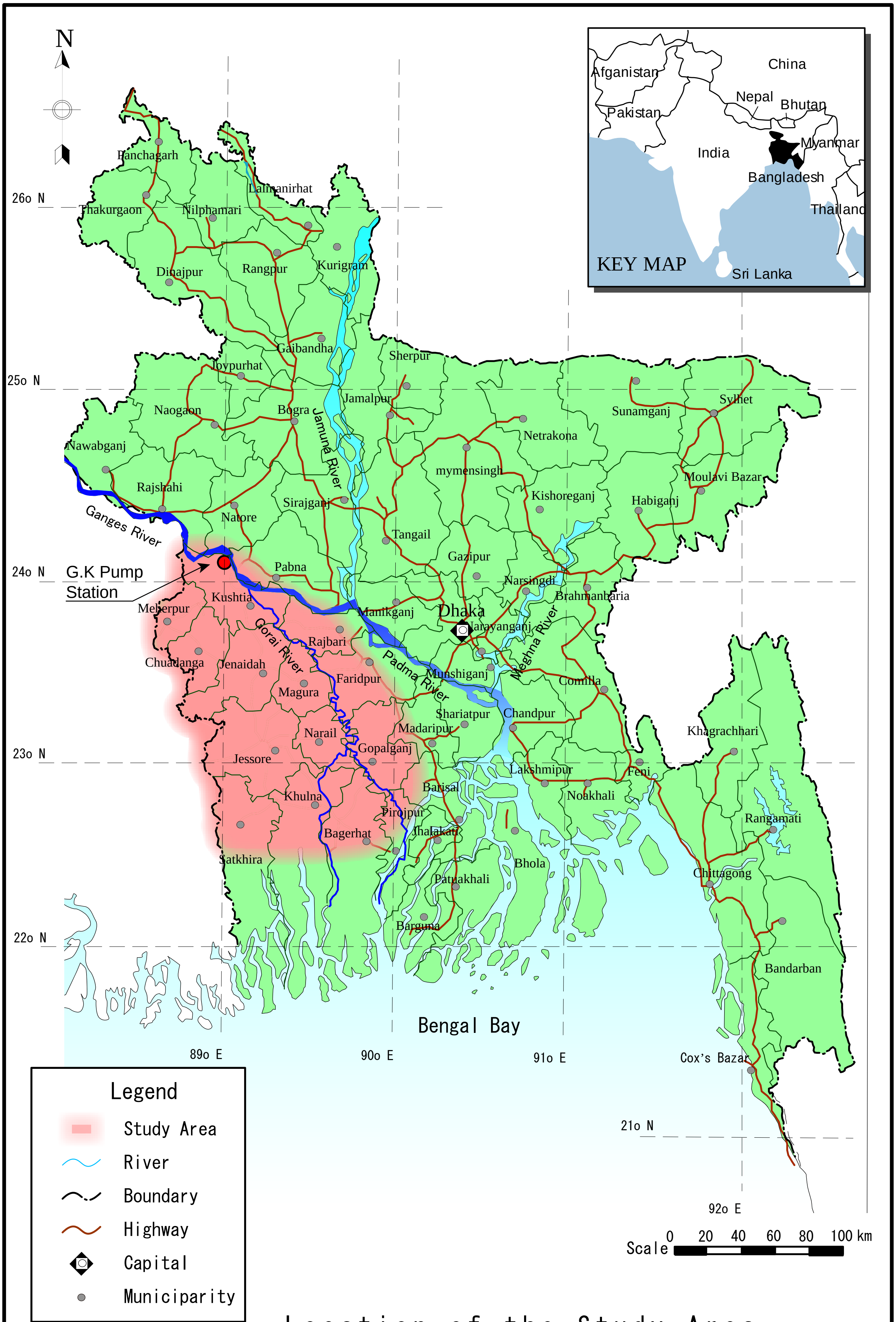

Location of the Study Area

ABBREVIATIONS

Abbreviation	English
ADB	Asia Development Bank
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
BWFMS	Bangladesh Water and Flood Management Strategy
CAD	Command Area Development
CADP-II	Second Command Area Development Project
DANIDA	Danish International Development Assistance
CDC	Citra Development Centre
CPP	Cyclone Preparedness Programme
DMB	Disaster Management Bureau
DoE	Department of Environment
DoF	Department of Fisheries
DPHE	Department of Public Health Engineering
DPP	Development Project Proforma/Proposal
DR	Direct Runoff
DRR	Department of Relief & Rehabilitation
DTW	Deep Tube Well
ECC	Environmental Clearance Certificate
ECNWRC	Executive Committee of the National Water Resources Council
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ETcrop	Crop Evapotranspiration
ETo	Evapotranspiration
FAP	Flood Action Plan
FCD/I	Flood Control, Drainage and Irrigation
FCPO	Flood Plan Coordination Organisation
FD	Forest Department
FFWC	Flood Forecasting and Warning Centre
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GKIP	Ganges-Kobadak Irrigation Project
GOB	Government of Bangladesh
GRDP	Gross Regional Domestic Product
GRR	Gorai River Restoration Project
GWR	Ground Water Recharge
GWT	Ganges Water Treat
HDI	Human Development Index
HPI	Human Poverty Index
HYV	High Yielding Variety
IEE	Initial Environmental Examination
ITCZ	Inter Tropical Convergence Zone
IPSWAM	Integrated Planning for Sustainable Water Management

IWM	Institute of Water Modeling
IWMP	Integrated Water Management Project
Kc	Crop Coefficients
LCG	Local Consultative Group
LGD	Local Government Division
LGED	Local Government Engineering Department
LLP	Low Lift Pump
MC	Main Canal
MoA	Ministry of Agriculture
MoFDM	Ministry of Food and Disaster Management
MoWR	Ministry of Water Resources
NGO	Non-Government Organization
NPDM	National Plan for Disaster Management
NWMP	National Water Management Plan
NWR	Net Water Rate
NWP	National Water Policy
NWRC	National Water Resources Council
O&M	Operation and Maintenance
PPWP	Pilot Priority Work Program
PRSP	Poverty Reduction Strategy Paper
PPTA	Project Preparation Technical Assistance
RAB	Rapid Action Battalion
RRI	River Research Institute
SAIWRPMP	Southwest Area Integrated Water Resources Planning and Management Project
SOD	Standing Orders on Disaster
SRDI	Soil Resource Development Institute
SRI	System of Rice Intensification
SSWRDP	Small Scale Water Resources Development Project
STW	Shallow Tube Well
SWMC	Surface Water Modeling Centre
TDS	Total Dissolved Solids
TRM	Tidal River Management
TW	Tube Well
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
US$	United States Dollars
WARPO	Water Resources Planning Organization
WASA	Water and Sewerage Authority
WMG	Water Management Group
WB	World Bank
WMIP	Water Management Improvement Project
WHO	World Health Organization

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DATA COLLECTION SURVEY ON WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST AREA OF BANGLADESH

(SUMMARY REPORT)

Table of Contents

1. INTRODUCTION

1.1 Objective of the Survey

The objective of the Survey is to furnish JICA with information regarding the needs and issues on water resources management in the southwest area of Bangladesh, for possible future cooperation with the country.

1.2 Target Area

The target area of the Survey is the northeastern part of Bangladesh's southwest region. The borders of the target area are the Ganges River on the north, the Gorai River basin on the east, and the border to India on the west. The southern border is set at Khulna City. The Survey area consists of 14 related districts out of the 26 districts in the southwest region, as follows:

Maherpur, Chuadanga, Jhenaida, Magura, Jessore, Narail, Kushitia, Rajbari, Faridpur, Gopalganji, Bagerhat Satkhira, Pirojpur and Khulna.

Fig. 1.1 shows the location of the target area.

Fig. 1.1 Target Area of the Survey

1.3 Assigned Experts and the Schedule

JICA organized a survey team with selected consultant-experts (the Survey Team), consisting of a team leader with specialty in water resources, a river engineering specialist, a hydraulic engineering specialist, a sediment hydraulic specialist, an irrigation engineer and an institutional specialist. In addition, six local engineers were employed to assist the Survey Team.

