SOCIAL PERCEPTIONS AND TECHNICAL EVALUATION OF PERFORMANCE OF SELECTED WATER CONTROL STRUCTURES IN NARAIL DISTRICT

By

Abul Bashar Mohammed Khan Mozahedy

Master of Science in Water Resources Development

Institute of Water and Flood Management (IWFM)

Bangladesh University of Engineering and Technology (BUET)

February, 2011

SOCIAL PERCEPTIONS AND TECHNICAL EVALUATION OF PERFORMANCE OF SELECTED WATER CONTROL STRUCTURES IN NARAIL DISTRICT

By

Abul Bashar Mohammed Khan Mozahedy

"Submitted to the Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET) in partial fulfillment of the requirements for the degree of Master of Science in Water Resources Development"

Institute of Water and Flood Management (IWFM)

Bangladesh University of Engineering and Technology (BUET)

February, 2011

Institute of Water and Flood Management (IWFM)

Bangladesh University of Engineering and Technology (BUET)

The thesis titled **"Social perceptions and technical evaluation of performance of selected water control structures in Narail district"** submitted by Abul Bashar Mohammed Khan Mozahedy, Roll No: M10062859P, Session: October, 2006, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Master of Science in Water Resources Development on February 12, 2011.

BOARD OF EXAMINERS

--- Chairman (Supervisor)

Dr. Md. Rezaur Rahman
Professor
Institute of Water and Flood Management (IWFM),
Bangladesh University of Engineering and Technology (BUET),
Dhaka-1000

--- Member (Ex-Officio)

Dr. M Shah Alam Khan
Professor and Director
Institute of Water and Flood Management (IWFM),
Bangladesh University of Engineering and Technology (BUET),
Dhaka-1000

--- Member

Dr. Sujit Kumar Bala
Associate Professor
Institute of Water and Flood Management (IWFM),
Bangladesh University of Engineering and Technology (BUET),
Dhaka-1000

--- Member

Mr. Md. Waji Ullah
Deputy Executive Director (Operation)
Centre for Environmental and Geographic Information Services (CEGIS),
Dhaka-1212

Candidate's Declaration

It is hereby declared that this thesis or any part of it has not been submitted to elsewhere for the award of any degree.

Signature of the student

Abul Bashar Mohammed Khan Mozahedy

Roll no: M10062859 P
Session: October, 2006

Acknowledgement

The author wishes to express most sincere gratitude and profound thanks to Dr, Rezaur Rahman, Professor, Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET), Dhaka for kindly supervising the research study. The author is indebted to him for the enormous amount of time, efforts and supports, which he has given in the whole process of the research.

The author thanks Dr. Hamidul Haque, Research Coordinator, Crossing Boundaries Project, IWFM for his valuable guidance and supports in the research works as well as in the field visits. The author thanks all officials, who have helped in the study under the umbrella of "Crossing Boundaries Project" both home and aboard.

The author thanks Dr. Musfiqus Salehin, Associate Professor, IWFM for his valuable guidance and supports in the research idea development as well as in the field visits.

The author thanks BWDB and LGED officials of the Narail district for their helps in the research, supplying relevant documents and literatures and helps during field visits and Focus Group Discussions (FGDs).

The author must express his thanks with deep sense of gratitude to local peoples, beneficiary farmers and women for their valuable helps and active participations in the Focus Group Discussions (FGDs).

The author expresses thanks relatives and friends for their supports and blessing during study.

Abul Bashar Mohammed Khan Mozahedy

Dhaka, Bangladesh

Contents

List of tables

List of figures

List of abbreviations

ADB	Asian Development Bank
BA	Benefited Area
BBS	Bangladesh Bureau of Statistics
BWDB	Bangladesh Water Development Board
BUET	Bangladesh University of Engineering and Technology
CEGIS	Center for Environmental and Geographic Information Services
EIA	Environmental Impact Assessment
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCD/I	Flood Control, Drainage/Irrigation
FGD	Focus Group Discussion
GOB	Government of Bangladesh
HYV	High Yield Variety
IWM	Institute of Water Modeling
IWFM	Institute of Water and Flood Management
IWRM	Integrated Water Resources Management
LGED	Local Government Engineering Department
LLPs	Low Lift Pumps
NGO	Non Government Organization
NS	Not Sufficient/ Not Satisfactory
O&M	Operation and Maintenance
PMO	Project Management Office
PPTA	Project Preparation Technical Assistance
PRA	Participatory Rural Appraisal
PRRA	Participatory Rapid Rural Appraisal
RRA	Rapid Rural Appraisal
S	Sufficient/ Satisfactory
SAWA	South Asian Water
SRP	Systems Rehabilitation Project
STWs	Shallow Tube Wells
SP	Sub-Project
SSWRDSP	Small Scale Water Resources Development Sector Project
SWAIWRPMP	South West Area Integrated Water Resources Planning and Management Project
TA	Technical Assistance
UP	Union Parishad
WARPO	Water Resources Planning Organization
WMCA	Water Management Co-operative Association

Abstract

Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED) have completed many water resources development projects in the coastal belt of the country in order to boost up agro-production through improved drainage, irrigation, salinity prevention and flood protection. Each project consists of various types of water control structures like embankment, canal, regulator, pipe sluice, culvert etc. Sometimes, expected outcomes may not be obtained from the projects as per design and beneficiaries show dissatisfactions and point out faults in many components.

Beneficiaries have experiences with extreme natural events like flooding, draught etc. Sociologists think that beneficiaries possess indigenous knowledge and skill from experiences, which might be integrated in planning and design of water control structures for better performance and outcomes. The claims about usefulness of the indigenous knowledge in planning and design have already been tested and the extent of this usefulness has been determined and verified in specific water control structures in this study.

Few complex and faulty water control structures (namely regulators) have been selected from a coastal district Narail. Social perceptions in performance parameters have been collected through Focus Group Discussions (FGDs). Indicator based social perceptions on selected performance parameters have been collected to measure hydrologic performance of water control structures. Performances have been cross checked and compared with technical planning and design of the structures.

Selected performance parameters in this study are drainage, flushing, water logging, salinity, water retention and flood protection. Specific indicators have been set and social perceptions have been collected for each of the performance parameters of the regulators. Finally, performance parameters have indicated relevant hydrologic performance (opening size, position, invert level and crest level) of the regulator, which has been tested technically to measure soundness of the indigenous knowledge.

Results in this study indicate that beneficiaries are competent to measure parameter performances of water control structures and to identify the discrepancies in design of hydrologic parameters. Most of the regulators score unsatisfactory in performance of drainage and flushing parameters. Out of six regulators, five regulators score unsatisfactory in drainage performance. Technical cross check of unsatisfactory regulators proves that they have smaller opening size than that of requirement.

Three regulators score unsatisfactory in performance of water logging parameter. Four regulators score unsatisfactory in performance of water retention parameter. Two regulators score unsatisfactory in performance of flood protection. All selected regulators have few unsatisfactory performance parameters. Position, invert level and crest level are relevant hydrologic parameters. Technical cross check verifies social perceptions and finds faults in the design of hydrologic parameters of the regulators.

Beneficiaries express opinion in performance of few hydrologic parameters of regulator differently from technical design. Technical design may differ within ranges and both social perceptions and technical design might be acceptable. Social perceptions might be incorporated in the design of water control structures to make it socially more acceptable.

Chapter 1
Introduction

1.1 Background

Bangladesh is the largest river based delta and floodplain of the world. About 203 tributaries and distributaries of the Ganges-Brahmaputra-Meghna systems have formed a dense river network across the country. It is an agriculture based country. Its agro-production mainly depends on proper drainage and irrigation systems by means of the river network. Prevention of salinity intrusion and protection from flood are equally important to reduce the crop damage in the coastal belt of Bangladesh. Appropriate level of drainage, irrigation, salinity and flooding are vitally important to increase agro-production. So, many water management projects have been completed throughout the whole country mostly by Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED). Each project consists of various types of water management structures like embankment, canal, regulator, pipe sluice, culvert etc.

After completion of few projects, expected outcomes could not be derived from the projects and beneficiaries showed dissatisfactions and various faults were found in many components. Duyne (1998) pointed out reasons of this situation and opined that most of the BWDB regulators were constructed without consultation of the local people about their demand and needs and without seeking their future involvement in O&M.

ADB et al. (2004) identified that past Flood Control and Drainage (FCD) schemes suffered a lot due to the management problem since local stakeholders were not included in the operation and management and they had no involvement in any phase of project planning, design, and implementation. Hence, these projects suffered from drainage congestion, water logging, severe salinity intrusion, scarcity of irrigation water and flood damage, which resulted in ineffectiveness of the projects and lowering of agricultural production.

Sometimes, it is claimed that proposals in the small scale water management projects should come up from the beneficiaries (bottom-up approach), as they know better about their needs. FPCO (1993) opined that it is essential to ensure participation of local people in full range of programmed activities including needs assessment, project identification, pre-feasibility, feasibility, design and construction, operation and maintenance, monitoring and evaluation.

Sometimes, it is thought that beneficiary stakeholders have experience of extreme natural events like flooding, draught etc. Sociologists think that local beneficiaries possess indigenous knowledge and skill, which could be used in planning and design of water control structures for better performance and outcomes. The claims about usefulness of the indigenous knowledge in planning and design need to be tested and the extent of this usefulness needs to be found out and verified in the field of water control structures.

1.2 Objectives of the study

The specific objectives of the proposed study are as follows:

i. To find out the present operational status of selected water control structures.
ii. To investigate performance of the water control structures through people's point of view.
iii. To compare the people's perceptions on performance with technical evaluation.

1.3 Scopes of the study

"Southwest Area Integrated Water Resources Planning and Management Project" (SAIWRPMP) is rehabilitating the Narial sub-project. So any study of this sub-project contributes in the better implementation of the rehabilitation project. Institute of Water and Flood Management (IWFM) has chosen this area for research study under Crossing Boundaries (CB) project keeping this notion in mind. Performance of water management infrastructures is one of the research issues of Crossing Boundaries (CB) project.

1.4 Limitations of the study

Limitations of the study can be noted as follows:

- Availability of the secondary data (i.e. base information) is limited as literature of the project planning and design is not kept in records properly by the respective agencies. Sometimes, data collected from field visits are used as secondary data, which are expected to obtain from recorded literature (secondary sources). Hence, proper comparison between field data and literature data is not made.

- This study requires season-wise field visits to verify social perceptions and observations in the field. Only three field visits have been conducted, which deems insufficient. Field visits are needed to examine extreme events like drainage congestion, flood, saline water intrusion etc. which are not made.

Chapter 2
Literature review

2.1 Introduction

Bangladesh has a long experience in water resources planning and management. During Mughal and British period, people dug canals to manage water by themselves to boost up agricultural production. A large number of water control structures (like regulator, embankment, revetment, pipe sluice etc.) were constructed mostly by Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED) in the whole country during pre and post liberation periods to meet the increasing needs of the increasing population.

Water control structures were constructed to manage water in a controlled way for the betterment of the people and to enhance societal benefits. Sometimes, these structures could not bring any benefits to the target group. Duyne (1998) opined that most of the structures were useful to the people although the level of satisfaction varies. Some of them had failed to meet the objectives as the people's participation was absent fully or partially during planning and implementation. Some of them were used to pursue entirely different objectives while they were designed for a certain purpose.

2.2 FCD/I projects in Bangladesh

Flood Control and Drainage with or without Irrigation scheme (FCD/I) is a system of water management infrastructures comprising flood embankments, regulators/sluices and networks of internal drainage/irrigation canals etc. FCD/I projects are planned and designed mostly for drainage purposes but can also be used for irrigation.

After the disastrous floods of 1954 and 1955, the United Nations employed *The Krug Mission* to study on flood control and water management in the then East Pakistan. To implement the recommendation of the mission report, BWDB (formerly EPWAPDA) had been created in 1959. One of its major outcomes was the initiation of large-scale Flood Control & Drainage (FCD) and Flood Control, Drainage & Irrigation (FCDI) projects including the protection of most coastal zones against tidal flooding (DFID et al).

Master plan (1964) suggested large size water management projects to control flood and salinity for boosting crop production. It assumed the state ownership concept in employing *Gate Khalasi* for Operation and Maintenance (O&M). 58 big projects were implemented under the FCD and FCDI by BWDB. People's participation was totally absent in those projects. Although the water control structures contributed positively, performance deteriorated considerably in terms of O&M (ibid).

Size of the water sector projects was changed after the devastating flood of 1974 when small and medium size labour intensive, low cost and quick yielding projects were emphasized. Early Implementation Projects (EIP) was the single largest water sector projects in the country started in 1975.

At present, there are numerous FCD/I projects at small scale throughout the country. Area of these projects is about 1000 hectares. Objectives of these projects are flood management, drainage, water retention for irrigation purposes, flushing and salinity prevention in the coastal area (Halcrow et al, 2004).

LGED has started infrastructure development of Small Scale Water Resources Development Sector Projects (SSWRDSPs) since 1997. Recently LGED is implementing FCD/I schemes of less than 1000 ha and transferring ownership and O&M responsibilities to local Water Management Co-operative Associations (WMCAs). Based on the successful outcomes of SSWRDSP Phase I and ongoing SSWRDSP Phase II, the follow-on Participatory Small-Scale Water Resources Project (PSSWRP) has been included in the country program for Bangladesh (Nahar, 2009).

BWDB (2008) prepares guidelines for rehabilitation works of the existing FCD projects in the Integrated Planning for Sustainable Water Management (IPSWAM) project. In step 4 (Plan formulation and finalization) of the process, it is said that both primary (direct beneficiaries) and secondary (implementing agencies) stakeholders will review jointly the options and agree upon solutions including infrastructure rehabilitation plan, Sustainable Environmental Management Plan (SEMP) and O&M responsibilities. In step 5 (Rehabilitation work) of the process, it is said that BWDB will draw on a high standard technical design in consultation with primary stakeholder group and will implement physical work in consultation with Water Management Organizations (WMOs).

2.3 Performance of FCD/I Projects

Systems Rehabilitation Project (SRP) carried out post engineering evaluation of various water control structures in BWBD. In this evaluation, major emphasis was given on the assessment of existing condition, appropriateness and effectiveness of the rehabilitated and constructed infrastructures. Approaches to planning and management of construction and O&M were also evaluated. Inter-disciplinary and inter-organizational teams collected pertinent data and information through review of reports, field observation and discussion with stakeholders (Nishat et al 1998).

Nishat et al (1998) assessed the successes and failures of SRP on the development of sustainable water resources management in Bangladesh in the SRP Final Evaluation Study. Structured framework of parameters for each water control structures (both qualitative and quantitative) had been used in this evaluation during field visits. Questionnaire survey was also conducted with the farmers about qualitative assessment of effectiveness of infrastructure and O&M practices.

SRP rehabilitated 55 major structures in Karnaphuli Irrigation Project, Dardaria khal, Kanchikata khal, Poder 55/1 and 64/1B subprojects. SRP evaluation study had shown that out of the total structures, 77% were found to be in good condition, 20% in reasonable condition and 3% in poor condition. The faulty gate fittings and damaged rubber seals were identified major defects of the regulators. Majority of the structures (58%) were found to be effective while 42% had not been functioning properly mainly due to leakage (ibid).

SRP constructed 30 new structures and most of them were found incomplete during field visit. The work completed so far was found to be satisfactory, except for the Surface Drainage Outlets (SDOs) in Chaptir haor. The guide walls of the SDOs had cracked and settled within three months of construction. The design of about one third of the structures was found to be inappropriate mainly due to high invert level and improper location (ibid).

Flood Action Plan (FAP)-13 (1992) was a detailed evaluation of O&M performance of 17 FCD/I projects selected jointly with FAP-12. These 17 projects were representative of a wide range of FCD/I projects, evaluated by multidisciplinary teams using a Rapid Rural Appraisal (RRA) methodology.

FAP-13 studied operation performance of selected case study projects, which mainly related to largely operation of water control structures. In most FCD projects, operation was synonymous with drainage. Virtually all projects had some operating problems, often because, drainage facilities were inadequate or could never be sufficient when embankments kept out high stages and heavy rainfall occurred over the internal catchment of the project.

FAP-13 studied maintenance of structures giving most importance. Embankments were poorly maintained although its widespread multiple use. Breaches were occurred in 11 out of 17 evaluated projects. Erosion had been notable in four of the projects and it affected ten projects to some extent. FAP-13 identified drainage congestion/water logging as a major problem in 10 out of 17 FCD/I projects and it also identified conflicts among beneficiary stakeholders as another major problem in 12 projects. It is found that most structures in the evaluated projects were in poor conditions (about 50% to 80%) and indentified planning and design problems in 12 projects, construction problems in 7 projects and O&M problems in 15 projects.