The Survey Team commenced the works in March 2010 and continued survey tasks for four months. During said period, the Survey Team held a meeting on 25 May 2010 with JICA Head Office and JICA Bangladesh Office, through visual telephone system to report the progress of the survey. On 29 June 2010, the Survey Team held another meeting at the conference room of the BWDB, to present the findings. Agencies and organizations concerned with the undertaking attended the meeting. Both meetings were useful in clarifying the survey results. The draft final report related to the survey was prepared and submitted to JICA on 16 July 2010. After receiving comments, the Survey Team further reviewed and modified the findings deemed necessary, then finalized the report. The Survey Team submitted to JICA the "Final Report on the Data Collection Survey on Water Resources Development in Southwest Area of Bangladesh" on 25 August 2010.

Potision	Name	FY 2009		FY 2010					
		2	3	4	5	6	7	8	9
Team Leader /Water Resources Management	Norio TAKAYANAGI								
River Planning	Yasuhiro AZUMA								
Hydrology /Hydraulics (Water Supply)	Naoki YAMASHITA								
Hydrology /Hydraulics (Sediment Flow)	Haishan JIN								
Irrigation Planning	Takashi KURAUCHI								
Institution and Organization	Mabubu REZA								

Fig 1.2 Staffing Schedule

2. The Planned Approach

2.1 Required Information and Works

The required information should substantially include the needs and issues on water resources management in the target area, to determine the appropriate fields for JICA's cooperation program. A certain preliminary processing of data is necessary to diagnose the on-going water resources management in the target area to identify consequent needs and issues. There could be some issues that will emerge in the near future, which must be identified as well. In order to identify such issues, some preliminary analyses, such as a water demand and supply balance study, are necessary on the basis of the data obtained. The Government of Bangladesh and some donors are already tackling or have plans on how to handle some of the issues thus identified. Hence, JICA's intervention is not necessary for such issues to avoid duplication of activities. These already contemplated issues are to be excluded from the list of subjects under JICA's future cooperation program. Lessons learned from the on-going or completed projects are also important information for JICA to consider for its future cooperation program.

2.2 Planned Approach

The survey identified the needs and issues on the basis of the data and information collected and preliminary analyses conducted. The logical flow of the approach adopted is presented in Fig. 2.1.

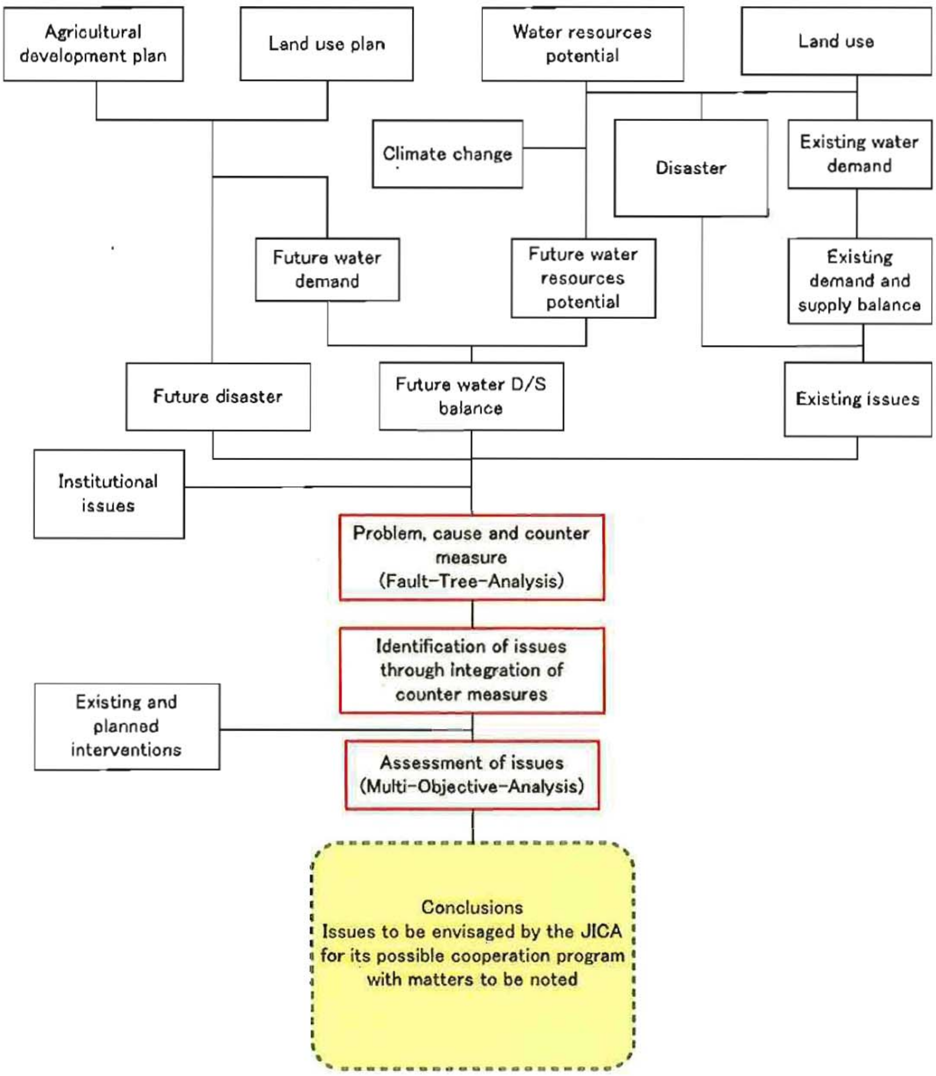


Fig. 2.1 Logical Flow of the Planned Approach

3. The Adopted Method of Data and Information Collection

3.1 Adopted Method to Collect Data and Information

In view of the available time and resources to perform the survey, the Survey Team adopted the following method of collecting data and information:

1) Interview surveys of government officials and staff of donor groups
2) Review of existing study reports and database
3) Questionnaire hearing surveys
4) Site reconnaissance surveys

3.2 Results of the Data Collection

The Survey Team visited government officials and staff of donor groups. All the offices warmly received the Survey Team and furnished them with valuable information. Said offices visited are:

Government Offices	MoWR, MoA, WARPO, BWDB, LGED, BADC, BMD, BARC, DPHE, Khulna WASA and AEO
Donor Groups	World Bank, ADB and Netherlands Embassy

The collected data include information on socioeconomic statistics, meteorology, hydrology, cropping pattern, agricultural production, disaster data and various maps. The collected documents are papers related to government's plans, Development Project Proforma (DPP) and various study reports.

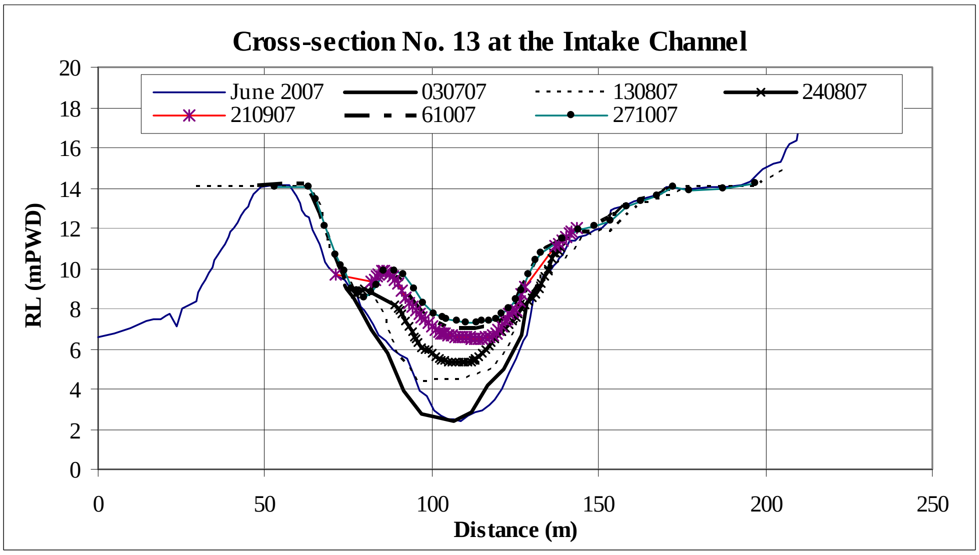
The Survey Team conducted a hearing survey to confirm the activities of the communities. There were 22 selected target communities for large-, medium- and small-scale projects. The other survey method conducted is the questionnaire survey, which aims to identify problems and causes regarding water resources management in the southwest area. The Survey Team conducted this survey in the whole 14 related districts. In each district, a government official, an urban resident, and a rural resident were selected as representatives of the district, which were designated to answer survey questions.