FAP-13 evaluated the existing physical conditions of the regulators/sluices and drainage channels in the selected 17 projects. Wing wall, box, apron, gate and rubber seal of regulators were evaluated technically both riverside and countryside and reported as good (G), fair (F) and poor (P). Evaluated regulators were found good mostly in wing wall (about 90%), box (about 85%) and gate (about 80%). Poor and fair conditions were found mostly in apron and rubber seal.

The evaluation study of Small Scale Water Resources (SSWR) Development Sector Projects (SSWRDSPs) Phase I, implemented by LGED, showed that about 95% of the evaluated regulators had technically satisfactory location, opening, sill and crest level (LGED, 2003).

2.4 Southwest Area Integrated Water Resources Planning and Management Project

'Southwest Area Integrated Water Resources Planning and Management Project' (SWAIWRPMP) is one of the five regional FAP studies (FAP-4) completed in 1993 (BWDB, 2005). This water management project covers the districts of Narail, Gopalganj, Jessore, Magura, Rajbari and Faridpur. This area is located in the common border of southwest and south central hydrological regions of Bangladesh which is the low Ganges river floodplain representing 27% of the total area of the country (ibid).

Halcrow et al (2004) have pointed out that since the early '60s, the Government of Bangladesh has invested heavily to develop water infrastructures, and less than optimal success has been achieved in many cases. The notion of this project has been developed to improve efficiency of the infrastructures through better water management. This project is designed in recognition of past deficiencies and to incorporate the lessons learned into the new paradigms of water management.

SWAIWRPMP is co-funded by the Asian Development Bank and the Government of the Royal Netherlands, which is being implemented by BWDB and LGED (BWDB, 2005). The overall objectives of the project are to increase economic growth and reduce poverty by improving the productivity and sustainability of the FCD/I schemes (Halcrow et al, 2004).

Halcrow et al (2004) planned the SWAIWRPMP to rehabilitate and upgrade existing FCD/I facilities of Narail subproject and Chenchuri beel subproject by:

(i) preparing Integrated Water Management Plans (IWMPs)
(ii) delivering improved water management infrastructure and support services for agriculture and fishery development and piloting mitigation of arsenic contamination and
(iii) strengthening institutions to undertake sustainable O&M of these facilities

Several water infrastructures will be constructed and existing water infrastructures will be rehabilitated under the project through holistic and participatory planning, development and management.

2.5 Narail Subproject

Implementation of the Narail Subproject had been started in 1979-80 and completed in 1984-85 (BWDB, 2005). Objectives of Narail Sub-project were to increase income and employment opportunities for landless, marginal and small farm households in the project area through enhanced agricultural and fisheries production. BWDB (2005) have identified water logging, drainage congestion, salinity intrusion and siltation as the main reasons of not giving desire benefits. ‘Participatory Improvement of Water Management Facilities and Other Infrastructure’ is a sub-component of Sustainable Water Management through IWRM in the SWAIWRPMP project. This sub-component initially addresses the implementation of the rehabilitation of two existing FCD schemes, namely Chenchuri Beel Subproject and Narail Subproject.

The Narail FCD/I Scheme Subproject is surrounded by the Chitra and Afra rivers in the east and the west respectively, having a gross area of about 31,600 ha (23,440 ha net). In this Narail sub-project, previous FCD scheme conception and design had paid insufficient attention to the specific needs of stakeholders resulting in a lack of perception of ownership (Halcrow et al., 2004).

Halcrow et al. (2004) have identified Novagram regulator, which is under severe erosion and needs reconstruction at a new location. In addition, performance of five additional regulators in the study area (including the largest Pateswari and Bagdanga regulators) is low due to leakage. Most of the sluices constructed by BWDB are not working properly and need modification.

Previous studies from SWAWRMP (DHV, 1993), SWARDP (DHV, 1998) and SWAWRMP Phase-I (2004) shows that the infrastructures which were constructed in 1981 and 1984 are not functioning well. Social surveys, Participatory Rapid Rural Appraisal (PRRA) and stakeholders consultation results also show that people are unhappy at the present situations and wants solution to their problems through implementation of rehabilitation schemes (ibid).

According to Annex B of the main report (Halcrow et al. 2004), Narail subproject (gross area is 35,000 ha.) contains proposal for rehabilitation of

(i) 10 km of existing embankment
(ii) construction of 16.59 km new embankment on Afra right bank and on both banks of Gobra khal
(iii) excavation of 0.5 km new drainage channels
(iv) re-excavation of 227 km existing channels
(v) constructions of 14 regulators
(vi) rehabilitation of 9 regulators
(vii) construction of 4 check structures
(viii) 4 nos inlets/outlets and
(ix) 16 water retention structures.

Planning, design, operation and maintenance of these construction and rehabilitation works on the existing FCD/I infrastructures will be made on a fully participatory basis and this will enhance localized water management.

2.6 Social Perceptions and Design

Abernethy et al (2001) described a methodology for quantitative measurement of the opinions of rural people who were affected by water-related development and conservation projects in Sri Lanka. Participatory Rural Appraisal (PRA) was the survey technique used in the quantitative data collection about reactions and satisfaction levels of the affected people. One statement of survey was designed in each subject areas of Ridi Bandi Ela. 12 subject areas of the 1st survey were water, agricultural advice, maintenance, agricultural inputs, labour, transport, credit, markets, post harvest facilities, health services, machinery and farm equipment. 12 subjects of the 2nd survey were water, maintenance, seeds, credit, DCO, company, agricultural advice, marketing, costs, equity SLFO, machinery and cooperation. Verbal scale was used to measure satisfaction such as 'absolutely agree', 'strongly agree', moderately agree', slightly agree' etc about the statements. Index of satisfaction was constructed based on 7 positive (agreement) and 7 negative (disagreement) scales. Mean and standard deviation of response were calculated for each statement to measure overall satisfaction. It enables project designers to obtain better insight into the wishes of the most affected people, and therefore to take better account of those wishes during formulation of projects.

Local inhabitants gain a lot of knowledge and skill from experiences and practices while living in the locality. These perceptions and knowledge could be used in the development process. Social perception is the social process of acquiring, interpreting, selecting and organizing sensory information (Wikipedia, 2008a) and Social design is the design in its traditional sense, meaning the shaping of products and services, as the creation of social reality, design of the social world (Wikipedia, 2008b).

Social design may be seen as a process that leads to human capabilities which in turn contributes to their well-being. As Amartya Sen writes, poverty is seen as deprivation of capabilities. By focusing on capabilities, Amartya Sen suggests that development within various social aspects of life may contribute to general development (ibid).

Traditional knowledge generally refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities. Traditional knowledge also encompasses the wisdom, knowledge, and teachings of these communities. Traditional knowledge may also reflect a community's interests and some communities depend on their traditional knowledge for survival (Wikipedia, 2008c).

Wikipedia (ibid) have written that indigenous and local communities have responded that their rights to control the use of their knowledge is an inherent right of self-determination, a right that is not granted by governments, but needs to be recognized and respected.

Chapter 3

Approach and Methodology

3.1 Selection of the Study Area

The south-west area of Bangladesh is still heavily dependent on the agricultural sector as the main source of income and livelihood. Numerous water control structures are constructed during post liberation period to boost up agro-production in this area. Narail subproject and Chenchuri beel subproject are two selected Flood Control and Drainage/Irrigation (FCD/I) schemes for rehabilitation under "Southwest Area Integrated Water Resources Planning and Management Project" (SWAIWRPMP). Narail Sub-project is selected as the study area because it is the designated research areas of Institute of Water and Flood Management (IWFM) under Crossing Boundaries (CB) project. For purpose of the study, eight regulators have been chosen from northern part (Compartment 1) of Narail Sub-project.

The selected area has easy access from Narail town and road communication between Dhaka and Narail is good. All the selected water control structures are in the same geographical location. They serve more or less same purposes.

3.2 Selection of the Water Control Structures

There are various types of water control structures in the study area e.g. embankment, drainage channel, regulator, check structure, inlet/outlet etc. Regulators are chosen for performance evaluation through socio-technical perceptions to maintain conformity and for better comparison in the study. Vent size of the selected regulators varies from one vent to two vents and their construction period varies from 1980 to 2008. Some of them are constructed without people's consultation and others are constructed with some degree of participation. These structures have been constructed by both Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED). Literature review shows that structures constructed by LGED have experienced some degree of people's participation. Sometimes, local stakeholders opine differently about hydrological and hydraulic design of the water control structures. To verify their idea, selected structures are as follows:

- Poradanga regulator of Chanduliar subproject
- Panu regulator of Panu subproject
- Boramara regulator of Baramara subproject
- Madhurgaera regulator and Duberbeel drainage check structure of Madhurgaera subproject
- Debipur and Seapagla regulators of Seapagla subproject
- Chamrul regulator of compartment 1 of Narail subproject

The designed functions of the selected regulators are as follows:

- Drainage of rainwater in a controlled way
- Flushing for irrigation and pollution dilution
- Prevent water logging
- Retention of rainwater and river water to facilitate irrigation
- Flood protection to prevent crop damage by flooding
- Prevention of salinity intrusion during dry season when river water becomes saline due to lack of upstream flow

Schematic diagram and relative position of the selected water control structures (regulators) are shown in the Figure 3.1. Few photographs of the selected regulators are given in the Appendix B.

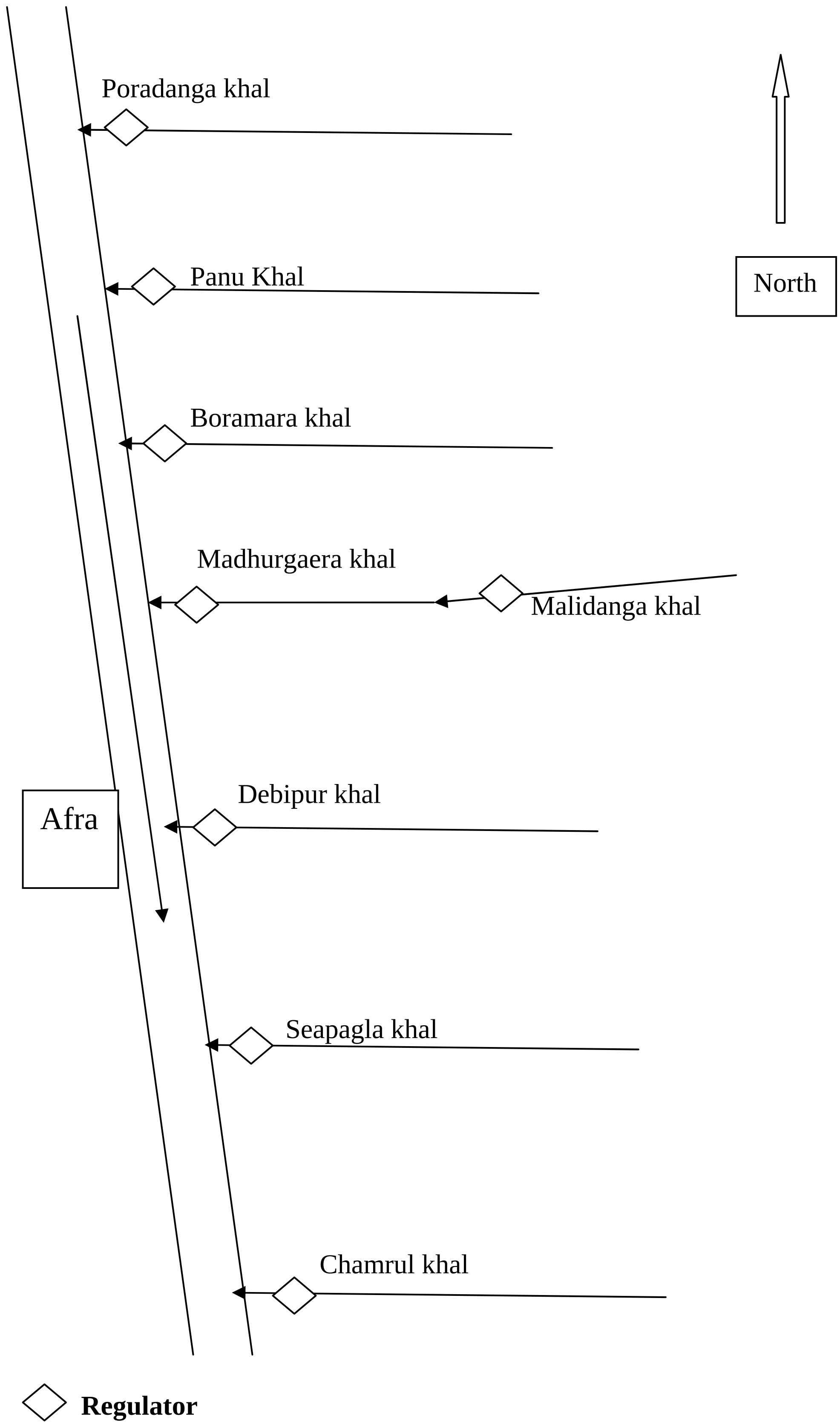


Figure 3.1: Schematic diagram of the selected regulators

3.3 Performance parameters of regulator

Regulator is an important water control structure of FCD/I projects. It is a culvert type of structure with gates to control and manage flow of water in and out of the project/benefited area. Normally it is located at the downstream off take of a discharge canal where it takes off water from the entire catchment. Objectives of a regulator are usually to drain out water in time to prevent crop damage from drainage congestion, maintain flushing, prevent water logging, control salinity intrusion, retain water for irrigation and protect project area from flooding. Performance of a regulator depends on its usefulness to fulfill these objectives.

Drainage

Drainage is an extremely important parameter influencing the water regime and agricultural production. After precipitation, infiltration and percolation take place and excess rainfall creates runoff. Runoff volume increases as duration of the rainfall increases due to moisture saturation of the soil. Runoff accumulates in the low land from high land by gravity and low land becomes deeply inundated. If the opening of the drainage channel or structure is not adequate enough, water becomes congested. Prolonged water congestion damage standing crops especially T. Aman. Ease of drainage depends on the opening, invert level and location of the regulator. Length of the drainage path across the catchment is also important as determining factor for drainage time.

Flushing

Flushing is the washing out system of the agricultural land. Flushing is a process where normally tidal or flood water enters into the agricultural land during flood tide or during high flood level in the river and subsequently leaves out the land into the river during ebb tide or during recession of the flood water. Flushing is an important parameter of water control structures. Flushing maintains soil fertility and moisture level within the poldered area. Opening size of the regulator determines timely flushing in and flushing out and maintains regularity in the canal section through appropriate water velocity. Standard flushing velocity is around 1.0 m/sec (BWDB, undated). Lower velocity may create siltation/sedimentation on the canal bed and higher velocity may create erosion on the canal bed.

Water logging

Water logging is the prolonged and seasonal water congestion. Normally rainfall runoff accumulates into low pockets of the catchment. The accumulated water cannot drain out due to absence of proper drainage system. The water logging may persist for 1-2 months unless it dries out by evaporation after monsoon season.

Permanent water bodies and wetlands such as haors, baors, pond, perennial rivers, beels etc. are not considered as water logging in this regard. Main causes of water logging are as follows:

- unplanned road networks,
- lack of proper canal networks within the catchment
- faulty and elevated invert level of the water control structures
- massive sedimentation in the river bed reduce the conveyance capacity of the canal

Salinity

Salinity is a major problem in boosting agro-production in the coastal belts of Bangladesh. Fresh water flow in the river pushes saline water interface towards sea. But this saline water interface moves upstream during dry season due to insufficient flow of water in the river. Recent years, this situation becomes severe due to water diversion from Ganges at Farakah. River water becomes totally saline during the months of February and March every year. Tidal fluctuation of water level pushes saline water into the crop field and damage standing crop. One of the major functions of the regulator in the tidal zone of Bangladesh is to prevent saline water intrusion into the crop field from canals and rivers.

Water retention

Water retention is an important objective of many Small Scale Flood control, Drainage and Irrigation projects in Bangladesh. Water is retained in the canals and artificial reservoirs. Farmers use the retained water to irrigate crop field by LLPs and other means of irrigation systems. There are two methods of collecting and storing water in the canal. Rain water is retained in the canal by closing lifting gates of the regulator in a controlled way so that flooding does not occur in the field. Secondly fresh water is allowed to enter in the canal from river during high tide (most effectively during spring tide) and this water is retained by closing the regulator gate before ebb tide starts. Capacity of water retention depends on regulator location, its invert level and opening size along with canal section.

Flood protection

Historically Bangladesh is a flood prone country because of its geographical location. It is common that flooding damages standing crops in the field fully or partially almost every year. FCD/I scheme usually creates polder in the project catchment with the help of embankments and regulators. Therefore, flood protection is an important objective of regulator. Regulator should be leakage free and it should have sufficient strength to withstand hydrostatic pressure during flood. More importantly its crest level should be sufficiently high so that flood water cannot flow over the crest. Regulator should be designed in such a way so that it always maintains sufficient freeboard during normal flood water level.

3.3.1 Parameter wise performance indicators

The responses of local beneficiary to performance indicators of water control infrastructures are collected through Focus Group Discussions (FGDs) in this study. For the purposes of the study, performance indicators of each parameter are selected and calibrated carefully through literature review, field survey, and consultation with experts and using own technical judgments. Checklist of the selected indicators for FGDs is attached in Appendix A.

Drainage

It is expected that rainwater will be drained out quickly from the field so that no crop damage takes place from inundation. Drainage is a common function of all sorts of regulators in Bangladesh. The lesser the drainage congestion and crop damage, the better the performance of the regulator. Two indicators for this performance parameter are selected in the following way:

1. Spatial extent: Average (last five years) maximum extent of water congested area (in percentage of the project area) during yearly peak rainfall (usually in monsoon).

2. Temporal extent: Average (last five years) maximum drain out time (in days) of the congested water after yearly peak rainfall (during non flooding condition in the river).

Flushing

Average flushing velocity should be about 1.0 m/sec to maintain the channel bed neither eroding nor silting. Opening size of the regulator determine flushing velocity, which ultimately results in eroding/neutral/silting bed.

3. Bed type: The type of bed (silting/eroding/neutral) in the approach canal of the regulator.

Water logging

Water logging within the project area due to the regulator construction is a good indicator to measure its performance. Social perceptions about this indicator are carefully assessed and calibrated because permanent water bodies are not water logging.

4. Water logging: Maximum extent of waterlogged area in the project area (permanent water bodies like beels, ponds, wetlands etc are not considered as water logged area).

Salinity

Water control structures prevent salinity intrusion within the project area. So, whether the salinity level within the project area is acceptable to the farmers for crop production is a good performance parameter. Other sources of salinity intrusion in the project area are also considered in the study for better result and calibration.

5. Concentration: Present salinity level (in percentage) within the project area compared to river water during dry season (February-April) and beneficiary assessment of salinity level for crop production.

Water retention

Irrigation water is retained in the canals within the project by regulator. So, water retention capacity is a good parameter in this study.

6. Irrigation coverage: Irrigation coverage in the project area with the retained water in the canal by regulator.

Flood protection

Overflowing record of the regulator during flood is a parameter in this study. One of the purposes of the regulator is to prevent floodwater intrusion in the project area so that no crop damage takes place from inundation.

7. Freeboard**:** Average freeboard (last five years) remained during yearly peak flood in the river and assessment of the prevailing freeboard.

Social perceptions about the above indicators for various parameters are collected during FGD to measure the performance of the regulator.

3.4 Hydrologic parameters of regulator

A regulator is designed to drain out excess runoff timely to avoid crop damage. Regulator parameters are designed according to local hydrology, land type, soil structure and texture, meteorology etc. Important hydrologic parameters are opening size, location, invert level, crest level etc. Hydrologic parameters determine performance of a regulator in terms of drainage, flushing, prevention of water logging and salinity intrusion, water retention capacity and flood protection.

Opening size

Opening of a regulator is important for drainage performance. There are various standards for regulator opening, which is known as vent. There is restriction for vent size to cope up with hydrostatic pressure in structural design consideration. BWDB uses standard vent size of 1.52 m width × 1.83 m height for regulator in Bangladesh (BWDB, undated). Regulator may have single vent or multiple vents considering the catchment area, precipitation, rainfall intensity, land type, quantum of flow etc. Normally lifting gates are used in the vent openings in Bangladesh and flap gates (one way passage of water) are also used in addition for flushing consideration.

Location

Location of a regulator in the catchment is a vital hydrologic parameter. Location of regulator determines spatial and temporal extent of drainage congestion, flushing effectiveness, water logging etc. Location should be at the periphery of the catchment where aerial elevation is the lowest to ease the drainage and to prevent water logging. Normally regulator is placed at the end of the existing drainage canal, few meters away from the river bank (ibid).

Invert level

Invert level means simply bottom of the regulator opening. Invert level is generally fixed considering the following things:

- Drainage requirement: The invert level of a drainage regulator is guided by the lowest basin level to be drained. For tidal sluices, this level should be as low as the minimum polder level in the dry season.

- Hydraulic consideration: Discharge increases if the invert level is lowered. Flushing regulator should have lower invert to have higher discharge and flow velocity to flush inside the project.

- Bed level: Invert level need to be fixed at the existing bed level or design re-excavation level of the drainage channel. Invert level higher than bed level will restrict flushing. For drainage regulator, downstream basin level should be fixed at the bed level to avoid scour or siltation.

- Low water level at riverside: Invert level need to be fixed by riverside low water level (tail water level) considering hydraulic jumping.

(Source: BWDB, undated)

Crest level

Crest level of a regulator is important hydrologic parameter considering flood protection and recorded maximum flood level. Crest level is normally fixed at or above existing or proposed top level of the embankment. Crest level should be fixed at maximum flood level (1 in 20 years, 1 in 30 years or 1 in 50 years return period) with acceptable freeboard (ibid).

3.5 Social perception

People live in society and everyone have social feelings gained from everyday life. They use land and water of their locality to produce agricultural output like rice, jute, sugarcane, wheat etc. They observe natural events like rainfall, drought, flood etc and they experience consequences like flooding, drainage congestion, salinity problems, crop damage etc. They have various structures to cope up with the natural events. From their observations and experiences, they have some sort of understanding about structures of their locality. They have perceptions about the faults, malfunctions of the structures. For example, from drainage congestion, they have perceptions about sufficiency of the regulator opening, its invert level etc. They can comment on the crest level of the water control structures from flooding records and experiences.

3.5.1 Measurement of Social perception

Various scaling methods are available to quantify peoples view and perception on specific matter. 3-point and 5-point Likert scales are two good examples (Wikipedia, 2008d). Many scaling systems have been reviewed to find a suitable scale to measure people's perception in the study. A 5-point scale is used in this study to quantify the beneficiary stakeholder's opinion on the performance of the indicators for the selected water control structures in Narail subproject. Description of the used measuring scale is given in the following Table 3.1:

Table 3.1: Performance level scale

Performance scale	Description of the scale	Assessment
0	The indicator value denotes highly unsatisfactory performance of the water control structure. Sometimes, it even aggravates the problem that it is supposed to solve.	Unsatisfactory
1	The indicator value denotes that the water control structure is not working properly. It provides very little help to fulfill the purposes.	
2	The indicator value denotes that the purposes of the project are being served but with frequent objections.	
3	The indicator value denotes good performance of the water control structure. Although there are faults however, purposes are being served very well.	Satisfactory
4	The indicator shows very good performance of the water control structure.	

3.6 Data Collection

A reconnaissance survey has been conducted over the study area to carry out preliminary assessment of the existing water control structures. Details of preliminary inspection of the study area in Narail subproject are as follows (Table 3.2).

Table 3.2: Details of preliminary investigation of the study area

Date	Location	Methods	Type of group
September, 2007 (5 days visit)	Kathner beel	Site visits, preliminary investigations and informal discussions.	Local people, WMA member and BWDB and LGED officials.
	Poradanga khal		
	Panu khal		
	Boramara		
	Mulia		
	Burendura		
	Seapagla		
	Chamrul		

This survey helped to observe the present status of the existing regulators and to realize the rationale of the study.

The study is carried out on the basis of both primary and secondary data that are described in detail as follows.

3.6.1 Primary Data Collection

FGD

Focus Group Discussions (FGDs) with the local beneficiaries are used as primary data collection tool in this study. FGDs are conducted for each structure. The researcher personally communicated with local people, interested groups and beneficiary farmers at least one day prior to FGD. They are well informed of the purposes of the study and requested to be prepared for the FGD on the fixed time and place. Time and place are carefully fixed with consultation to ensure their presence in the FGD. Focus group consists of members from local stakeholders, mainly farmers to make it homogeneous. Structured checklist is formulated to collect useful data. The checklist is described to them and sought their response. Enough time is given to them for discussion among themselves. They have discussed each indicator to provide a consensus response. Although FGD participants should be in the range of 8-12, few farmers have participated instantly during FGDs. Hence, number of participants has exceeded the range in FGDs. List of FGDs conducted are given in the Table 3.3. Few photographs of the conducted FGDs are given the Appendix B.

Table 3.3: FGDs and informal interviews conducted at different locations

Date	Location	Related structures	Method used	Type of group	No of participants
June, 2008 (3 days visit)	Mulia bazar	Mulia regulator	Informal interview	Mix of stakeholders	6
	Mulia bazar	Burendura regulator	Informal interview	Mix of stakeholders	5
	Chamrul ghat	Chamrul regulator	Informal interview	Mix of stakeholders	4
	Malidanga bazar	Seapagla regulator	Informal interview	Mix of stakeholders	7
	Malidanga bazar	Debipur regulator	Informal interview	Mix of stakeholders	4
July, 2009 (5 days visit)	Tularampur	Chamrul regulator	FGD	Farmer	16
	Kathakhali	Seapagla regulator	FGD	Farmer	17
	Char Peruly	Debipur regulator	FGD	Farmer	12
	Malidanga bazar	Madhurgaera regulator	FGD	Farmer	12
	Hosenpur	Panu regulator	FGD	Farmer	20
	Porandanga ghat	Chanduliar regulator	FGD	Farmer	21
	Malidanga	Duberbeel check	FGD	Farmer	20
	Boramara	Boramara regulator	FGD	Farmer	14

Interview

Interview is considered as an important method for information collection on the overall aspects of the selected regulators and study area. Interview has been conducted with selected Key Informants who have observations and experiences of local knowledge and activities of the implementing agencies such as BWDB, LGED etc. List of interviews are given in the Table 3.4 below.

Table 3.4: Interview with Key Informants at different locations

Date	Location	Methods	Key Informants
July, 2009	Poradanga	Informal interview	WMA cashier of Chanduliar subproject
	Upazila Parishad Complex, Narail sadar	Purposive interview	Upazila Agriculture Officer
	Narail O&M division, BWDB	Purposive interview	Executive Engineer
	LGED, Narail	Purposive interview	Facilitator, Small scale water sector project
	Malidanga	Informal interview	WMA member of Madhurgaera subproject
	Tularampur	Informal interview	UP member of Tularampur union, ward no 04, Narail
	Malidanga	Informal interview	UP member of Tularampur union, ward no 08, Narail
	Narail O&M division, BWDB	Purposive interview	Sub Assistant Engineer
	LGED, Narail	Purposive interview	Sociologist, Small scale water sector project

3.6.2 Secondary Data Collection

Secondary data of the selected water control structures such as location, benefited area, catchment area of the projects, maps of the related projects, hydrological design parameters of the structures (size of opening, location, invert level, crest level etc), hydrological information (rainfall data, temperature, catchment’s area, tidal range etc), discharge through the control structures, process of planning and implementation, design life etc. are collected from BBS, BWDB, and LGED headquarters and local offices and other related offices, documents, literatures, internet based various application softwares and journals. List of important secondary sources of data are given below in the Table 3.5.

Table 3.5: List of secondary sources

Sources	Type of data
BWDB	Areal data, Maps, Topography, Landscape, Soil and climate data, Hydrologic design parameters of the structures
LGED	Climate and tidal data, Hydrologic design parameters of the structures
BBS	Demographic and socio-economic data
Banglapedia, Google earth and other internet based sources	Maps and other related data
Field visits and local people	Information on catchments and hydrologic parameters of the structures

3.7 Technical Assessment

Technical evaluation is a board term meaning assessment of anything on the light of established theory, scientific facts and formula. A technical knowhow person is capable to guess rightness or wrongness of a fact from close observation and knowledge although it may not be precise. Technical check can be defined as test of a fact with established technical knowledge.

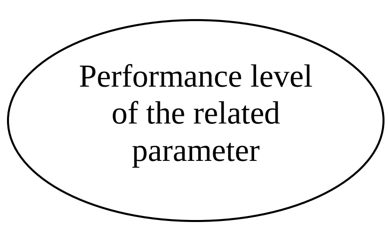
Regulator is a technical artifact, which is designed by technically established facts and formulas using various hydrologic, hydraulic and meteorological data. Technical check of the regulator means simply checking the design using the same design procedure or different technical procedure.

Social perceptions and performance of indicators of the selected regulators have been collected from FGD. Social perceptions and scaling of performance result in either satisfactory or unsatisfactory grading. On-field observation provides instant preliminary investigation of social perception. Social perceptions of performance parameters are immediately converted to the relevant hydrologic parameters (showing in the Table by tick sign) for technical check, which is shown in the Table 3.6. Technical evaluation is made to cross-check social perception. Schematic flow chart of the whole analysis is given in the Figure 3.1.

Table 3.6: Hydrologic parameters from performance parameters

Performance parameter	Relevant hydrologic parameter for technical and on-field check			
	Opening size	Location	Invert level	Crest level
Drainage	√			
Flushing	√		√	
Water logging		√	√	
Salinity				
Water retention			√	
Flood protection				√

The above Table 3.6 shows that unsatisfactory perception of drainage parameter means insufficient opening of the regulator. Similarly unsatisfactory perceptions of flushing parameter refer to insufficient and faulty fixation of opening size and invert level of regulator. Unsatisfactory opinion about water logging refers to insufficient fixation of location and invert level. Similarly unsatisfactory opinions about water retention and flood protection refer to insufficient fixation of invert level and crest level respectively. Salinity problems mainly depend on the overall functions of all hydrologic parameters of the regulator and its management.



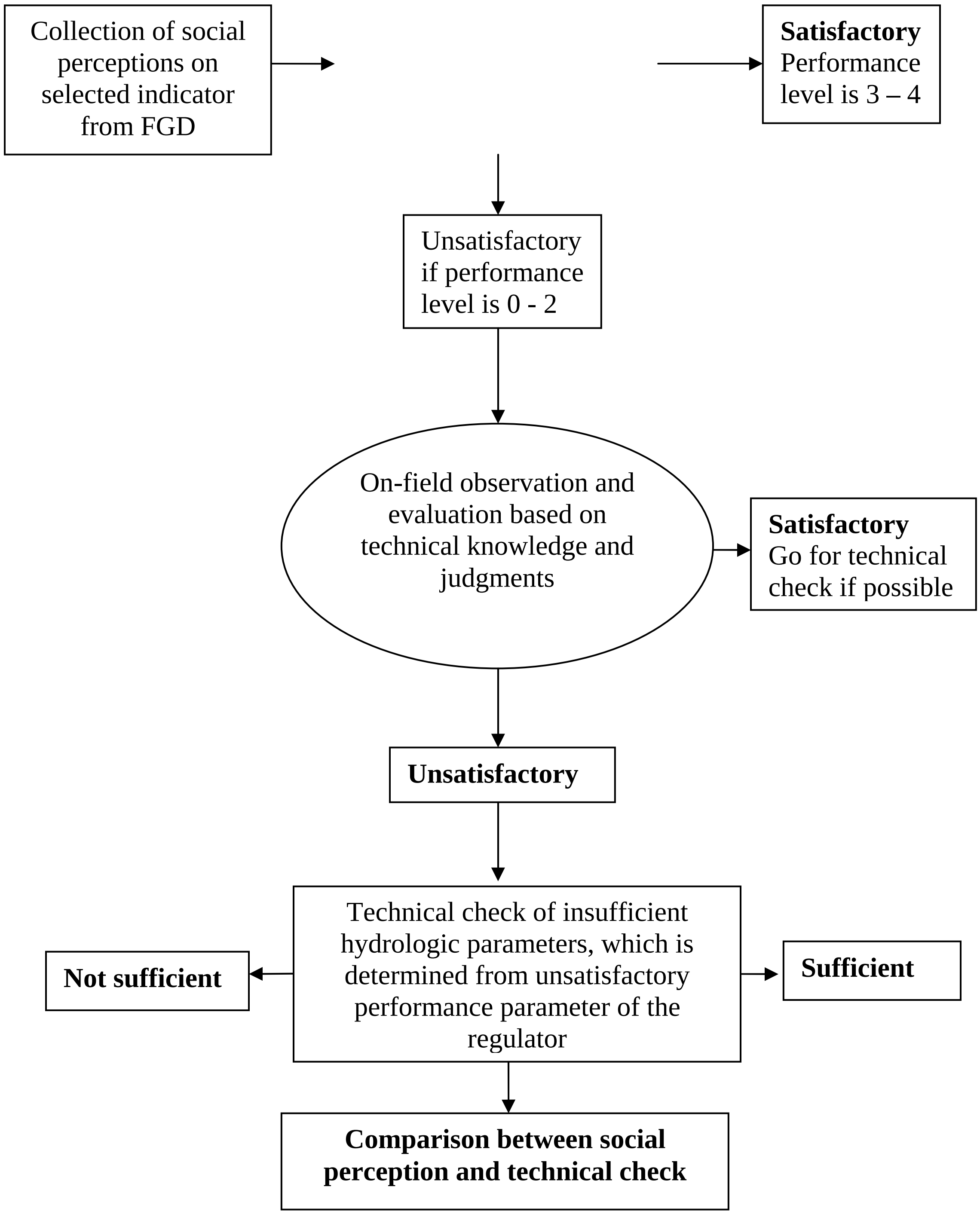


Figure 3.2: Schematic flow chart for the analysis

3.7.1 On-field observation and evaluation

FGDs with farmers are conducted in a suitable location close to regulator. Therefore, social perceptions become handy immediately after the FGD. Regulator site and its benefited area, catchment area, topography, land type etc. are visited and the performance parameters are judged. Similarly hydrologic parameters are judged based on technical knowledge and simple on-field technical measurements.