The Survey Team also conducted site reconnaissance surveys in the target area. The issues and needs identified were confirmed at the site.

4. Diagnosis on Water Resources Management

4.1 Identification of Needs and Issues

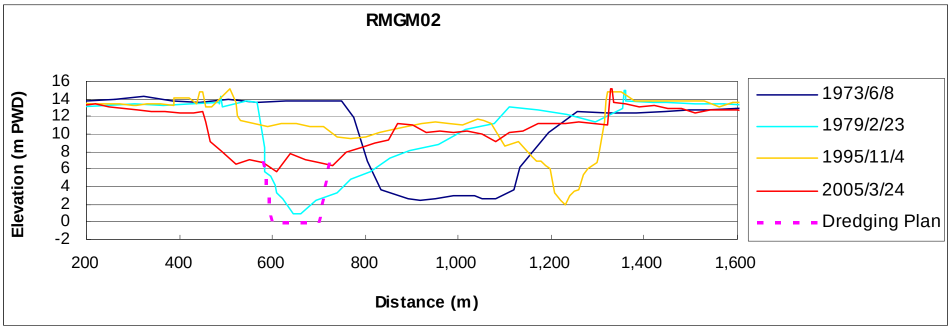
A problem regarding water resources management indicates needs of intervention to solve or to alleviate the problem. The solution is the basis of issues to be scrutinized for JICA's possible future cooperation. Along this line, the Survey Team diagnosed water resources management in the target area to identify problems, causes that brought or will bring the problems referring the collected data and information. The following figure shows an example of the collected data on the cross sectional variability of the intake canal of Ganges-Kobadak Irrigation Project (GKIP) in year 2007. The 'Hydraulic Study for Intake Canal Improvement for Urgent Rehabilitation of Pumping Facilities of G. K. Irrigation Project for Sustaining Rural Economic Development' conducted periodic cross sectional surveys in the intake canal. The figure indicates that sediment deposits in the canal during the period from July to September. The rising of the channel bed due to sediment deposition subsides in October.



Source; Hydraulic Study for Intake Canal Improvement for Urgent Rehabilitation of Pumping Facilities of G. K. Irrigation Project for Sustaining Rural Economic Development

The study conducted sediment sampling and particle size analysis in the Ganges River and the intake canal. While the average diameter of the sample from the Ganges River bed is 0.15 mm, that of the sample from the intake canal bed is 0.06 mm. The result of the study further provided the Survey Team notable information that the particle size of suspended sediment in Ganges River varies from 0.001 mm to 0.1 mm, with the average at 0.04 mm. The survey team could assume that the suspended sediment in Ganges River plays an important role of the sediment deposition in the canal. Furthermore, the silting process in the intake canal could be applied in that in the Gorai River. The following figure copied from the Gorai River Restoration DPP shows a long period variability of the Gorai River channel. The flow area at the section narrowed remarkably after 1995 due to sediment deposition in the channel.

Channel Variation of the Gorai River



Source; DPP for Gorai River Restoration

For this survey, all the data collected are indicative in identifying the problems and their root causes. The Survey Team further conducted preliminary future water demand and supply balance study in the target area to identify potential problems.

Conceivable countermeasures were studied to remove or alleviate the identified causes. The Survey Team applied the Fault-Tree-Analysis (FTA) method to conduct the works discussed above in a comprehensive manner. The FTA is commonly utilized in automatic diagnosis of electronic equipment systems. While the identified problems and causes are the basis of the needs, the conceivable countermeasure becomes a component of the intervention or issue to be proposed.

4.2 Fault-Tree-Analysis

Water resources management has three missions namely, management for water utilization, management for prevention from water-related disasters, and management for water conservation. The developed Fault-Tree defined the problems for each mission. The identified problems for the water utilization mission are seven including the interruption of the Gorai River flow due to the sediment deposition in the river channel. There are five problems on disaster prevention, including flooding in the area due to the insufficient drainage capacities of rivers. Salt water intrusion to ground water is an identified problem regarding the water conservation mission, which has two more additional problems. There are 72 identified root causes that are supposed to incur the 15 problems in total. Conceivable countermeasures are 81 which are expected to be effective to remove, or at least alleviate the 15 problems.

The Survey Team presented the developed Fault-Tree to government staff members concerned in the 29 June 2010 meeting to explain the findings of the study held at the conference room of BWDB. The Study Team accordingly revised the FT reflecting the comments given by the participants in the meeting.

The finalized FT is presented in the following pages;

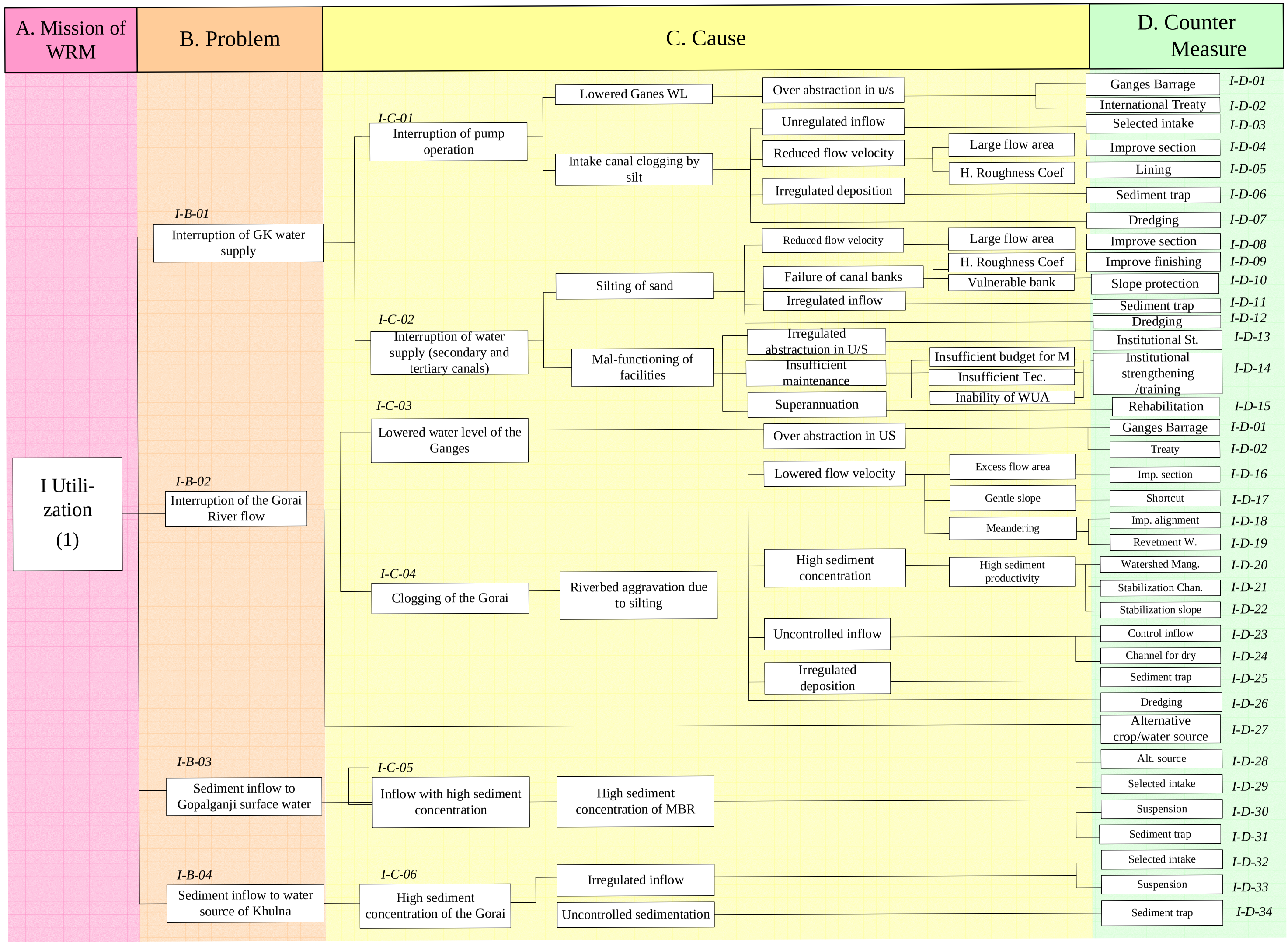
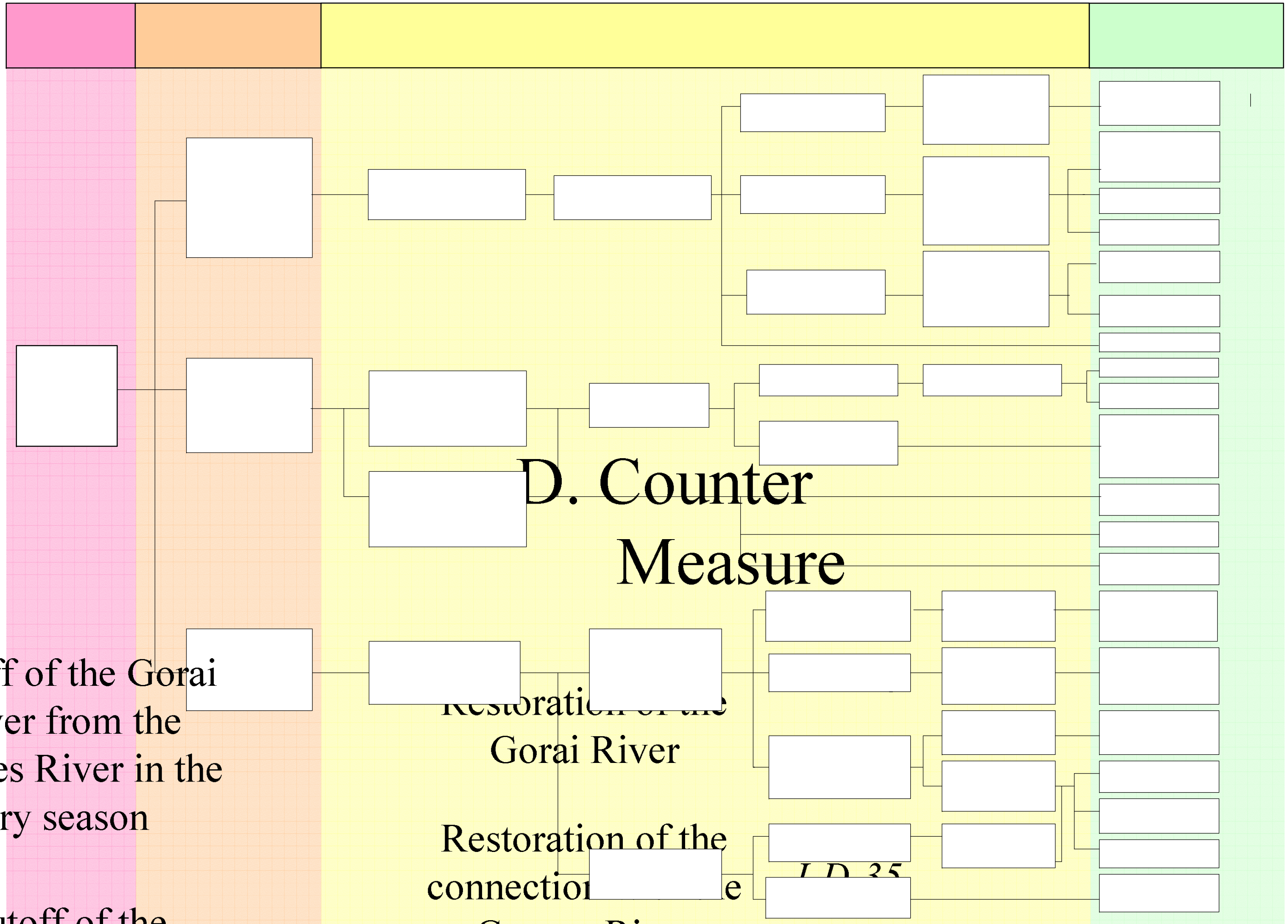


Fig. 4.1-1Fault-Tree (Water Utilization-1)



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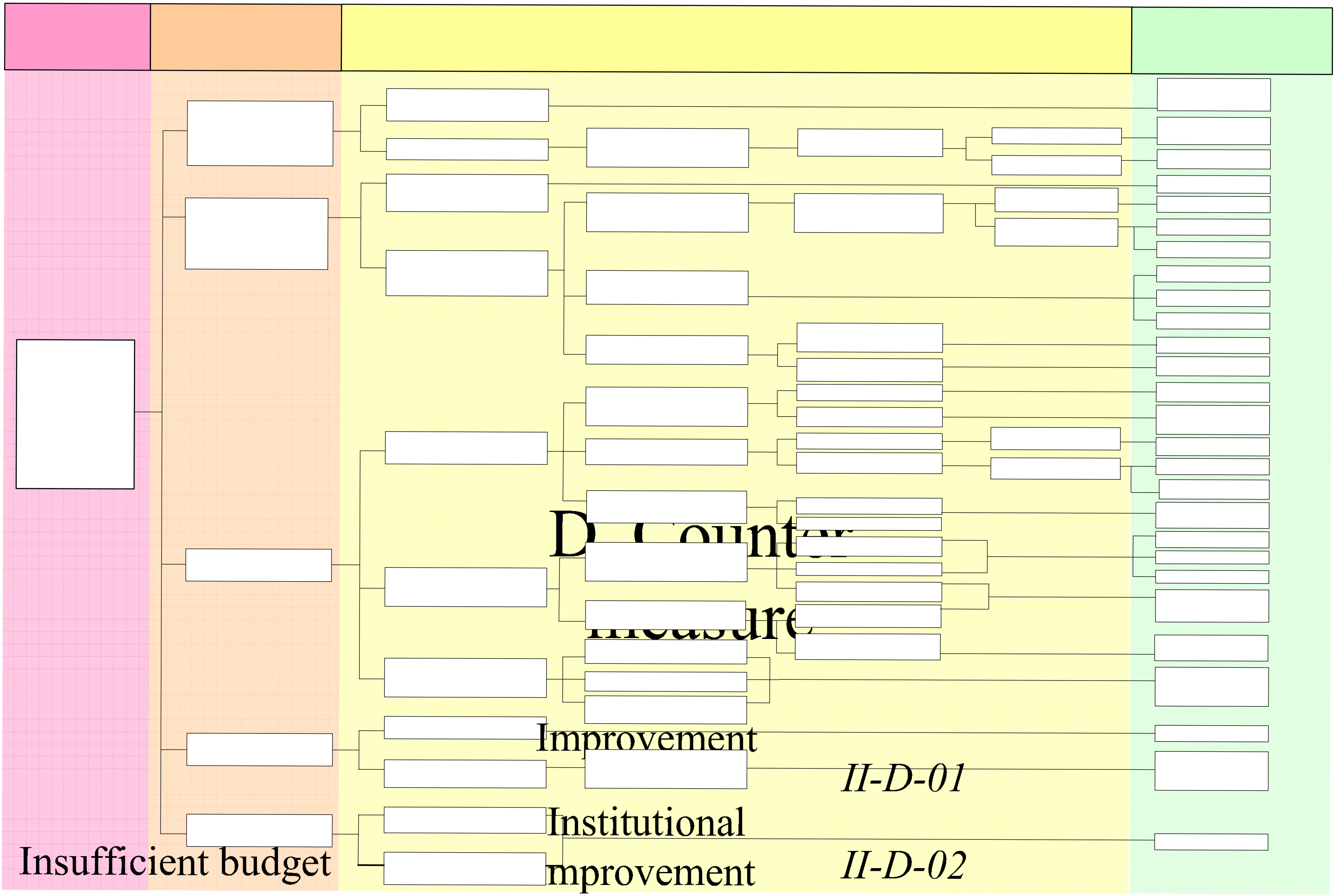
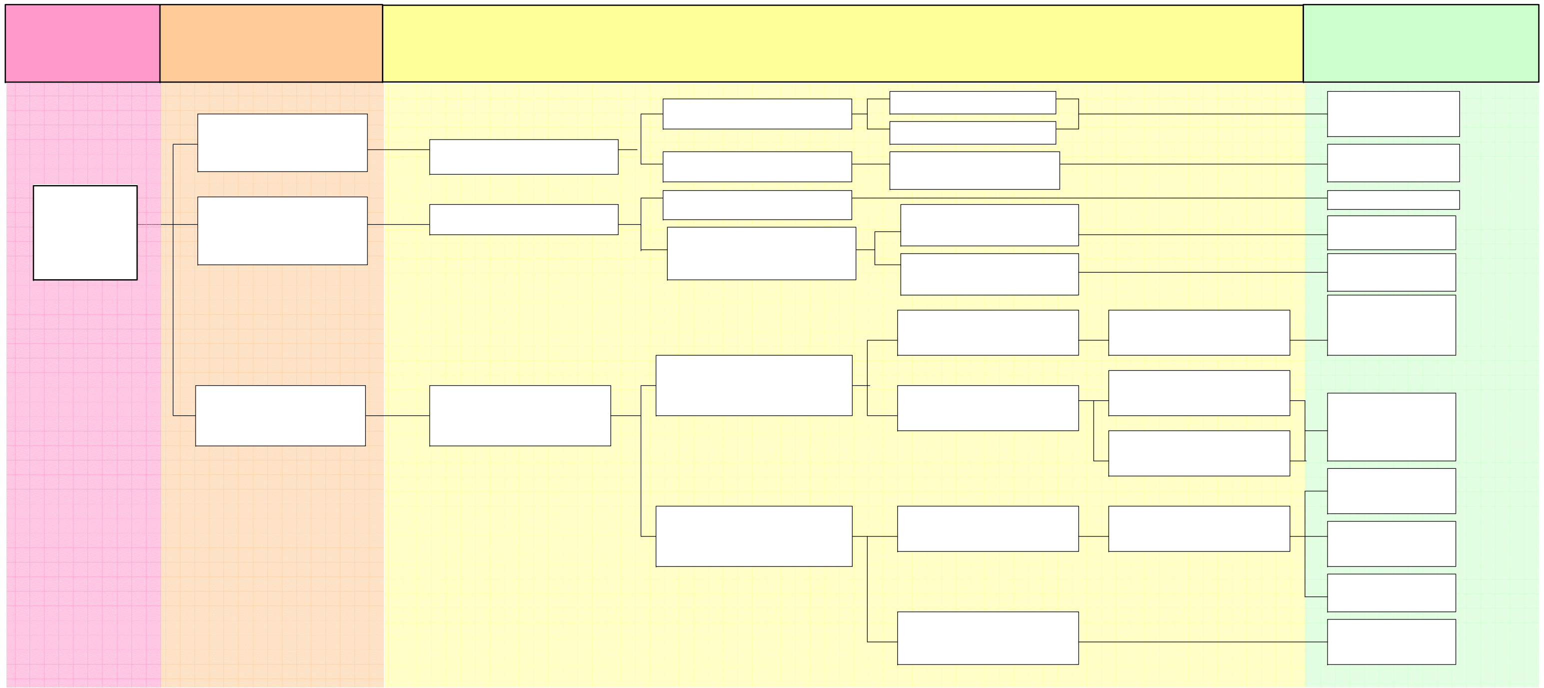