On field observation and evaluation are made on:

- Vent no and size
- Crest and invert level
- Water depth and Tidal range
- Velocity during ebb tide and flood tide
- Land type and land use
- Cropping pattern
- Topography and contour elevation of the catchment and benefited area
- Canal section and canal condition (eroding/silting/neutral)
- Water logging in the benefited area
- Embankment section and height relative to regulator crest level
- Salinity of the project water and river water etc.

3.7.2 Technical Check

Technical evaluation is made to check the sufficiency of the designed hydrological parameters of the selected regulators of which performance becomes unsatisfactory according to social perception and ranking. Size of opening, location, invert level and crest level of the structure are considered for technical evaluation. BWDB design manual for regulator design is hereby followed (BWDB, undated) in this check.

Location of the structure

Location of the regulator is normally selected through the field experiences of the expert engineers. Location is checked based on the topography of the catchment, canal and river position.

Crest level

Crest level is checked with average annual flood level (1 in 2.33 years) and 1 in 20 years flood level of the river during monsoon season at nearest water level measuring station (Khatur station, Chitra and Afra ghat station, Bhairab).

.

Invert level

Invert level generally be fixed with the existing bed level or the proposed re-excavation level of the channel to avoid water logging and to facilitate maximum drainage and water retention. It is checked and compared with water level, tidal data of the Afra khal and topography of the area following BWDB design manual (BWDB, undated).

Size of opening

It is directly related to the drainage performance of the regulator. Standard vent size of any BWDB and LGED regulators is 1.52 m × 1.83 m. There are few methods to determine number of vents of regulator such as IECO, Rational formula, Drainage modulus etc (ibid). Required vent is checked using the following empirical formula (according to Drainage modulus method) and assumptions.

No of required vent calculation based on Drainage modulus method (empirical)

Catchment area in hectare = A

Drainage modulus in mm/day = R

Drainage time factor = T

3.7.3 Comparative Analysis

Here, comparative study simply means comparison among the results of social perceptions with technical assessment. Comparative study has verified the validity, usefulness and limitations of the social perceptions about regulator performances through technical checks.

This comparison has indicated the extent of social perceptions in the hydrologic planning and design of water control structures (regulators).

Chapter 4
The study area

4.1 Location

Narail is a coastal district in the south-western part (Khulna division) of Bangladesh (Figure 4.1). The selected study area is mainly north-western part of Narail Sadar Upazilla (Figure 4.2) and topography of the northern part of the Narail sub-project (Figure 4.3). Geographical co-ordinates of the Narail sub-project are 89º 22' E to 89º 36' E and 23º 02' N to 23º 18' N (Figure 4.3).

Narail subproject consists of Narail sadar and part of Abhoynagar upazilla of Jessore, the area bounded by Afra-Chitra-Bairab river systems (Figure 4.5). The surrounding areas are Kalia and Lohagara upazilla of Narail dristrict to the east and north-east, Jessore district to the south-west and west. Chenchuri beel sub-project (Figure 4.5) is located adjacent to the east of Narail sub-project.

Narail subproject is subdivided into 6 Compartments (Figure 4.3) based on hydrological boundaries, topography and catchment. Compartment 1 (Figure 4.6) is located to the north of this sub-project and the study area belongs to this area. Administrative unions of Compartment 1 are Maijpara, Tularampur and Sahabad of Narail sadar Upazilla (Figure 4.2).

Main focus of the study is the regulators and hydraulic infrastructures of the Compartment 1 of Narail subproject.

Major portion of the study area is located in between upper part of Afra khal and Chitra river systems. Most of the selected regulators are situated on the left bank of the Afra khal (Figure 4.6).

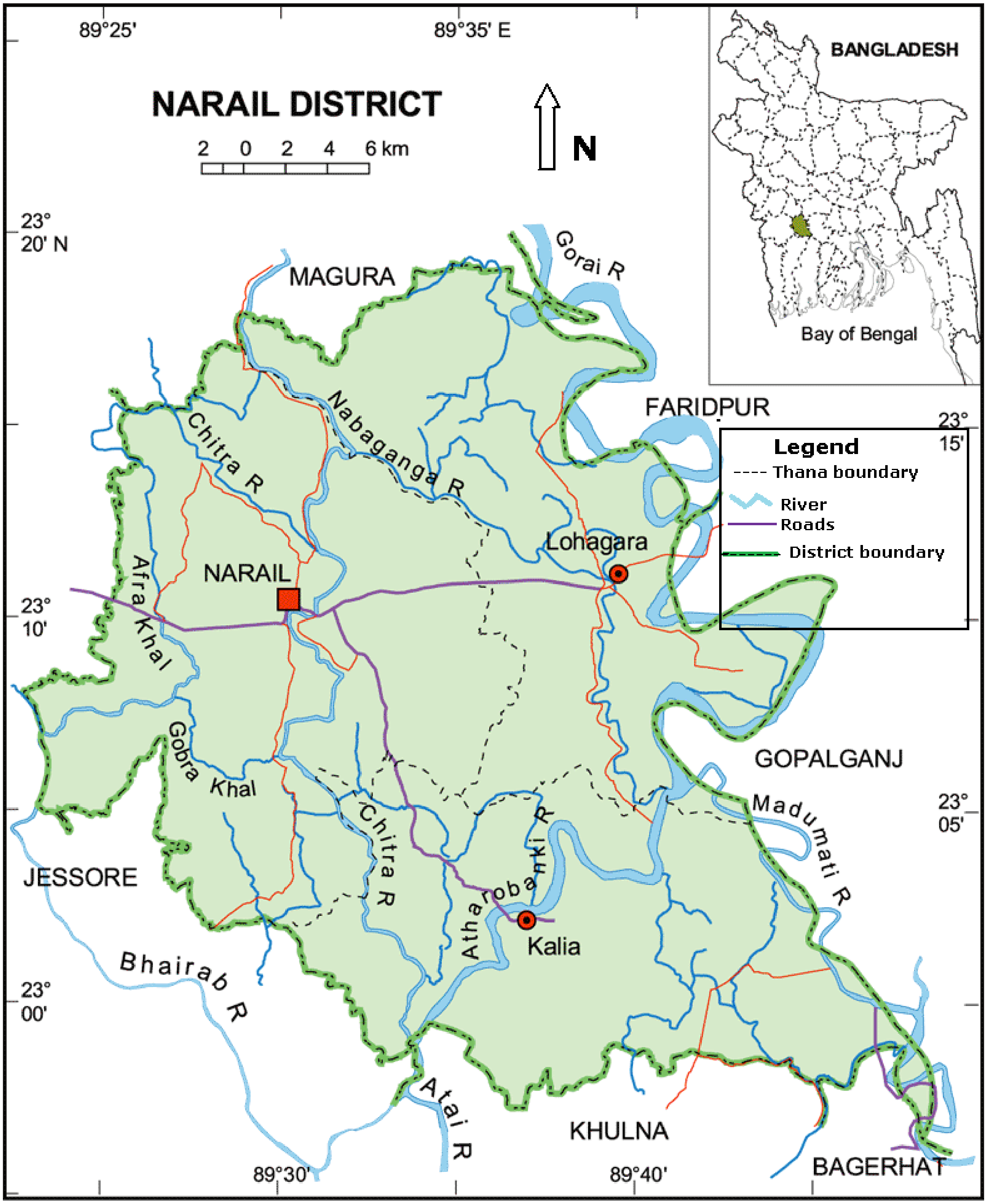


Figure 4.1: Location map of Narail district (Banglapedia, 2009)

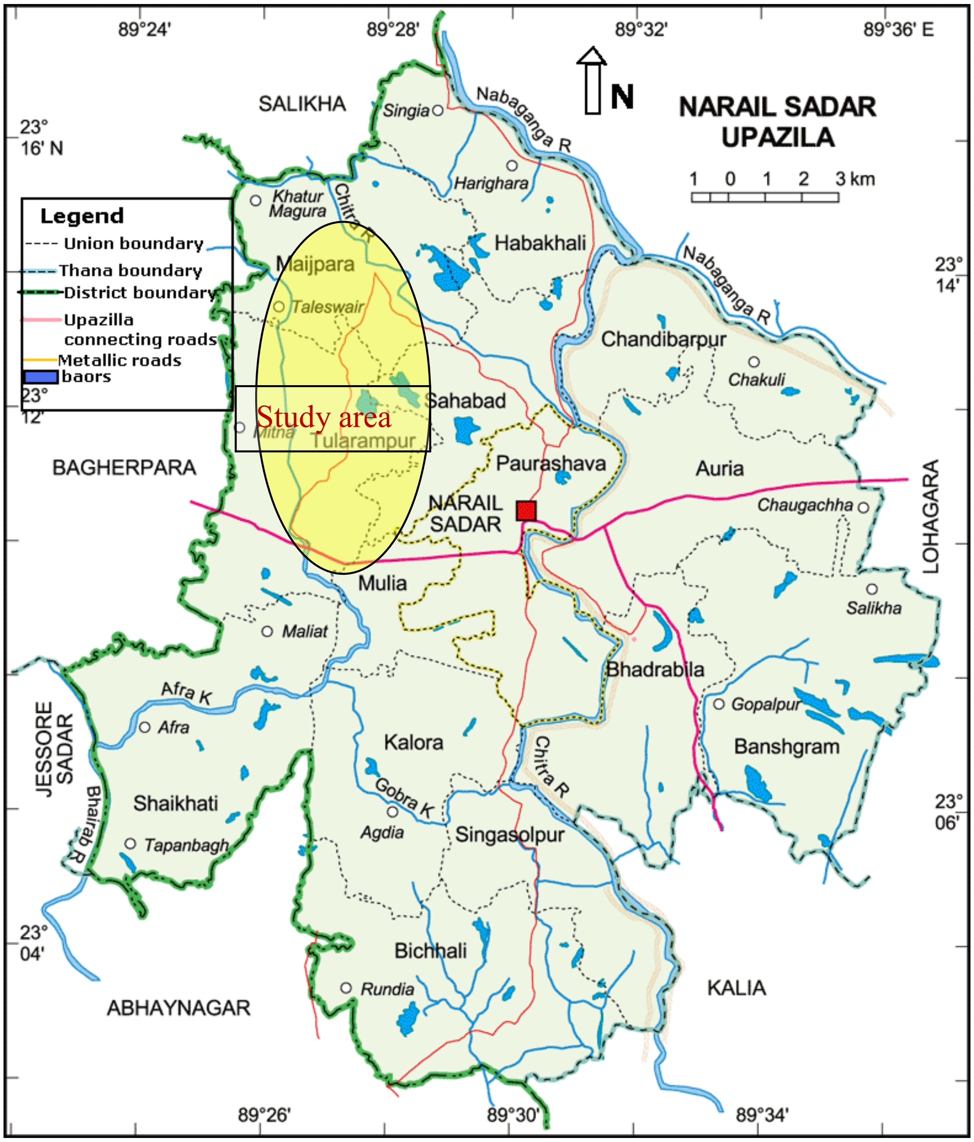


Figure 4.2: Narail sadar upazilla and study area (Banglapedia, 2009)

4.2 Topography

The selected Narail Sadar upazilla falls in the Ganges delta (Low Ganges river floodplain). The Narail subproject slopes from north to south with elevation varying from 4.5 m PWD to 1.5 m PWD (Figure 4.3). The area has typical meandering landscape of broad ridges and basins. Differences in elevation between ridge tops and basin centers are normally varies from 3 m to 5 m. There is a number of low lying areas (beels), interconnected by drainage channels and water courses, make the landscape complex. There are narrow artificial levees

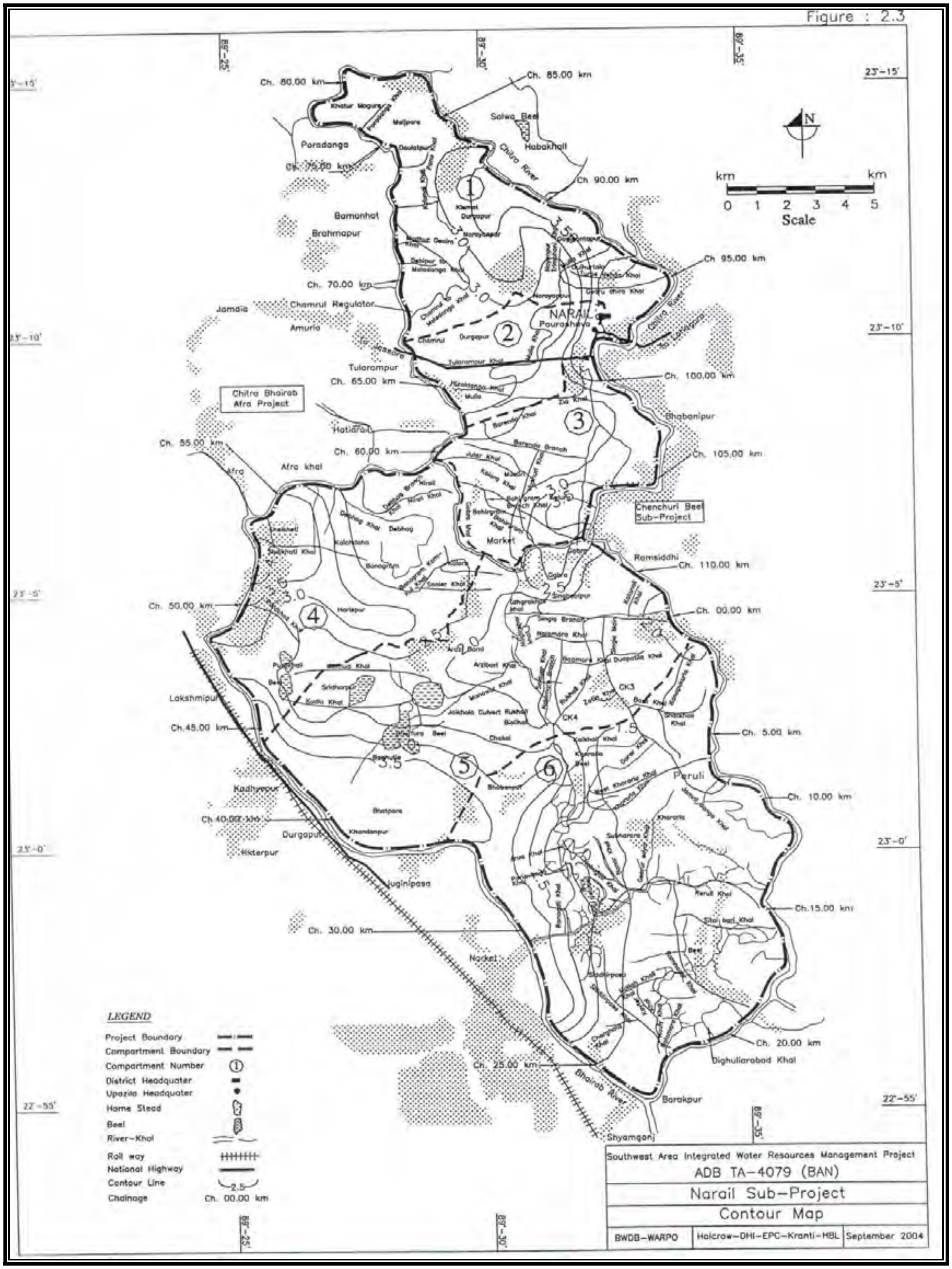


Figure 4.3: Topographic contour map of Narail sub-project (Source: BWDB)

along the banks of the rivers within the area (Halcrow et al. 2004). Digital map (Figure 4.4) shows that the human settlements in the region stand mainly along the rivers and canals.

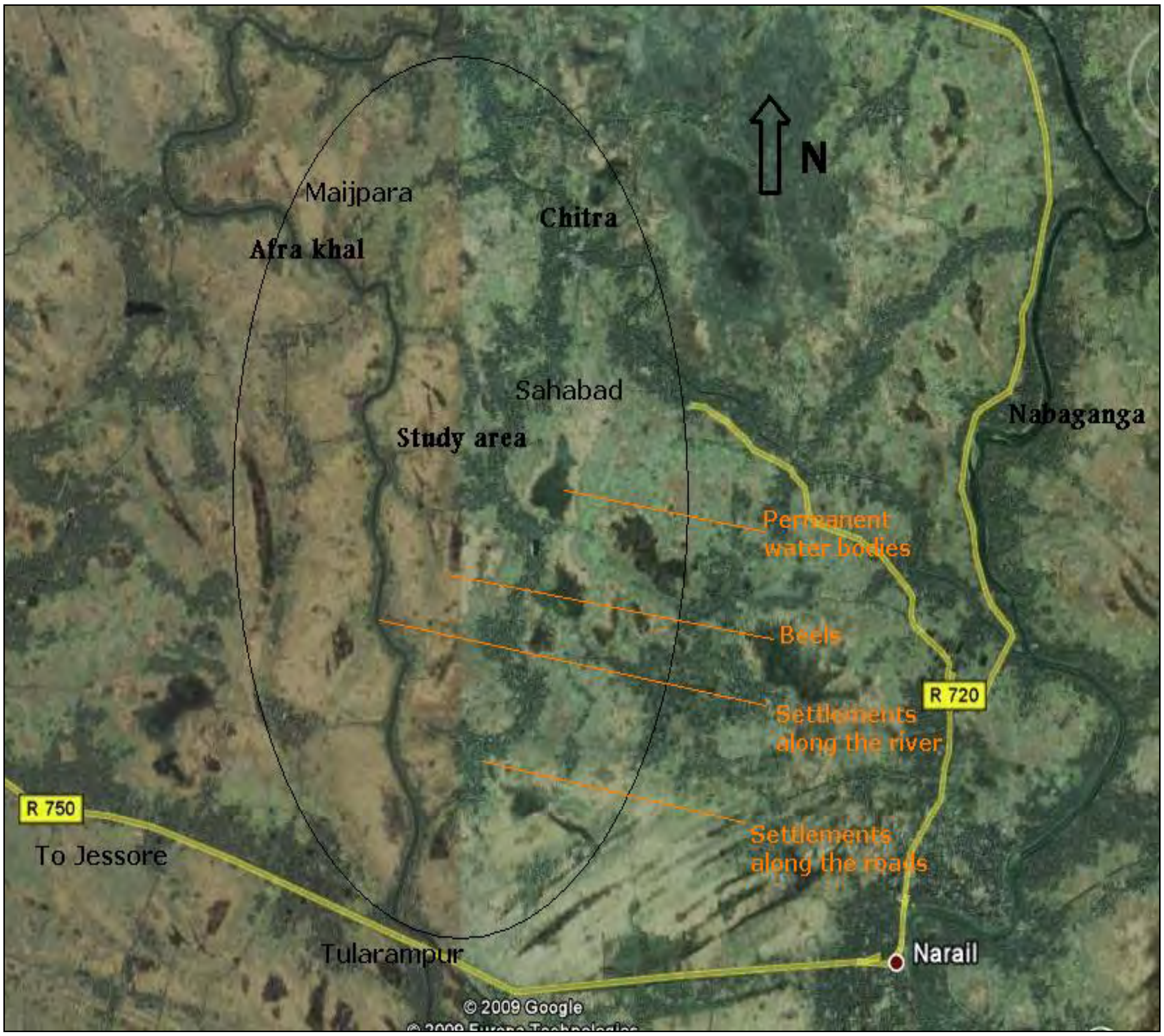


Figure 4.4: Digital map of study area (Google earth, 2009)

4.3 Climate

The selected area experiences sub-tropical monsoon climate, broadly similar to the rest of Bangladesh. Narail is the nearest climatic station of the area. Details of climatic data are given in the Table 4.1.

- Mean monthly temperature of this area varies from 11.9ºC (in January) to26.2ºC (in August).
- Basically, March, April and May are the hottest and driest months of the year.
- Monthly average relative humidity varies from 65% (in February) to 88% (in July).
- Mean annual rainfall over the study area is 172.7 cm.
- The rainfall exhibits a seasonal variation with a sharp peak in July and August. More than 70% of the annual rainfall occurs in the monsoon months of June to September whereas only 6.3% of the annual rainfall occurs from November to March.

Table 4.1: Climatic data of the study area (source: LGED)

Month	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	De c	Jan	Feb	Mar
Temperature (^{0}C) Station Name: Narail												
Max	41.2	42.2	37.2	35	36.1	35	33.9	32.3	30.6	30.6	35	39.4
Mean	23.3	25.1	25.8	26.1	26.2	25.8	23.6	17.7	12.8	11.9	14.1	9.3
Min	15.6	18.9	21.2	22.8	23.3				12.4	11.6	14.2	16.5
Evaporation (E mm/day) Station Name: Narail												
Avg.	3.7	3.9	3.4	2.7	3.2	2.8	2.6	1.8	1.4	1.5	2.4	3.0
Evapo-transpiration (ETo mm/day) Station Name: Narail												
Avg.	5.7	5.5	4.3	3.7	3.8	3.6	3.6	2.8	2.3	2.4	3.3	4.6
Rainfall (mm/month) Station Name: Narail												
Max	357	1009	584	670	569	553	372	204	98			219
Mean	151	302	298	361	307	279	146	29	11			72
Min	7	28	28	38	120	104	41	0	0			9

4.4 Geology and Soil types

The area is located in the south-west part of the Bengal basin (Low Ganges river flood plain) and its top soil is formed through a long subsidence and deposition. The surface geology consists mainly of sediments. The soils of this area are silt loams and silt-clay loams to heavy clays. Clay soils are prevalent in the low laying areas, and medium textured soils at the higher grounds. Morphologically the area is active and general fertility of the soil is medium. Permeability is relatively low in this soil.

4.5 River system and surface water hydrology

Chitra and Afra khal are two dominant rivers in the northern part of the Narail sub-project area along with a boundary river (Nabaganga) to the north-east. The Bhairab is a boundary river in the southern part of Narail sub-project too. The Chitra flows along the northeast boundary and joins with a branch of the Nabaganga near Gazirhat. In the southeast corner the Nabaganga rejoins with the Chitra. On the western side, Afra khal joins with the Bhairab near Shaikhati (Figure 4.5). Gobra khal originates from Afra khal. It bifurcates the Narail sub-project (Figure 4.5).

All the rivers are tidal and a large quantum of water enters and leaves the area twice a day. The tidal river system carries huge silt (comes from Ganges). Significant sedimentation and erosion occur in many places of the area. The tidal amplitude varies from 0.5 m to 1.0 m during the dry season and 1 m to 1.5 m during the wet season. Nearest water level gauge stations are Khatur Magura (station no 55) on the Chitra river and Afra Ghat (station no 30) on the Bhairab river. 22 years (from 1981 to 2002) of water level data of these two stations are used and interpolated for the study area. Monthly tidal data of the study area is given in the Table 4.2. Average annual (1 in 2.33 years) and 1:20 years monsoon flood levels of the study area are 3.34 m PWD and 4.23 m PWD respectively (source: LGED).

There are many low lying areas (beels) in between the two rivers and these beels are connected with the rivers by narrow canals. Rain water is drained out from beels into rivers and flood water enters vice versa. Most of the beels dry up during the dry season and become deeply flooded during the monsoon season.

Table 4.2: Tidal range in the study area (source: LGED)

Month	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	De c	Jan	Feb	Mar
Monthly higher tide level in the tidal zone (m PWD)												
Max	2.49	2.61	3.45	3.59	4.21	4.38	3.98	3.35	2.39	2.14	2.30	2.57
Mean	1.99	2.19	2.58	2.94	3.22	1.98	3.32	3.15	2.57	1.96	1.74	1.89
Min	1.69	1.8	2.00	1.89	2.59	2.87	2.53	2.04	1.57	1.38	1.45	1.49
Monthly lower tide level in the tidal zone (m PWD)												
Max	0.75	0.88	1.50	2.56	2.87	3.84	2.68	1.54	0.87	0.85	0.55	0.60
Mean	0.36	0.51	0.85	1.50	1.98	2.06	1.71	0.96	0.53	0.32	0.21	0.24
Min	0.10	0.27	0.47	0.68	0.52	0.77	0.91	0.40	0.24	.004	-.01	-.06

Upstream river flow during dry season has been reduced in the study area due to water withdrawal at Farakka and hence saline water intrudes further into the river system. Mean monthly maximum salinity (after ratification of the Ganges water sharing treaty) ranges at Chitra (Gobraghat station) from 17 ppt (in June) to 27 ppt (in January). Mean monthly maximum salinity [ppt] is given in the Table 4.3 below.

Table 4.3: Mean monthly maximum salinity [ppt] (source: BWDB)

River Name	Station name	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Nabaganga	Gazirhat	20	22	22	22	27	25	24	23
Nabaganga	Bardia	29	22	19	20	22	24	26	19
Chitra	Gobraghat	18	20	27	26	22	24	21	17

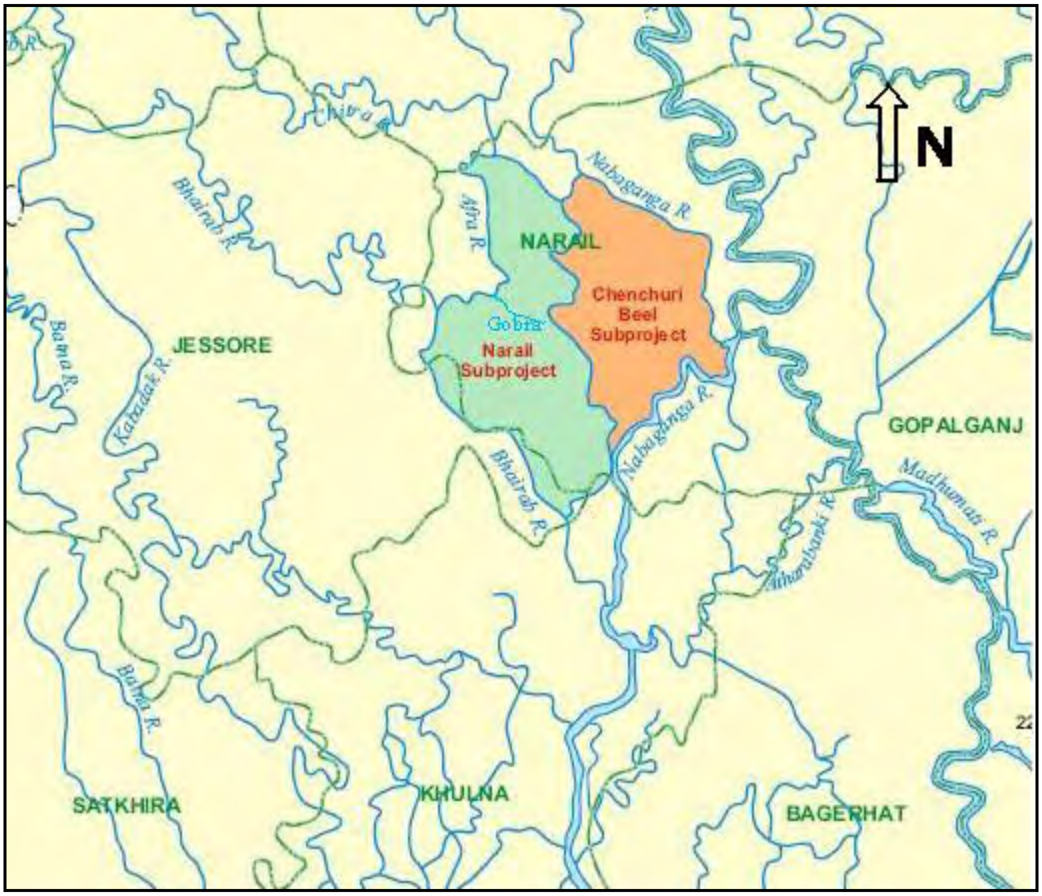


Figure 4.5: River system in the study region (source: BWDB)

4.6 Water management

Both surface water (rivers, canals, beels etc) and groundwater are used for meeting up the optimal irrigation requirement in the study area. River water is retained in the canal by regulator and Low Lift Pumps (LLPs) are used to irrigate the land using surface water. Shallow Tube Wells (STWs) are installed to withdraw ground water for irrigation during dry season.

There are a large number of infrastructures in the Narail sub-project area for flood control, water retention for irrigation, flushing and salinity prevention and drainage improvement. These infrastructures are mainly constructed by BWDB and LGED. The existing infrastructures are flood embankments, drainage canals, regulators etc.

Previously management of these infrastructures was controlled by the implementing agencies (BWDB, LGED etc.). Management of the newly constructed infrastructures (embankments, regulators, check structures etc) is handed over to the Water Management Association (WMA) and they are managing very well. Existing infrastructures are being rehabilitated gradually and handed over to the local stakeholders group for better management.

As Narail sub-project was not functioning well, "Southwest Area Integrated Water Resources Planning and Management Project" (SAIWRPMP) has been initiated to rehabilitate this sub-project along with other sub-projects for better water management under Integrated Water Resources Management (IWRM) framework.

4.7 Overview of water control structures

The study area is Compartment 1 of Narail sub-project. Important water control structures (Figure 4.6) of this Compartment are constructed by both BWDB and LGED.

BWDB constructed water control structures are

- About 32 km dike (from ch. 68.00 km to ch. 100 km) along Chitra and Afra khal.
- Regulator at Chamrul.

LGED constructed water control structures are

- 1-vent regulators at Poradanga, Panu, Boramara and Debipur along left bank of Afra khal.
- 2-vent regulators at Seapagla and Madhurgaera along the left bank of Afra khal.
- Cheek regulator at Narayanpur.
- Check structure at Duber beel.

Among the above mentioned structures, some are constructed under the Narail subproject scheme during 1980s, which are included in the SAIWRPMP for rehabilitation. Others are proposed structures under the same project which are already constructed by mainly LGED in various small scale water resources projects during 1990-2008 periods. Some other structures, which are still at proposed levels under the same SAIWRPMP, are as follows:

- Regulator at Tularampur (right side of the Jessore-Narail road near the Tularampur Bridge, whereas Chamrul regulator is in the left side) along the left bank of Afra khal.
- Regulators at Sorospur, Turosdanga, Daljitpur along the left bank of Chitra near Narail municipality.

Apart from the regulators, there are many bridges and culverts across roads and highways to ease water flow across the catchments.

The selected water control structures are mainly regulator or sluice, which are namely Poradanga regulator, Panu regulator, Boramara regulator, Madhurgaera regulator, Duber beel check structure, Debipur regulator, Seapagla regulator and Chamrul regulator. A brief description of the selected regulators is given in the Table 4.4.