D. Counter
measure
Improvement
II-D-01
Institutional
mprovement
II-D-02
Insufficient budget
nt maintenance
Lack of awareness
Participation
II-D-03
Improvement
II-D-04
Sediment runoff
f drainage bed
o siltation
Production cotrol
II-D-05
TRM
II-D-06



D. Counter Measure

ry period

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5. Identified Issues

5.1 Integrated Water Resources Management

The Survey Team adopted the concept of integrated water resources management in identifying the issues. Each countermeasure that was proposed in the former chapter is useful solely in solving a relevant problem. However, relying too much on a countermeasure is likely to bring about another problem since these countermeasures could cause adverse impacts to the environment. Today, we have already loaded the environment to the warning level. Hence, the environment is sensitive to impacts to be brought by any intervention. Accordingly, it is advantageous to implement several countermeasures together to remove the cause of a problem. In this manner, the scale of each countermeasure could be reduced so as not to cause a significant impact. The countermeasures should be so integrated in order to amplify the effects by mutual reactions. Furthermore, an integration of countermeasures usually provides safer solutions because of the interpolating effects of countermeasures.

Consequently, the integration of possible countermeasures forms the issues to be envisaged by JICA. However, there are cases that two countermeasures used for one problem like Ganges Barrage and the improvement of an international treaty become two issues because the nature of the countermeasures are completely different from each other. On the other hand, two problems are integrated into one if one countermeasure is effective to solve these two problems. The countermeasure used, for example, of diverting water of the Ganges River through the extension of GKIP is effective in solving the water shortage problems in various areas.

5.2 Identified Issues Related to Integrated Water Resources Management

On the basis of the developed Fault Tree, the issues to make water resources management appropriate in the target area were identified by applying the integration principle mentioned above. Water resources management in the target area requires 13 issues to be dealt with. These issues are presented in Table 5.1.

Table 5.1 Issues identified through Integration of the Countermeasures

No	Issue	Integration of Counter Measure
1 1)	Ganges Barrage	ID01
2 2)	Promotion of cooperation on revision of International Treaty	ID02, ID20, ID21, ID22
3 3)	Rehabilitation and Extension of GKIP	ID03, ID04, ID05, ID06, ID07, ID08, ID09, ID10, ID11, ID12, ID13, ID14, ID15, ID27, ID36, ID39, ID42 and ID47（IID27）
4 4)	Maintenance of the low flow channel of the Gorai River	ID16, ID17, ID23, ID24 and ID25
5 5)	Restoration of the Gorai River	ID18, ID19, ID26, IID25 and IID26
6	Sediment Removal from Water Source for water Supply	ID28, ID29, ID30, ID31, ID32, ID33 and ID34
7	Desalination of Surface Water	ID35, ID37 and ID38
8	Development of Surface Water	ID40, (ID42), ID43 ID44, ID45, ID46, ID50 IIID01, IIID02 and IIID04
9 6)	Small Scale Water Resources Development	ID41, ID48 and ID49
10	Flood Protection in the Northern Part	IID01, IID02, IID03 and II27
11	Flood Protection in the Southern Part	IID04, IID05, IID06, IID07, IID08, IID09, IID10, IID11 and IID12
12	Restoration of Polder Dyke	IID13, IID14, IID15, IID16, IID17, IID18, IID19, IID20, IID21, IID22, IID23 and IID24
13	Development of Rural Water Supply	IIID03

Study is on-going by BWDB, Denmark and China.

1） Important issue but intervention by third party is very difficult.

2） DPP was approved.

3） Cooperation is necessary to Restoration of the Gorai River（2）。

4） Nederland Government and WB have a plan to assist for five years. Sustainable intervention after 5 years is necessary

5） LGED is conducting with cooperation extended by the JICA and ADB.

The following are the identified issues including brief descriptions of each:

1) Ganges Barrage

In the dry season, the lowered water level of the Ganges River has impeded inflow to the GKIP intake canal and to rivers in the target area such as Gorai River and Nabaganga River. The canal and rivers were dried up in the dry season. Consequently, these areas could not use surface water. Some water users have shifted to groundwater for their water source even though some are contaminated by arsenic. The proposed measure is to raise up the water level by a 1800-m long weir with 84 gates. Three new canals will convey stored water to various areas. BWDB will be the executing agency.

2) Promotion of International Cooperation

India constructed Farrakka Weir to divert water of the Ganges River during the dry season. The discharge from the weir is estimated to be around 600 m3/s, which is almost one-third of the average discharge before 1975 (the year when the weir commenced operation). The promotion of international cooperation may enhance such relationship among riparian countries and it may also facilitate in establishing a river basin management organization.