Table 4.4: overview of selected regulators (sources: BWDB and LGED)

No	Structure name	Type of structure	Year of construction	Agency	No of vent	Benefited area, ha
1.	Poradanga regulator	Drainage cum flushing	1998	LGED	1	700
2.	Panu regulator	Drainage	2002	LGED	1	291
3.	Boramara regulator	Drainage	1995	LGED	1	208
4.	Madhurgaera regulator	Drainage cum flushing	2008	LGED	2	540
5.	Duber beel check structure	Drainage check	2008	LGED	-	
6.	Seapagla regulator	Drainage cum flushing	1998	LGED	2	975
7.	Debipur regulator	Drainage cum flushing	1999	LGED	1	
8.	Chamrul regulator	Drainage cum flushing	1978	BWDB	2	5000

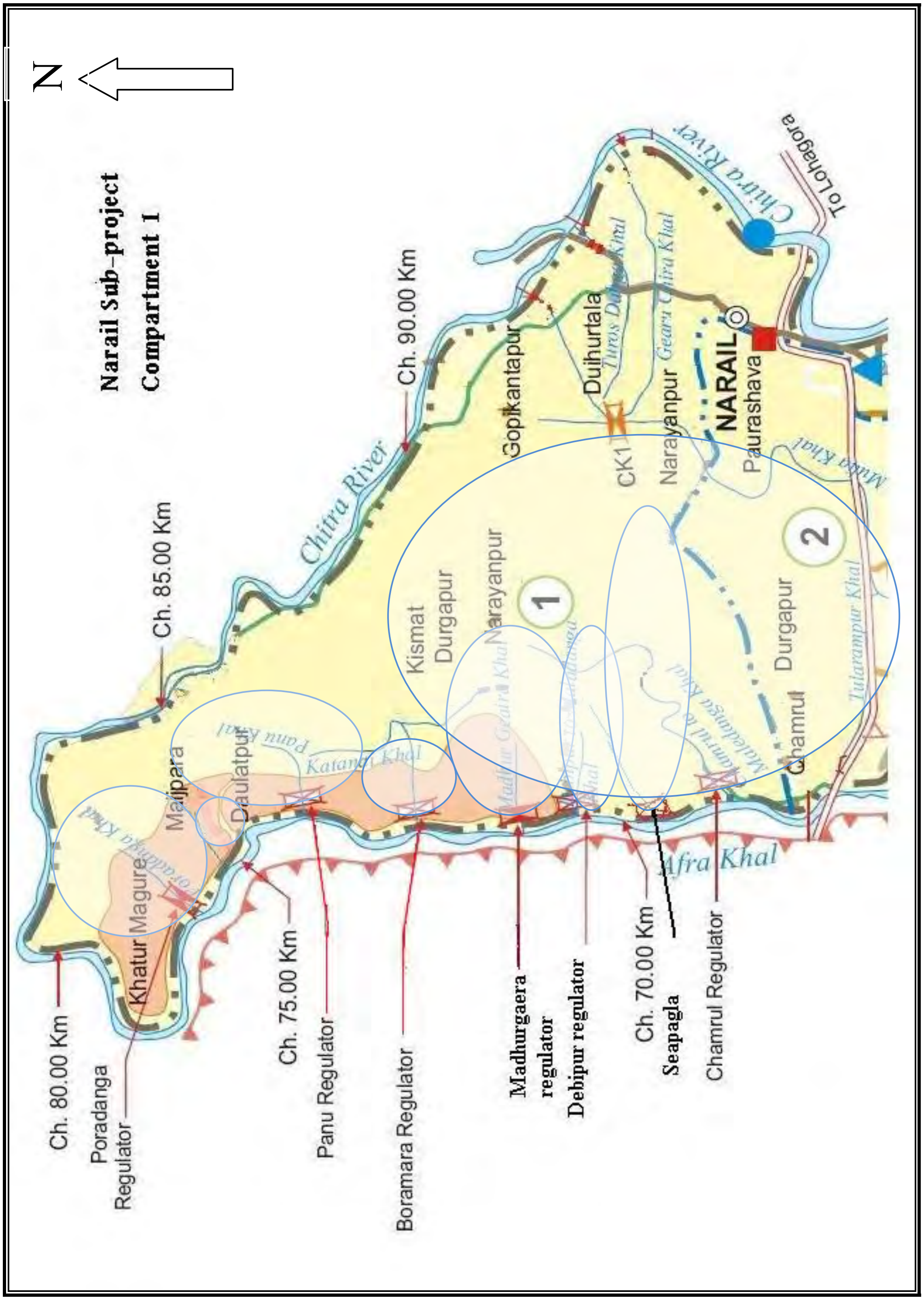


Figure 4.6: Locations and catchments of water control structures (source: BWDB and LGED)

4.7.1 Poradanga regulator

Chanduliar subproject is one of the LGED water resources subproject under Small Scale Water Resources Development Sector Project (SSWRDSP) implemented in the year 1998. This subproject is located at the northern corner of the Compartment 1 of BWDB Narail Subproject (Figure 4.6). Catchments of the subproject include Angulbaria (a village of Jessore district), Kalukhali, Magura and Poradanga villages of Maijpara union of Narail sadar. The catchment is about 1050 ha and bounded by Afra khal and Chitra. This area slopes towards south and south-west. The elevation of the place is comparatively higher from the southern areas. There is about 500 meters long canal and a 1-vent regulator at the end of the canal. This subproject is also known as Poradanga subproject. The regulator was constructed in 1998 and came in operation next year. The regulator has one lifting gate and one flap gate in the vent opening. The approach dike in this portion is about 4.0 meters wide and average height in the country side is about 1.0 meter. Adjacent LGED water resources subproject is Panu khal subproject, which is nearly 3.0 km south. Regulator and canal details are given in the Table 4.5.

Table 4.5: Poradanga water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Poradanga	Chandulia	Drainage cum flushing	1	1.5 m × 1.8 m	1.7 m PWD	5.5 m PWD	Canal mouth	700 ha

Canal Name	Place	Type	Length	Average width	Average depth
Poradanga khal	Chandulia	Drainage	500 m	8 m	2 m

4.7.2 Panu regulator

This regulator is located on the left bank of Afra khal nearly six km upstream from the Tularumpur Bridge (Figure 4.6). It is a one-vent drainage regulator constructed by LGED in the year 2002. This regulator stands on the Panu canal and adjacent catchments are Boramara to south and Chandulia to the north.

Panu khal subproject is one of the LGED water resources subprojects under SSWRDSP. Catchments of the subproject include Hosenpur, Daulatpur, Poradanga, Kathalbaria, Guchchagram, Maijpara villages of Maijpara union of Narail sadar. Benefited area of this subproject is about 291 ha and its slope is towards south and south-west. There is about 850 meters long canal and a 1-vent regulator at the end of the canal. The regulator has one lifting gate in the vent opening. The approach dike in the portion is about 4.0 meters wide and average height in the country side is about 2.0 meters. Details of Panu regulator and its approach canal are given in the Table 4.6.

Table 4.6: Panu water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Panu	Panu khal	Drainage	1	1.2 m × 1.8 m	0.5 m PWD	4.0 m PWD	Canal mouth	291 ha

Canal Name	Place	Type	Length	Average width	Average depth
Panu khal	-	Drainage	850 m	8 m	2 m

4.7.3 Boramara regulator

It is located on the left bank of Afra khal nearly 4.0 km upstream from the Tularumpur Bridge (Figure 4.6). It is a one-vent drainage regulator constructed by LGED in 1995. This regulator is constructed at the mouth of Mandia canal and adjacent catchments are Seapagla to south and Panu to the north.

Borarama subproject is one of the LGED water resources subproject under SSWRDSP implemented in 1995. Boramara regulator is the oldest LGED regulator in this area. Benefited area of this subproject is about 208 ha and its slope is towards south and south-west. There is a 1-vent regulator and about 600 meters long canal. The regulator has one lifting gate in the vent opening. Details of Boramara regulator and its approach canal are given in the Table 4.7 below.

Table 4.7: Boramara water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Boramara	Mandia khal	Drainage	1	1.2 m × 1.8 m	0.5 m PWD	4.5 m PWD	Canal mouth	208 ha

Canal Name	Place	Type	Length	Average width	Average depth
Mandia khal	-	Drainage	600 m	5 m	1.5 m

4.7.4 Madhurgaera regulator

This regulator is located on the left bank of Afra khal nearly 2.5 km upstream from the Tularumpur Bridge and about 9.0 km west from Narail sadar (Figure 4.6). It is a two-vent drainage regulator constructed by LGED in the year 2008 under SSWRDSP-2. Objectives of Madhurgaera subproject is flood management, drainage and water conservation.

Madhurgaera subproject is one of the latest LGED water resources subproject under SSWRDSP. It covers Malidanga, Kodla, Boramara, Charikhada, Kismat Durgapur and Alokdia. Benefited area of this subproject is about 540 ha, whereas catchment area is about 610 ha and its slope towards south and south-west. There is a 2-vent regulator on Madhurgaera khal at Boramara village and a drainage check structure on Malidanga khal adjacent to the Malidanga bridge under this subproject. The regulator has both lifting gates and flap gates in the vent openings. Details of Madhurgaera regulator and its approach canal are given in the Table 4.8.

Table 4.8: Madhurgaera water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Madhur-gaera	Madhur-gaera khal	Drainage cum flushing	2	1.5 m × 1.8 m	0.5 m PWD	5.0 m PWD	Canal mouth	540 ha

Canal Name	Place	Type	Length	Average width	Average depth
Madhurgaera khal	Boramara	Drainage	300 m (2 km)	4.0 m	2.0 m

4.7.5 Duberbeel drainage check

This is a drainage check structure of Madhurgaera subproject. It is located on the Malidanga khal adjacent to the Malidanga bridge at the mouth of the Duber beel. The Malidanga canal is connected with the Madhurgaera canal and the check structure is about 1.5 km up of the Madhurgaera regulator along this canals. This drainage check structure is constructed by LGED in the year 2008 under SSWRDSP-2.

It covers Shapraja, Kuchugaera, Bashtala, Baor and Duberbeel. The drainage check structure has lifting gate in the vent opening. Details of Duberbeel drainage check stucture and its approach canal are given in the Table 4.9 below.

Table 4.9: Duber beel drainage check structure details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Duber beel check structure	Malidanga khal	Drainage	-	-	-	-	across canal	-

Canal Name	Place	Type	Length	Average width	Average depth
Malidanga khal	-	Drainage	5 km	4 m	1 m

4.7.6 Seapagla regulator

This regulator is located on the left bank of Afra khal nearly two km upstream from the Tularumpur Bridge (Figure 4.6). It is a two-vent drainage regulator constructed by LGED in the year 1998.

Seapagla subproject is one of the LGED water resources subproject under SSWRDSP constructed in 1998-99 having gross catchment area is about 1275 ha and benefited area is about 975 ha. Seapagla subproject has two regulators, one in Seapagla and another in Debipur, half km north of Seapagla. Debipur regulator is one vent, so total three vents discharge all the catchments rainfall runoff into the Afra khal. The Seapagla regulator has lifting gates and flap gates in the vent opening. The width of approach dike is about 4.0 meters and average height in the country side is about 2.5 meters. Details of Seapagla regulator and its approach canal are given in the Table 4.10.

Table 4.10: Seapagla water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Seapagla	Seapagla khal	Drainage cum flushing	2	1.5 m × 1.8 m	1.0 m PWD	5.0 m PWD	End of Canal	975 ha Combined with Debipur regulator

Canal Name	Place	Type	Length	Average width	Average depth
Seapagla khal	-	Drainage	6 km	4 m	2.0 m

4.7.7 Debipur regulator

This regulator is located on the left bank of Afra khal nearly two and half km stream from the Tularumpur Bridge (Figure 4.6). It is a one-vent drainage regulator constructed by LGED in the year 1999.

Seapagla subproject is one of the LGED water resources subproject under SSWRDSP constructed in 1998-99. Seapagla subproject has two regulators, one in Seapagla and another in Debipur, half km north of Seapagla. Its gross catchment area is 1275 ha and benefited area is about 975 ha. Debipur regulator is one vent, so in total three vents discharge rainfall runoff of the combined catchments. The Debipur regulator has lifting gates and flap gates in the vent opening. The width of approach dike in this portion is about 3.0 meters and average height in the country side is about 1.5 meters. Details of Debipur regulator and its approach canal are given in the Table 4.11.

Table 4.11: Debipur water control structures details (source: LGED and field visit)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Debipur	Debipur khal	Drainage cum flushing	1	1.5 m × 1.8 m	0.5 m PWD	4.5 m PWD	Canal mouth	975 ha Combined with Seapagla regulator

Canal Name	Place	Type	Length	Average width	Average depth
Debipur khal	-	Drainage	1 km	3 m	1.0 m

4.7.8 Chamrul regulator

This regulator is located on the left bank of Afra khal adjacent to the Tularumpur Bridge (Figure 4.6). It is a two-vent drainage regulator constructed by BWDB during 1980s. This regulator has been constructed to drain out water from the whole Compartment 1 of the Narail subproject. The Chamrul canal runs parallel to the Jessore-Narail road from Afra khal and adjacent catchments are Mulia to south and Seapagla to the north.

On-field observation, it is observed that the two-vent Chamrul regulator is totally in-operative. There are no gates in the regulator opening. A cross-dam has been constructed downstream of the regulator, which obstructs the normal flow. Local people produce culture fisheries in the canal and a small rectangular pipe in the cross-dam allows water from the river to the canal. The approach dike in this portion is used as union connecting road with flexible pavement and its width is about 5.0 meters and its average height in the country side is about 2.5 meters. Details of Chamrul regulator and its approach canal are given in the Table 4.12.

Table 4.12: Chamrul water control structures details (source: BWDB and field)

Regulator Name	Place	Type	Vent nos.	Vent size	Invert level	Crest level	Position	Benefited area
Chamrul	Chamrul Khal	Drainage cum flushing	2	1.5 m × 1.8 m	0.0 m PWD	5.0 m PWD	Canal mouth	-

Canal Name	Place	Type	Length	Average width	Average depth
Chamrul khal	-	Drainage	12 km	6 m	2 m

4.8 Socio-economy

The study area is one of among the highest poverty-stricken areas of Bangladesh. About 44.4% people are poor and 36.3% people are hard-core poor. Causes of extreme poverty include lack of productive resources (water, land etc), lack of income opportunities, frequent natural disaster and hazard (flood, cyclone, drought etc) and limited access to the public resources. Average literacy level of this area is very poor, only 34.6% (Halcrow et al. 2004).

Agriculture is the dominant occupation of the rural population; about 75% of lands are used for agricultural cultivation. About 63.2% people of Narail sub-project area are engaged in the agriculture sector. About 56.3% people of Narail sub-project area are landless farmers and about 30% are marginal small farmers. Majority of people live in the rural area. Other secondary and tertiary occupation includes fishing, boating, wage labor, formal and informal services etc. (Halcrow et al. 2004)

Chapter 5
Results and Discussion

5.1 Social perceptions about performance of regulators

Focus Group Discussions (FGDs) have been conducted once for each of the selected eight regulators of Compartment 1 of Narail Subproject. Parameter wise summary of consultation of the FGDs are presented in the following sections.

5.1.1 Poradanga regulator

Drainage

Beneficiaries of this regulator and subproject are mainly farmers. During FGD, they have informed that about 600-700 hectares of the project area becomes inundated during peak rainfall (usually in Shrabon and Bhadra of Bengali calendar) in the last five years. Most of the runoff drains out through this regulator and excess runoff flows to the south. Average tidal range in the monsoon is about 1.5 meters. They have identified drainage of this rainfall runoff depends on the water level and daily tidal range of the river. At normal water level in the river, the runoff usually drains out into the river within 4-6 days. T.aman is capable to sustain standing water 4-5 days and hence this condition is acceptable to them.

Flushing

The beneficiaries have identified the water velocity high inside the regulator during peak runoff. If there were no basement, then soil below the regulator would be washed away.

Water logging

During FGD, farmers have said that there is a place south of this benefited area where about 50 bighas of land usually goes under water during monsoon season and this situation persists for more than one month.

Salinity

River water becomes saline during dry period (usually Chaitra and Baishak of Bengali calendar). Saline water from the river enters into the field if farmers/WMCA do not close the gate on time. WMCA of this sub-project is more active and vigilant about salinity problem and hence salinity condition within the project area remains satisfactory.

Water retention

WMCA/farmers allow water to flow into the canal during high tide and close the regulator to store water in the canal for irrigation. The flap gate of the regulator obstructs the inflow for water retention. In dry period of the year, water retention becomes difficult due to low water level in the river. People use LLPs to draw water from canal and river. Currently 200 acres of land are being irrigated by using water stored in the canal and there are possibilities to increase this irrigation coverage in future. Additional 100 acre of land can be irrigated if the canal is made 1-2 feet deeper. In this case, bottom of the sluice need to be fixed slightly lower than the existing condition for better water retention and drainage.

Flood protection

Farmers conclude the discussion that average freeboard during peak flood for the last ten years is about 2.0 feet. This area is relatively high. Crest level is satisfactory to them although higher level in future construction will be appreciable.

Results of FGD with beneficiary farmers and on-field assessment of this regulator are summarized in the Table 5.1:

Table 5.1: Beneficiary assessment about Poradanga regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	70-80 % of benefited area becomes congested	3	Not done
	Temporal extent	4-6 days		
Flushing	Flushing velocity	Eroding bed	2	Canal width and depth is increased in front of regulator
Water logging	Water logging	50 bighas	2	Separate small low lying pocket within the catchment
Salinity of canal water	Concentra-tion	5 % of river water concentration	3	Not done
Water retention	Irrigation coverage	100 bighas, possible to increase	3	Good amount of water in the canal
Flood protection	Freeboard	2 ft	3	Not done

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.2 Panu regulator

Drainage

The farmers during FGD have opined that catchment area is larger than the benefited area in this subproject. The extent of water congested area is about 1.0 km in length and about 1.0 km in width. The whole runoff accumulates in front of the gate but cannot be drained out timely due to small opening. More than 1 week is needed to drain out the rain water and often it damage standing crop. They have expressed deep dissatisfaction about opening size of the regulator.

Flushing

FGD participants describe the channel as eroding and inform that velocity during flushing is enormous. The opening size of the gate is not enough and so, running water creates high level of sound while passing the gate. Hydrostatic pressure becomes high and shakes the regulator. The sound becomes so high that people cannot hear normal talking of each other near the regulator.

Water logging

Lands along the canal are relatively low land. There are two baors just outside the project area and the canals connecting them are silted up and the existing culvert is not sufficient, which are creating problem of water logging. The main Panu canal is excavated recently and a small dike is made along both bank of the canal, which may improve this condition.

Salinity

There is no flap gate in the regulator opening. The lifting gate is being corroded by saline water. The lifting gate does not fit in the bottom properly and about 1.5 inches (two fingers) gap remains in between them. Saline water enters easily through the gap and it hampers rice cultivation in the low lying land during dry season. Farmers are trying to close the gate with wooden sheet this year (2009), but it does not work.

Water retention

Farmers are satisfied with the water retention capacity of the canal and present irrigation coverage with the retained canal water is about 200 acre. Additional 100 acre of land may come under irrigation if the canal depth becomes 1-2 feet more deep. They also use ground water in dry season irrigation, and they use DTWs to extract ground water. LLPs are used to extract water from river and canal. Invert level should be slightly lower especially when canal will be deeper to increase water retention capacity.

Flood protection

During flood the freeboard reduces and average freeboard is about 1.0 feet. They reminiscent during FGD that flood water was about to touch the crest of the regulator in the year (2004) of last Tsunami attack in Indonesia. Participants find crest of the regulator is about 3.0 feet lower than the existing road. It is highly probable that it can be flooded and overflowed in any upcoming flood.

A fruitful, interactive and live Focus Group Discussion has been conducted with beneficiary farmers of this regulator, which can be summarized in the following Table 5.2:

Table 5.2: Beneficiary assessment about Panu regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	About 1.0 km^2 becomes congested	1	Not done, need technical check
	Temporal extent	More than 1 week		
Flushing	Flushing velocity	Eroding bed	2	Regular channel, no sign of erosion
Water logging	Water logging	200 acre	2	Lands along canal are low
Salinity of canal water	Concentra-tion	100 % of river water salinity	1	Corroded gate
Water retention	Irrigation coverage	200 acre	3	Good amount of water in the canal
Flood protection	Freeboard	1.0 ft	2	Much lower than exiting eroded dike

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.3 Boramara regulator

Drainage

FGD participants have agreed in the discussion that the whole benefited area of this regulator is inundated during yearly peak rainfall, but all the water usually drained out within 3 days. The field is small and generally there is no inflow from other areas. Recently a regulator in the adjacent Madhurgaera canal has been completed which will improve drainage situation, because previously water from that area has created pressure on this regulator.

Flushing

Local residents (farmers) of this area think that the canal bed is neutral near the regulator. The flow is normal and does not create erosion or siltation.

Water logging

There is no water logging in this project.

Salinity

Saline water does not enter into the project area.

Water retention

People do not use the canal water for irrigation. The canal is silted up 100 meters ahead of the regulator. Water retention capacity of the canal is very low. People use LLPs to extract water from river and DTWs to extract ground water. Farmers want to use canal water for irrigation and canal capacity may be increased excavating it.

Flood protection

Average freeboard remains 3 feet during yearly peak flood for last five years and farmers are happy with the flood situation.

Focus Group Discussion has been conducted at WMCA local office near this regulator. FGD has been conducted with beneficiary farmers of this regulator, which can be summarized in the Table 5.3:

Table 5.3: Beneficiary assessment about Boramara regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	80-100% area becomes congested	3	Not done
	Temporal extent	3 days		
Flushing	Flushing velocity	Neutral	3	Regular channel, no sign of erosion
Water logging	Water logging	0	3	-
Salinity of canal water	Concentra-tion	0	3	-
Water retention	Irrigation coverage	0	2	Existing canal is short in length and shallow
Flood protection	Freeboard	3 ft	3	Crest level is high enough

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.4 Madhurgaera regulator

Drainage

During FGD, beneficiaries inform that the regulator has been constructed in 2008 and started operation in 2009. Before regulator construction, the congested water was drained out through Boramara regulator and Debipur regulator. But there was only 1-vent regulator at Debipur, which was not enough. The whole area was usually inundated during every heavy rainfall and it took long time to be drained out. They had huge damage to crop each year. Eventually, water from many beels flows to Madhurgaera and makes water congestion. Now farmers are hopeful that water congestion and crop damage will reduce since the regulator has 2-vents and sufficiently large.

Flushing

Since the regulator is new, farmers are not aware of this fact. But they are hopeful that this will be satisfactory as the regulator is large.

Water logging

Before the regulator construction, there was standing water on about 100 hectares of land for nearly 2 months (shrabon and bhadra of Bengali calendar) every year. The land comes under cultivation this year (2009). Regulator construction has eliminated this water logging situation.

Salinity

There was not any regulator before. But sometimes, farmers cut the dike to drain out the congested water into the river. Hence, it was open and saline water usually entered through the cut. Farmers faced again crop damage. After regulator construction farmers hope to manage preventing saline water intrusion by closing the gate timely with the help of Madhurgaera Water Management Co-operative Association (WMCA).

Water retention

Famers inform that the existing Madhurgaera canal is silted up and not functional now because it has been closed for many years. Some farmers have encroached it and added it with their own adjacent land. Only 300 meters are excavated in front of the regulator although the length of the canal is about 2 km. Farmers want to use canal water for irrigation and for this reason, canal excavation is necessary. When canal will be excavated, they may retain water in the canal during high tide to use it to irrigate the land.

Flood protection

As the regulator is new, it does not have any flood experiences. But farmers think that the crest level is sufficient for flood protection and they assume that the free board against peak flood will be about 4 feet.

This regulator has been constructed last year (2008) and beneficiary farmers have started use of the regulator this year (2009). Hence perspective of the FGD for this regulator is different, which can be summarized in the following Table 5.4:

Table 5.4: Beneficiary assessment about Madhurgaera regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	More than 100% of the project area becomes congested	3	2-vents regulator
	Temporal extent	-		
Flushing	Flushing velocity	-	3	-
Water logging	Water logging	-	3	-
Salinity of canal water	Concentra-tion	-	3	-
Water retention	Irrigation coverage	0	3	Canal is not excavated yet.
Flood protection	Freeboard	4 ft	3	Regulator crest level is high enough

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.5 Duberbeel drainage check

Drainage

Rainfall runoff from Shabraja beel, Kuchugaera beel, Banshtala beel falls into the Duber beel and finally flows through Malidanga canal into Madhurgaera. According to them its catchment is about 500 ha (2.5 km in length and 2 km in width) and there are inflows from other areas also. Length of the canal is about 5 km (it flows through Maijpara and Shahabad union). Drainage congestion is a regular problem in the Duber beel due to silted up canal and inadequate passage across Tularampur-Maijpara connecting road. Farmers feel that drainage congestion (both spatial and temporal) will increase due to small and peculiar opening of the newly constructed drainage check structure.

Flushing

Tidal water cannot reach here due to Madhurgaera regulator and silted up canal.

Water logging

As Duber beel is a beel, there is a small perennial water body. Beside that about 150 acre of land remains under water for more than two months during monsoon period. Farmers do not know right now what will be the situation next year due to this insufficient structure. At present, they think that this water logging situation will improve because its invert level is deep enough.

Salinity

Saline water is not a problem in this area and saline water never enters in this beels.

Water retention

Farmers inform that there is no plan to irrigate land by canal water this year (2009). Usually tidal effects do not reach up here. Although the check structure is constructed to retain water in the canal and lower part of the beels, its crest level is so low that it makes water retention impossible. Crest of the drainage check structure is not sufficient and farmers inform that if there is 1 foot of water in the beel, there is 1 foot of water on the check structure also.

Flood protection

The land is protected from outside flood. Dikes and regulators along the rivers Afra khal and Chitra protect the land from flooding. But the land becomes flooded every year by congested runoff. Rainfall runoff from the upper catchments creates temporary and localized flood and damages standing crops. Main cause of this flooding is silted up canal and these flooding scenarios will be deteriorated due to insufficient opening and lower crest level of the structure next time.

This drainage check structure has been constructed last year (2008) and beneficiary farmers find lots of problems of the structure immediately after construction, which can be summarized in the following Table 5.5:

Table 5.5: Beneficiary assessment about Duberbeel check structure (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	-	1	opening is very small
	Temporal extent	-		
Flushing	Flushing velocity	-	-	Not required
Water logging	Water logging	-	-	Not done
Salinity of canal water	Concentra-tion	-	-	Not required
Water retention	Irrigation coverage	0	1	Low crest level, silted up canal
Flood protection	Freeboard	0	0	Very low freeboard

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.6 Seapagla regulator

Drainage

Farmers have said that the whole area becomes inundated during yearly peak rainfall. Most of the rain water flows through this regulator. This is the passage of rain water from Duruli, Charkhada, Shaspur, Narayanpur, Alokdia, Peruli, Malidanga and Bakshadanga. Drainage becomes quicker during ebb tide in the river. Peak rainfall occurs usually in the monsoon season when water level in the river is also high. Hence it takes long time for complete drainage of the rain water. Crop damage (Aman paddy) occurs due to standing water especially in the low pocket of the catchment. Flood tide retards drainage and increases drain out time significantly.

Beneficiaries have indicated inflow from outside of the benefited area, but newly constructed Madhurgaera regulator will decrease this inflow. They think that larger regulator will further improve this drainage facility. They have also pointed out the inoperative Chamrul regulator and opined that extra flow may be diverted through this regulator if it becomes operative.

Flushing

Farmers do not find any problem due to flow in the canal but they think that the canal bed is gradually silting up.

Water logging

No water logging area is identified within the benefited area. Initially farmers have identified some area as water logged (for 5-6 months) but finally all of them have agreed that it is actually a permanent water body (Khas land).

Salinity

Farmers think that presently there is no salinity problem in their agricultural land.

Water retention

Irrigation coverage from canal water by means of LLP in the project is nil or nearly absent. They have informed that they neither use nor demand canal water for irrigation purposes. They think that reliability of the canal water is very low and it is only seasonal. They always use DTWs for water supply and irrigation round the year. Extra efforts are needed to have both types of water supply systems. Few of them normally withdraw river water along the dike for irrigation.

Flood protection

The regulator is located at about 50 meters away from the river bank along the canal, so flood water does not directly hit the regulator. Average freeboard remains about 3 feet during yearly peak flood as observed last years.

The Seapagla regulator shares the same catchment with Debipur regulator. Beneficiary farmers are asked to keep this fact in mind to rank various parameters during FGD. Results of the conducted FGD are summarized as follows:

Table 5.6: Beneficiary assessment about Seapagla regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	The whole area becomes congested	2	Not done, requires technical check
	Temporal extent	6-7 days		
Flushing	Flushing velocity	Neutral bed	3	-
Water logging	Water logging	0	3	-
Salinity of canal water	Concentra-tion	0	3	-
Water retention	Irrigation coverage	0	-	Good amount of water in the canal
Flood protection	Freeboard	3 feet	3	Crest level is high enough

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.7 Debipur regulator

Drainage

During FGD, beneficiary farmers have delineated the catchment in the villages of Peruly, Malidanga, Bakshadanga and Debipur. These villages are also within the catchments of the Seapagla regulator. Farmers have informed that during yearly peak rainfall, 100% area goes under water with both the rain water inside the project and inflow from outside of the catchments. Farmers have identified rainwater inflow pressure from Maijpara (which is high land relative to other adjacent areas) as a major cause of the drainage congestion.

Flushing

Observed velocity is higher than normal. If the gate becomes bigger, then velocity will be normal.

Water logging

There is no water logging area within the benefited area.

Salinity

When saline water enters into the field, crop damage occurs. After regulator construction, this problem occurs when gate of the regulator does not work properly. They indicate it as a management problem. Saline water problem usually occurs during dry season. But water level in the river is lower enough that it cannot cross the regulator during dry season. Hence, saline water problem is not severe in this area.

Water retention

Farmers have informed during FGD that irrigation coverage using canal water is nearly zero. They have complained of unavailability and unreliability of the canal water. Invert level is high and create obstructions to entrance of river water especially in the dry season. Canal also needs re-excavation in order to retain water for irrigation.

Flood protection

Beneficiary stakeholders have recalled past flood events occurred during last years for a while. They have estimated average freeboard for this regulator about 2 feet. Flood safety level may be increased if the crest level becomes 1-2 feet higher. River bed is silting up gradually and flood frequency is increasing during current years. Hence, higher crest level of the regulator may make it compatible for the floods in the coming years

Results of the FGD for this regulator are summarized as follows (Table 5.7):

Table 5.7: Beneficiary assessment about Debipur regulator (source: FGD and field visits)

Indicators		Beneficiary assessment		On-field assessment
		Quantitative	Performance level	
Drainage	Spatial extent	About 100% of the project area becomes congested	2	-
	Temporal extent	3-4 days		
Flushing	Flushing velocity	Eroding bed	2	-
Water logging	Water logging	0	3	-
Salinity of canal water	Concentra-tion	0	3	-
Water retention	Irrigation coverage	0	0	Narrow canal
Flood protection	Freeboard	2 feet	2	-

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.1.8 Chamrul regulator

Drainage

The FGD participants are mainly farmers. Farmers have identified the catchment of the regulator as Sharatola, Betenga, Naldanga, Chanpur, Bahirdanga, Shitarampur and Chamrul beels of the Tularampur union. The catchment is very big. About 18 km^2 area (9 km length × 2 km width) becomes flooded during monsoon peak rainfall. Presently runoff does not drained out through this regulator and it creates water congestion in the adjacent areas of the regulator. The congested water gradually passes through the bridges of the Jessore-Narail road towards Mulia regulator of the Compartment 2 of the Narail subproject. They have demanded immediate rehabilitation of this regulator and they think that 3-vent regulator instead of two will be better. They have complained that the present invert level is slightly low and hence, river water enters into the canal. This problem will be gradually increasing as river bed is being silted up.

This regulator was serving well just after implementation in 1980's. But then local elite group had started culture fishery in the beels and created obstruction to the drainage canal which ultimately led to closure of the regulator.

Flushing

The gates are inactive and there is earthen cross dam which obstructs the flow. Velocity was higher than average while it was functional.

Water logging

Farmers have informed that other than permanent water bodies (beels, ponds etc) there is about 50 ha of land, which remains flooded during four months (Ashar, Shrabon, Badra and Ashin of the Bengali calendar) every year. If the regulator becomes functional again, this 50 ha will come under Aman cultivation. More land could be brought under Jute cultivation using this regulator facility.

Salinity

Normally river water becomes saline during Chaitra and Baishak every year. Saline water cannot enter into the field and beels as river water remains down compared to the water level in the beels at this time of the year. But water in the canal becomes slightly saline.

Water retention

As the regulator is closed, presently there is no water retention facility in the canal. But there is potentiality of water retention in the canal and irrigation using the retained water. They estimate the potential land for irrigation is about 500 bighas in this project area.

Flood protection

Farmers estimate average freeboard about 2.5 feet. It may be better if the platform (crest level) becomes higher. They think that as slit is being deposited on the river bed, flood water level is gradually increasing in the recent years.