3) Rehabilitation and Extension of GKIP

BWDB conducts dredging of the intake canal from December to March in order to offtake water from the Ganges River. Water supply is interrupted until dredging is completed. The superannuated irrigation facilities hamper on-farm water distribution. This proposed measure will improve the situation. In addition, if the canal is extended, GKIP will supply fresh water even to the southern part of the area because the existing pump has surplus capacity for water demand in the commanding area. The components of the measure are: a) provision of a sediment trap; b) rehabilitation of irrigation facilities; c) extension of the system to the south; d) stabilization of the Ganges River banks; e) introduction of demand control measures such as real-time operation system, SRI and salt-bearing variety (Brritar 47); and f) institutional strengthening for water rights, water tariff collection, and OMR by the communities. The executing agency may be BWDB.

4) Maintaining of Low Flow Channel of Gorai River

The proposed GRRP will provide low flow channel to discharge water in the dry season by means of dredging. After the completion of GRRP (five years), the silting in the river channel may occur like in 2002 and thereafter. A measure to maintain the dredged low flow is necessary. A kind of spur dike may be applied for this purpose just in the case of Yodo River in Japan. The executing agency may be BWDB.

5) Restoration of Gorai River

BWDB is planning to dredge Gorai River under the assistance of WB and the Government of Netherlands. Dredging will be recurrently conducted annually for five years.

6) Sediment Removal from Sources for Water Supply

The Gopalganji supply system halts its operations from time to time during the flooding season due to the high turbidity of the water source. Enlargement of the capacity of the sediment trap is necessary to stabilize the operation. The same will become necessary for Khulna Water Supply because it is planned to tap water from the Madhmati River.

7) Desalination of Surface Water

Salt water intrudes into the surface water in the southern part of the area. Provision of an estuary barrage is a countermeasure.

8) Development of Surface Water

Water shortage has become a common issue in the northern part of the area since the rivers in the area were cutoff from the Ganges River. Silting in the river channel and the lowered water level of the Ganges River are the causes of the issue. Restoration of these rivers is the countermeasure for this issue.

9) Small-Scale Water Resources Development

Water impounding and storage in conveyance canals and beels are effective for small-scale water resource development. Such small-scale storages could harvest rainwater. LGED is conducting this measure under the assistance of the Government of Japan and ADB.

10) Flood Protection in the Northern Part

Sediments are deposited in drainage canals. Therefore, discharge capacity has deteriorated. Dredging of channels and stabilization of channel slopes will reduce flooding.

11) Flood Protection in the Southern Part

Tidal sediments have silted the drainage channel and caused flooding. BWDB is providing TRM. In many cases, TRM functions well and flooding occasions are reduced.

12) Restoration of Polder Dike

When Cyclone Aila attacked the coastal area, many polder dikes were breached. Several breached dikes are yet to be restored.

13) Development of Rural Water Supply

A substantial number of people depend on groundwater for their domestic use even though they are aware of arsenic contamination in some groundwater. A public water supply system using surface water is necessary. Facilities for intake, conveyance, treatment and distribution are necessary.

6. Existing Plans of the GOB and Other Donors

In the target area, there are several water resources management projects that are being handled by the government, of which many are closely related to the issues proposed in the previous chapter. Furthermore, there are some that are planned by other donors for technical and financial cooperation with the government. These are as follows:

Ganges Barrage

BWDB is conducting a feasibility study and detailed engineering of the Ganges Barrage Project in order to secure water abstraction from the Ganges River during the dry season by damming up the water level and providing a river crossing barrage. The study has narrowed down the location into two proposed sites. The plan proposes 84 gates with ship lock and fish passes, and is considering hydropower generation and water diversion through three main canals. The Governments of Denmark and China are cooperating on the Study.

Restoration of Gorai River

BWDB has a plan to conduct capital dredging for two years in Gorai River and then maintenance dredging for the succeeding three years. The main works envisaged in the plan are: dredging of the river for 30 km from the mouth with a bed width of 100 m, provision of a bifurcation in front of the river mouth, and embankment along Ganges River and Gorai River at the bifurcation. The plan considers the provision of revetment works for Gorai River channel as well. The Netherlands Government and World Bank have offered technical and financial cooperation intended for the plan. BWDB conducted dredging works in the last dry season to provide a low flow channel in Gorai River.

Small-Scale Water Resources Development

LGED is conducting small-scale water resources development projects all over the target area. The project strengthens flood protection embankments, restores the drainage channel, and enlarges canals to store water for the driest periods. The project rehabilitates small water storages (also known as beels) to harvest rainwater. The project is supported by the Government of Japan and ADB.

Tidal River Management (TRM)

Sediments carried by the high tide are deposited in the river channel at the southern part of the target area. The deposition elevates the riverbed and decreases the flow capacity of the river. Flooding is rather frequent in the southern part due to the deterioration of drainage capacity. BWDB is conducting TRM to solve the problem. TRM aims to guide tidal water with high sediment concentration to depressed land (beel), and return water with less sediment concentration to the river. A part of the sediment is deposited in beels,, thus deposition in the river channel is controlled. Flow capacities of some river channels have been restored as a result of the provision of TRMs. The measure is effective if sufficient beels are available at appropriate sites.

Integrated Water Resources Management Project

BWDB is implementing IWRMP at the southern part of the target area. The project is a substitution for the former Flood Control, Drainage and Irrigation Project (FCDI). ADB supports the government while the Narail and Century Beel Projects are being implemented.

Restoration of Polder Dikes

Cyclone Aila brought significant damages to the southwest region on 25 May 2009. The high tide and waves breached polder dikes, especially in the coastal area. BWDB struggled to restore polder dikes in which many donors assisted the government. There are some which remained submerged and are yet to be restored since dewatering for construction works is difficult.

7. SCREENING OF ISSUES AND CANDIDATE ISSUES

7.1 Screening of the Identified Issues

Diagnosis on the target area identified 13 issues to enhance water resources management as discussed in Chapter 5. Table 5.1 presents the identified issues. There are some which are scheduled to be implemented by the Government as described in Chapter 6. They are;

1; Ganges Barrage
5; Restoration of the Gorai River
9; Small Scale Water Resources Development
11; Flood Protection in the Southern Part by TRM

These are to be screened out from the Candidate Issues which JICA envisages for her cooperation program.

Meanwhile the issue No.2, the Establishment of International Cooperation System for the watershed management of the Ganges River including the review of the Ganges Water Sharing Treaty, is fundamental for water resources management in the Ganges River Basin. The implementation thereof is urgent. However it is not appropriate to handle by bilateral cooperation program. JICA could support the Government for this matter in a different way, such as to dispatch a specialist for the preparation of the establishment. In this consequence, this issue is screened out from the candidate as well.

In this addition, the restoration of the Gorai River and the diversion of the Ganges Water through the extension of GKIP are the alternative solutions for the salinity problem of surface water, issue No. 7 and the development of surface water issue (No.8). Further the alternatives are more practical than the solution to provide an estuary barrage at present. Consequently, the issues, No. 7 and 8 are amalgamated in two alternatives and they are screened out from the candidates.

The consequent candidate issues are selected as follows;

a) Rehabilitation and extension of GKIP
b) Maintenance of low flow channel of the Gorai River
c) Sediment removal from water source for water supply
d) Flood protection in the Northern part
e) Restoration of polder dyke
f) Development of rural water supply

7.2 The Candidate Issues

The screening process selected 6 issues as the candidates for JICA's cooperation program as discussed in the former section. The following descriptions brief the outlines of the selected 6 candidates;

<u>a) Rehabilitation and extension of GKIP</u>

There are 6 main components as follows;

1; Improvement of the Intake Canal
2; Restoration of facilities including secondary and tertiary canals

3; Extension of main canals to divert water to southern areas
4; Stabilization of the Ganges River Channel at the vicinity
5; Institutional strengthening for collection of water tariff, water abstraction and maintenance of the facilities
6; Introduction of demand management measures and new variety

Sediment deposition in the Intake Canal hampers the water abstraction for about 3.5 months in the dry season until the dredging works completed. The improvement of the Intake Canal controls the deposition and shortens the dredging period to one month. The key improvement works is to provide a sediment trap at the uppermost reach of the Intake Canal. The sediment trap will shorten the interrupted period of water supply from on-going 3.5 months to one month.

Restoration of the irrigation facilities affords stable water supply in the irrigable areas of 140,000 ha. The crop intensity could be enhanced to 200% from ongoing 60%.

The renovated pump system has a capacity of about 130 m^3/sec in total including subsidiary. Meanwhile the estimated maximum water demand is about 80 m^3/sec although it depends on cropping pattern to be adopted. The surplus of the capacity could be availed for water supply to southern area. Extension of canal is necessary to convey water to the existing canal like the Citra River.

The Ganges River Channel has been rather stable for more than 10 years recently in the up-and downstream reaches from the intake. However there is a possibility that the river channel will change in future and stabilization is necessary to secure the sustainability of the Intake Canal.

Institutional strengthening is necessary to collect water tariff regularly from the beneficiaries. Stable and reliable water supply is imperative for tariff collection but a transparent procedure is required. Abstraction of water from the canals should be in orderly manner so that water availability of a consumer in the downstream reach is secured. In this connection institutional strengthening to encourage participation and training of farmers is necessary because water user’s associations are to be entrusted to operate and maintain the on farm facilities.

Irrigation water supply should be effective so that the surplus water could be supplied to the downstream areas. In this respect actual effective rainfall should be estimated on the basis of the measured actual rainfall. Irrigation water supply should be defined on the real time basis reflecting the measured rainfall. A special information and data processing technologies are necessary. Another demand control measure is introduction of System for Rice Intensification (SRI). The intermittent irrigation system will reduce irrigation water consumption by 40 % according to various experiences.

b) Maintenance of the low flow channel of the Gorai River

Sediment deposition in the Gorai River is significant in the upstream reach for about 30 Km. The bed elevation of the river channel becomes higher than the water level of the Ganges River in the dry season due to the silting. No water from the Ganges River could flow into the river and the river is dried up for more than 4 months. The southern part in the target area has depended on the Gorai River for its fresh water source and is suffered from water shortage.

BWDB has a plan to restore the River providing mainly a bifurcation, revetment works and dredging for five years (Restoration of the Gorai River). This maintenance of the low flow channel of the Gorai River is the issue to enhance the sustainability of the restoration achieved by Restoration of the Gorai River. The main component of this issue is to provide spur dykes (groins) which control flow direction in the river channel. The spur dykes could concentrate the flow along the low flow channel provided by the dredging works even in the period from the latter half of the high flow season and the beginning of the dry season. The flow could have sufficient traction force in the low flow channel and could discharge the sediment coming from the Ganges River.

The cross sectional profiles of the Gorai River Channel indicate the contrary situation of erosion in the 100 Km downstream from the mouth in the recent 10 years. The sediment discharge from the upstream reach by this issue will restore the river channel in the downstream reach.

The issue requires a detailed hydraulic study before it is implemented because the response of a river against an intervention is complicated. And yet, adaptive implementation is crucial because the flow conditions of the Ganges River are changeable. A detailed monitoring on the effect of provision of a pair of spur dyke is necessary before another pair is installed.

There is a possibility to install more than a hundred pairs of spur dykes. The materials of the dyke should be produced in the vicinity of the site.

c) Sediment removal from water source for water supply

The water supply of Gopalganji rely a part of water source on surface water. It suspends water abstraction from time to time in case the turbidity of the water source is high. The sediment trap owned by the DPHE office which treats the abstracted water is superannuated without proper maintenance and the function is deteriorated.

Rehabilitation or provision of sediment trap is necessary to treat water. The sediment concentration in dry period is very low and it is not necessary to utilize sediment trap in this period. The maintenance works of the sediment trap in this period will not affect water abstraction if abstracted water is conveyed bypassing the sediment trap. There is a slight difference in the sediment concentration along the depth. The concentration of top water is low as compared with that of bottom water. Sediment control could be efficient if a pump could abstract water with low sediment concentration.

The main components of this issue are;

1; Rehabilitation or provision of a sediment trap
2; Provision of a channel which bypass the sediment trap
3; Provision of floating pumps

d) Flood protection in the Northern part

The rivers in the northern part of the target area have degraded their flow capacity due to deposition of sediments. The river bank erosion is the main sources of the sediment followed by surface erosion. There are some sections where local people constructed small dams to intake water in the dry period. Such dams have impeded the river flow as well and have caused flooding in the wet season if a heavy rainfall is received in the catchment area. Restoration of flow capacity is necessary removing such impediment. Revetment works to stabilize river channel is necessary as well to reduce sediment production and conserve lands. Institutional strengthening is prerequisite to restrict the encroachment of local people to the river channel and to encourage participation of the local people to maintain desirable river channel. The components of the issue are as follows;

1; Dredging and excavation to remove the deposition of sediment in the rivers of Mathabanga, Nabaganga, Citra, Kumar, Bhairab, the Citra and others
2; Revetment works
3; Institutional strengthening to manage the right-of-ways and to encourage participation of local people to maintain river channel

e) Restoration of polder dyke

Low lying target area is protected from flooding by polder dyke especially in the southern part. The height and width of the dyke are deteriorated in some portions. Enforcements of the embankment are necessary in those portions. Some drainage facilities such as gates are superannuated and do not function well. The necessary components are as follows;

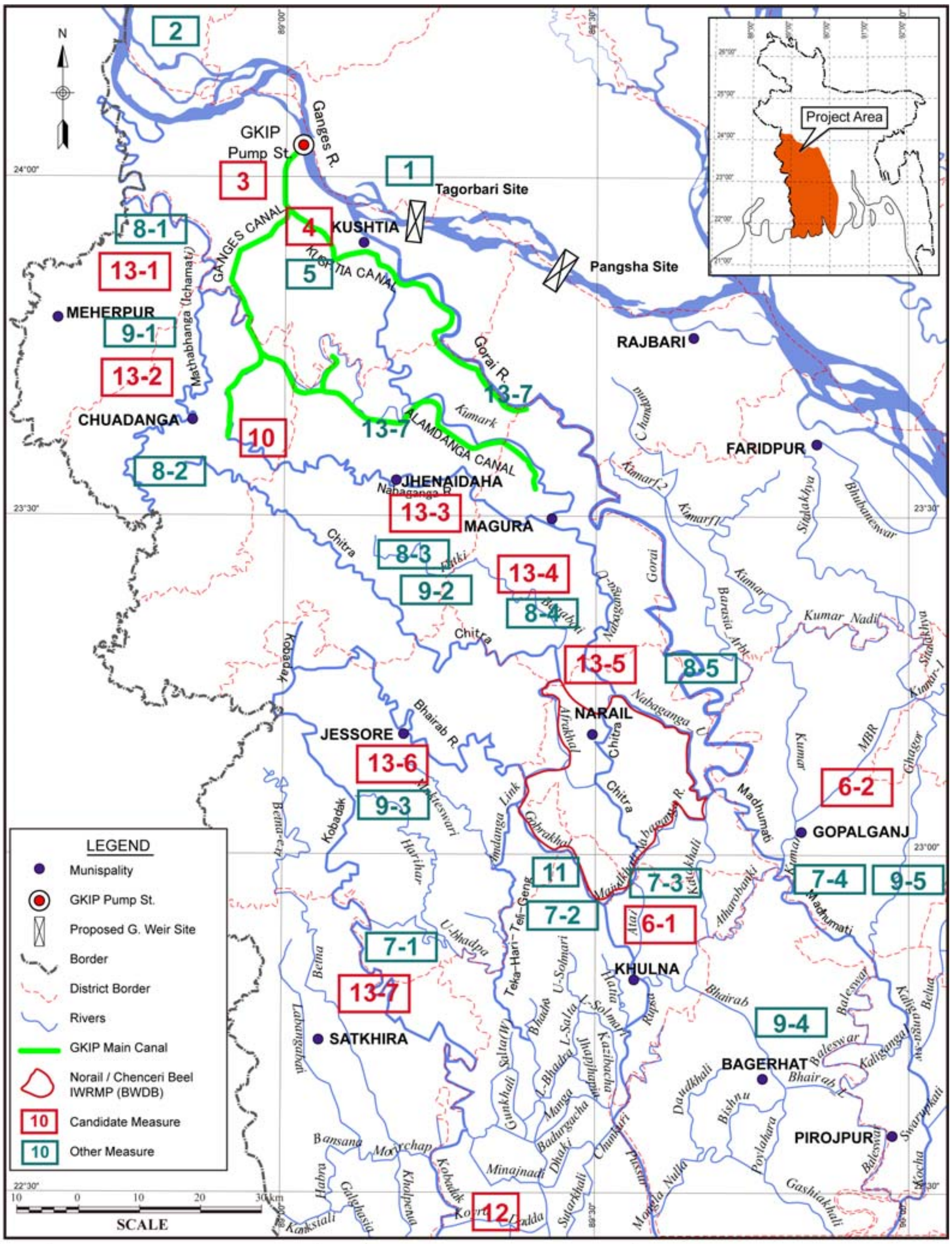
1; Enforcement of embankment
2; Rehabilitation of drainage facilities
3; Strengthening of institution to encourage participation of local people to operate and maintain the drainage facilities

f) Development of rural water supply

Unconfined ground water is the main source of water supply systems although 30 % thereof are affected by arsenic contamination and they are dried up in the driest period. It is hard to sift water source from the unconfined ground water to surface water because dependable surface water source is limited and the cost for treatment is high considering the size of the population. A part of the dependable water source problem could be solved by the extension of GKIP, the first issue. Accordingly the first priority should be vested on the security of people and rural water supply system should be considered. The main components of the issue are as follows;

1; Provision of intake facility
2; Provision of water treatment facility
3; Provision of distribution system
4; Institutional strengthening to establish government subside system for water supply and to establish water tariff collection system

The issues identified and the selected issues are depicted on the following Fig.7.2.1.



No.	Counter Measure	No.	Counter Measure	No.	Counter Measure
1	Ganges Barrage	6	Protection of Water Source from Salinity	11	Protection of Southern Part from Flooding
2	Promotion of International Cooperation for River Basin Management	7	Protection of Surface Water from Salinity	12	Restoration of Polder Dike
3	Rehabilitation and Extension of GKIP	8	Development of Surface Water	13	Development of Rural Water Supply System
4	Maintenance of the Gorai River Low Flow Channel	9	Small Scale Water Resources Development		
5	Gorai River Restoration Project	10	Protection of Northern Part from Flooding		

Note: 10 Candidate Measure

Fig.7.2.1 Identified and Candidate Issues

8. Assessment of Candidate Issues

8.1 Policy of Cooperation and the Assessment of the Issues

There are several policies which form the framework of the cooperation by the Government of Japan. According to the policies, the basic and common targets of the cooperation are social development and human security. The targets are consistent with the concept of the National Water Policy and National Water Management Plan of Bangladesh. The strategic issues to achieve the target are economic development, poverty reduction, enhancement of sanitary conditions, disaster prevention, and food self-sufficiency in Bangladesh. These strategies are intended for the enhancement of agricultural productivity, supply of safe water, protection from flood and inundation, and alleviation of water shortage in the target area, in relation to water management. Along this line, the criteria to assess the candidate issues are developed as follows:

i) Contribution to enhance agricultural production
ii) Contribution to supply safe water
iii) Contribution to protect the communities from flood and inundation
iv) Contribution to mitigate water shortage

Candidate issue a) - Rehabilitation and extension of GKIP, as presented in Chapter 7, directly contributes to three out of the four criteria. The maintenance of the low-flow channel of the Gorai River also contributes to two out of the four criteria. The issue on removing sediment from water contributes to the supply of safe water. The flood protection issue contributes to the third criterion. Restoration of polder dyke contributes to agricultural production in addition to flood protection, although such contribution is indirect. Development of rural water supply system contributes to safe water supply criterion. It should be noted that this issue depends on the implementation of the Ganges Kobadak Irrigation Project (GKIP) issue.

Based on the assessment discussed above, the order of priority for the candidate issues should be

First priority: a), Rehabilitation and extension of GKIP
Second priority: b); Maintenance of the low-flow channel of the Gorai River
Third priority: e): Restoration of polder dikes

8.2 Confirmation of the Priority through the Multi-Objective Analysis

The proposed candidate issue for JICA's future cooperation may cause impacts to various disciplines. The degree of the advantage of each issue was preliminarily examined through the Multi-Objective Analysis, which aims to assess impacts to multiple disciplines or objectives. The adopted four objectives and the items for each are presented below:

1) Impact to the society (objective)
Enhancement of sanitary condition
Employment
Land acquisition and resettlement

Security and activation of community

2) Impact to the economy (objective)

Agricultural productivity

Food security

Poverty reduction

Cost

3) Impact to the environment (objective)

Salinity of water

Drought

River

Sander Berns

4) Readiness or urgency (objective)

DPP

Feasibility Study

Detailed Engineering Study

Other studies

For each item, the impact was assessed by assigning a score between -3 and 3. The weights for the objective and item were fixed as 1. The desirability is assessed based on two indices, namely, the total point (Gross Magnitude of Impact - GMI) and the imbalance of the impacts to objectives (DUB). GMI is the index that indicates the total benefit of the issue. Meanwhile, DUB indicates how the scoring varies among the objectives. A high DUB indicates that, for example, the issue contributes significantly to economic development but tends to cause adverse impacts to the environment.

The GMI and DUB are obtained from the equations presented in the attachment.

The estimated total point (GMI) and the degree of imbalance (DUB) are presented in the following table, together with the total score for each respective assessed objective.

Assessed Objectives	Candidate Issues					
	(a)	(b)	(c)	(d)	(e)	(f)
Impact to Society	8	3	2	5	4	4
Impact to Economy	7	4	1	1	1	0
Impact to Environment	4	8	1	3	0	3
Readiness	7	1	1	1	4	1
Total Point (GMI)	26	16	5	10	10	8
Degree of Unbalance（DUB)	0.46	1.27	0.69	1.33	1.65	1.58

Issue (a), Rehabilitation and extension of GKIP, presents the dominant result with the highest GMI and the lowest DUB. Thus, the first priority should be given to issue (a). Issue (b), Maintenance of the low-flow channel of the Gorai River, presents the second highest GMI. Its DUB meanwhile is the third lowest, and higher than that of issue (c). Since the GMI of (c) is the lowest, the second priority should be given to issue (b).

The implementation of issue (a) is urgent and could be implemented independently. A feasibility study is necessary prior to designing a sand trap. The implementation of the improvement of the intake canal, restoration of irrigation facilities and institutional strengthening should be implemented first. The implementation of stabilization of the Ganges River bank and extension work could be the second stage. In the last stage, Real-Time Operating System, SRI and introduction of a new variety could be implemented.

The study related to maintaining the low-flow channel should follow the restoration of the Gorai River.

The rural water supply should follow issues (a) and (b) to secure the water source.

Other issues have no special relation and could commence independently.

ACKNOWLEDGEMENT

Since the commencement of the field works on 19 March 2010, the Team was kindly received by the agencies visited in spite of their tight schedules. The discussions therein were indicative and useful for the survey. All the suggestions given to the Team were effective to guide the survey to an appropriate direction.

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The comments raised in the meeting held at the conference room of BWDB on 29 June 2010 steered the survey works. Taking this opportunity, the Team wishes to express its hearty gratitude to the participants for their attending the meeting in spite of their tight schedule and our short notice.

Equations applied for the Multi-Objective-Analysis

1) Gross Magnitude of Impact（GMI）by Candidates

$$GMI = \sum_{i=1}^{n} \left\{ WOB(i) \times \sum_{j=1}^{m(i)} \left(WIT(i, j) \times P(i, j) \right) \right\}$$

where,	*GMI*:	Gross magnitude of impacts of the subprojects
	WOB(i):	Relative importance of the i-th objective(=1)
	WIT(i,j):	Relative importance of the j-th item in the i-th objective(=1)
	P(i,j):	Point (= -3 ~ 3)
	n:	Number of objectives (4)
	m(i):	Number of items in the i-th objective

2) Balance of Impacts by Objectives

$$GD = \sqrt{\sum_{i=1}^{n} \left\{ WOB(i) \times (IOB(i) - O) \right\}^2}$$

$$DUB = \frac{GD}{O}$$

where, *GD*: Generalized distance of impacts of a subproject