Chamrul is the oldest regulator of the Compartment 1 of the Narail subproject constructed during 1980s. Presently the gates are not functional. Farmers during FGD, have tried to remember the past events related to the indicators and comment with consultation among themselves. Results of the FGD for this regulator are summarized as follows (Table 5.8):

Table 5.8: Beneficiary farmer's assessment about Chamrul regulator (source: FGD and field visits)

<table>
<tr><th colspan="2" rowspan="2">Indicators</th><th colspan="2">Beneficiary assessment</th><th rowspan="2">On-field assessment</th></tr>
<tr><th>Quantitative</th><th>Performance level</th></tr>
<tr><td rowspan="2">Drainage</td><td>Spatial extent</td><td>About 18 km^2 area becomes congested</td><td rowspan="2">1</td><td rowspan="2">Huge and wide meandering flat field</td></tr>
<tr><td>Temporal extent</td><td>-</td></tr>
<tr><td>Flushing</td><td>Flushing velocity</td><td>-</td><td>2</td><td>-</td></tr>
<tr><td>Water logging</td><td>Water logging</td><td>50 ha</td><td>1</td><td>-</td></tr>
<tr><td>Salinity of canal water</td><td>Concentra-tion</td><td>0</td><td>4</td><td>-</td></tr>
<tr><td>Water retention</td><td>Irrigation coverage</td><td>Negligible</td><td>0</td><td>-</td></tr>
<tr><td>Flood protection</td><td>Freeboard</td><td>2.5 feet</td><td>2</td><td>-</td></tr>
</table>

Note: Performance level 0-2= Not satisfactory, 3-4= Satisfactory

5.2 On-field Observation and Technical Evaluation

Based on FGD, on-field observation and technical evaluation has been done for each of the regulator, which are presented in the following sections

5.2.1 Poradanga regulator

Beneficiary assessment implies sufficiency of the most of the hydrological parameters of the regulator during FGD. Parameter-wise performance level of Poradanga regulator is converted into sufficiency / not sufficiency scale of hydrologic parameters in the following way.

Table 5.9: Checklist matrix of Poradanga regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	3	S			
Flushing	2	NS		S	
Water logging	2		NS	S	
Salinity	3				
Water retention	3		S	S	
Flood Protection	3				S

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

From the above Table it is seen that in case of flushing and water logging, farmers have pointed out that opening size and Location of the regulator are not satisfactory to them.

During on-field observation, it is found that canal bed is being eroded and width of the canal in front of the regulator is about 20 meters. Wider approach canal proves farmer’s claim that velocity increases enormously during flushing and peak drainage. Hence, opening of the regulator is smaller than the requirements.

High tidal difference has been found and it is about 4 feet in the monsoon season. Invert level is found at 1.7 m PWD, but water level in river is found compatible with the invert level of the regulator.

During field visit, it is found that regulator is located at mouth of the canal. Water logged area has been visited as well and it is found that the area is a small low pocket surrounded by relatively high land and dike. There is a small drainage culvert across the dike to drain out the water into the Afra khal. Saline water cannot enter through the culvert as the invert level is high enough compared to river water level during dry season. During flood, villagers close the culvert to prevent river water intrusion. This area is in the Poradanga village and very close to the Chanduliar subproject benefited area.

This congested and logged water may be drain out by excavating a canal connecting the Poradanga canal. Alternatively a small pipe sluice in the dike may improve the drainage and water logging problem.

Desk evaluation

Checklist matrix of the Poradanga regulator shows that beneficiary farmers find opening size is insufficient for proper and smooth flushing. Field observation finds erosion and widening of the approach canal, which acts as proof of insufficient opening. For smooth passing of water, water velocity should be about 1.0 m/s through the regulator. Desk evaluation is done for drainage to check opening size of this regulator.

Desk evaluation of opening size

Data used are

Catchment area = 700 ha (benefited area)

(During FGD, farmers find the catchment is about 1050 ha)

Allowable velocity of flow = 1.0 m/s (assuming)

Free flow of 9 hours with blockage of 3 hours (tidal river consideration)

Drainage modulus = 43.5 mm/day (for Narail district)

Tidal factor = 1.33 and Drainage time factor = 0.000116

Therefore, design discharge = $700 \times 43.5 \times 0.000116 \times 1.33 = 4.7\ m^3/sec$

Required vent = $4.7/(1.52 \times 1.83) = 2$ vents (standard vent size $1.52 \times 1.83\ m^2$)

Hence, it is seen from the above analysis that the existing opening size of the regulator (1-vent, 1.52 m ×1.83 m) is not sufficient technically for proper drainage. But people have shown satisfaction on the drainage performance of the regulator. Hence, there might be an outflow from this catchment to the adjacent catchments.

Comparative analysis

Comparative study of social perception and field observation shows that people's assessments about performance of Poradanga regulator are compatible with field observation and evaluation. Social perception and assessment does not differ widely from actual situation of Chanduliar subproject.

Table 5.10: Comparative matrix of social perception and technical evaluation for Poradanga regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS (for flushing only)	NS (for flushing only)	NS (for drainage)
Location	NS	S	-
Invert level	S	S	-
Crest level	S	S	-

Note: S= Sufficient, NS= Not sufficient

From comparative matrix, beneficiaries think that opening of the regulator is not sufficient as water velocity becomes higher and on-field observation finds some proof of this claim. Desk evaluation for opening size finds that it is insufficient for drainage consideration. Although they think that the opening is good for drainage, they also think that the catchment is about 1050 ha. As the land is relatively high, there might be an outflow to the south. People claim that Location of the regulator is erroneous, but it seems that this parameter is quite good.

5.2.2 Panu regulator

Beneficiary farmers in Panu khal regulator express dissatisfaction for almost all of the performance parameters. Hence, assessments imply insufficiency of the hydrological parameters of regulator. Parameter-wise performance level of Panu regulator is converted into sufficiency / insufficiency of hydrologic parameters in the following way.

Table 5.11: Checklist matrix of Panu regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	1	NS			
Flushing	2	NS		S	
Water logging	2		S	S	
Salinity	1				
Water retention	3		S	S	
Flood Protection	2				NS

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

During field visit, a big paddy field is found and a canal is running across the field. It is not possible to observe spatial and temporal extent of drainage congestion and water logging.

Because, amount of rainfall runoff is relatively low although it is monsoon this year (2009). Map study shows that catchment is large and there might be inflow from north part, which is relatively high land.

Canal is excavated and there is a small dike along both sides of the canal. Canal section is found smooth, straight and regular. It seems that the land in the both banks of the canal is flat and slightly sloppy towards the canal.

During field visit, the vent size of the regulator is found about 1.2 meters × 1.8 meters, which is smaller than the standard vent size of 1.52 meters × 1.83 meters. The size of the regulator opening seems to be very narrow compared to the width of the approach canal. The 2-vents size (standard size) regulator could be best fit in this canal.

There is road in the project area, which may create water logging in the low pockets of the other side of the road due to lack proper of culverts. It seems that invert level is quite good.

There is only one lifting gate and no flap gate. This gate is also found faulty. Wooden sheet are set upon the steel sheet to prevent leakage. Recently, saline water intrudes due to faulty and corroded gate. Canal is found full of water, which is potential for irrigation coverage.

Crest level of the regulator is found 2 feet lower than the existing eroded road. During start of ebb tide, water depth is found about 2.2 meters and there is only 1.3 meters freeboard. It is definitely unsatisfactory for flood protection.

Desk evaluation

Technical evaluation has been done to check the sufficiency of the opening size and crest level. Simple mathematical equations, flood record and land elevation has been used in this regard.

Desk evaluation of opening size

Data used are

Catchment area = 291 ha (benefited area)

Gross catchment area = 400 ha

Allowable velocity of flow = 1 m/s (assuming)

Free flow of 9 hours with blockage of 3 hours (tidal river consideration)

Drainage modulus = 43.5 mm/day (for Narail district)

Tidal factor = 1.33 and Drainage time factor = 0.000116

Therefore, design discharge = 400×43.5×0.000116×1.33 = 2.68 m^3/sec

Required vent = 2.68/(1.52 × 1.83) = 1 vent (standard vent size 1.52 × 1.83 m^2)

Hence, technically the existing opening size of the regulator (1-vent, 1.2 m ×1.8 m) is not sufficient for proper drainage.

Moreover, farmers in the Chanduliar subproject express satisfaction over drainage through 1-vent regulator although its catchment is about 1050 ha. Hence there must be an inflow from the Chanduliar subproject into the Panu subproject. Although benefited area is about 291 ha, its catchment area is bigger. Hence, the present opening size is technically insufficient.

Desk evaluation for crest level

From analysis and interpolation of water level data of 22 years (1981-2002) of Khatur station, Chitra and Afra ghat station, Bhairab.

Annual average (2.33 years) monsoon flood level = 3.34 m PWD

1: 20 years monsoon flood level = 4.23 m PWD

(Source: LGED subproject feasibility study reports)

Hence, the present crest level of the regulator (4.0 m PWD) is not technically sound considering 1 in 20 years flood level. Moreover, freeboard is needed and river is gradually being silted up requiring higher crest level.

Comparative analysis

Similar implication about social perception of performance of water control structure has been found for Panu regulator. On-field observation and simple technical check verify social perception of the regulator. Comparative matrix between social perception and technical check for this regulator is shown in the Table 5.12.

Table 5.12: Comparative matrix of social perception and technical evaluation for Panu regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS	Not done	NS
Location	S	-	-
Invert level	S	S	Not done
Crest level	NS	NS	NS

Note: S= Sufficient, NS= Not sufficient

Social perceptions for Panu regulator are quite good. People have identified that opening size and crest level are not sufficient for this regulator and desk assessment makes this claim true. Hence it can be said here that people can correctly percept natural events like drainage congestion, salinity, flood etc and capable to make evaluation of the hydrologic parameters of regulator during post construction period.

5.2.3 Boramara regulator

Beneficiary farmers indentify nearly all indicators satisfactory to them and hence all hydrologic parameters of this regulator are sufficient. Social perceptions about performance and hydrologic parameters of Boramara regulator are given in the Table 5.13 below.

Table 5.13: Checklist matrix of Boramara regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	3	S			
Flushing	3	S		S	
Water logging	3		S	S	
Salinity	3				
Water retention	2		S	S	
Flood Protection	3				S

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

A field visit has been made to the project area and found that the benefited area is nearly flat. There is only one agricultural field, of which water is being drained out through this regulator. Adjacent catchment is Madhurgaera-Debipur.

The width of the regulator is about 1.2 meters and there is one lifting gate and no flap gate. Hence it is a drainage structure. It is not compatible with standard vent size. The width of the vent opening is smaller than the standard size.

The canal is about 15 feet wide with 5 feet water depth at the end of the ebb tide (during field visit). The flow through the regulator is normal.

Desk evaluation

As people's perception about performance parameters of this regulator is satisfactory and preliminary field observation is also satisfactory, detail technical analysis is not made for the hydrologic parameters of this regulator. Moreover, the opening size of this regulator (1.2 m × 1.8 m) is not standard.

Comparative analysis

Social perception about performance of this regulator has been found satisfactory. On-field observation is found satisfactory too. Comparison is given in the following Table 5.14.

Table 5.14: Comparative matrix of social perception and technical evaluation for Boramara regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	S	Not done	Not done
Location	S	S	Not done
Invert level	S	S	Not done
Crest level	S	S	Not done

Note: S= Sufficient, NS= Not sufficient

5.2.4 Madhurgaera regulator

Madhurgaera regulator has been constructed in the year 2008 and implemented in the year 2009. People's participation has been ensured in every phase of this subproject. People express their positive attitude to all the indicators of performance parameters. Hence all hydrologic parameters are sufficient to them. It can be noted here that this is only an anticipated opinion. Social perceptions about performance and hydrologic parameters of this regulator are given in the Table 5.14.

Table 5.15: Checklist matrix of Madhurgaera regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	3	S			
Flushing	3	S		S	
Water logging	3		S	S	
Salinity	3				
Water retention	3		S	S	
Flood Protection	3				S

Note: S= Sufficient, NS= Not sufficient

On-field observation

There is a road in between Debipur field and Madhurgaera field. During inspection and visit along the road, it seems that the land along the road is relatively high and the lands slope towards the regulators. There are paddy fields in the both sides of the roads. There are no fellow lands or water logged areas. The canals in the paddy fields are found blocked and encroached in many places. The canal bed is silted up and it is hardly possible to distinguish from the paddy field.

Construction of the regulator has been found good and complete. Approach embankment has been re-sectioned along with regulator construction. It is a 2-vents regulator of standard opening (1.53 m × 1.82 m) size with lifting gates and flap gates. The approach canal has been excavated. Water level (at the time of ebb tide) at the foot of the flap gate is about 1.5 meters and freeboard is about 3.0 meters during field visit.

Invert level and crest level of the regulator seems satisfactory during inspection of the regulator side comparing with water level and invert level and crest level of other adjacent embankment and regulators.

Discussion with key informants

Mr. Jaidur Rahman, Member, WMCA of the Madhurgaera subproject says that it seems to him and the farmers that the situation is satisfactory. But actual situation will realize after few years. Comparing adjacent subprojects, he thinks that Madhurgaera subproject is better in all sides.

Mr. Jahangir Alam, Facilitator, LGED, Narail says that peoples participation has been ensured in all phase of planning, design and implementation to make it successful subproject. He adds that initially 1-vent has been proposed in the feasibility study, and then 2-vent regulator has been constructed to meet the demand of the local beneficiary. He mentions also that pipe sluice have been designed to construct in Duberbeel in the feasibility study and then it is replaced by drainage check structure with consultation of the local stakeholders.

Desk evaluation

Beneficiary stakeholders express positive and satisfactory attitudes and preliminary field observation is also satisfactory. Hence, detail technical analysis is not done for the hydrologic parameters of this regulator.

Comparative analysis

Social perceptions about performance of this regulator have been found satisfactory. On-field observation is satisfactory too, which is shown in the Table 5.16.

Table 5.16: Comparative matrix of social perception and technical evaluation for Madhurgaera regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	S	S	Not done
Location	S	S	Not done
Invert level	S	S	Not done
Crest level	S	S	Not done

S= Sufficient, NS= Not sufficient

In this regulator, peoples participation is ensured during design, planning and construction phase. Hydrologic parameters are designed with consultation. Location, invert level and crest level are quite good. There are two adjacent regulators (Debipur and Boramara regulators), which are 1-vent each and within half km of distance. Hence, there is a possibility that 1-vent regulator could be sufficient. Feasibility study also had determined 1-vent regulator for construction. In that case, 2-vents regulator is superfluous one, although the more the vents, the more would be the drainage performance, whether it is economically feasible or not.

5.2.5 Duberbeel drainage check

Although it is a new structure, farmers raise objections about hydrologic parameters (opening size and crest level) rather than parameters of performance. Collected social perceptions during FGD are converted and shown in the Table 5.17.

Table 5.17: Checklist matrix of Duber beel drainage check structure technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	1	NS		S	
Flushing	-				
Water logging	-				
Salinity	-				
Water retention	1			S	
Flood Protection	0				NS

S= Sufficient, NS= Not sufficient

On-field observation

In site visit, the drainage check structure is found with rectangular opening. Width of the opening is measured about 55 inches or 1.4 meters and it is 2.0 meters deep. It is located about 100 meters west from the Malidanga bridge. It is an open structure constructed across the canal with no floor or platform on it. There is one lifting gate. The local UP member has disconnected the gate and taken it to his home for storage. It seems that the catchment is very large and wide, the existing opening is not sufficient.

Water retardation and storage is main purpose of this structure. Crest level is found insufficient and during field visit, it seems that the water is nearly touching the crest while the situation is normal (non-flooding situation).

Discussion with key informants

UP member of this area says that they (the beneficiary farmers) ask for larger structure but LGED has constructed a smaller one. Finally it will create problems (like water congestion and water logging) and it will have little help to its main purpose (water retention). They say that they have already informed it to Executive Engineer of LGED and he has assured them that he would take necessary steps to change the structure.

Facilitator of Narail LGED says that originally it is a pipe structure in the feasibility study but beneficiary farmers has asked for this type of structure in the consultation meeting. So it has been constructed with beneficiary participation. Now they are complaining about its opening size and crest level. LGED will reconsider this structure, when they get formal proposal from the beneficiary farmers.

Desk evaluation

Beneficiary stakeholders express dissatisfaction about opening size of the structure and its crest level. Preliminary field observation is unsatisfactory for these two hydrologic parameters too. Detail technical analysis is not done for the hydrologic parameters of this regulator due to unavailability of data. Moreover, field investigation is sufficient to confirm the unsatisfactory opening and crest level. Furthermore, it does not comply with any standard hydrologic structures.

Comparative analysis

Social perception about performance of this check structure has been found unsatisfactory. On-field observation has justified these unsatisfactory perceptions of the beneficiary farmers too (Table 5.18).

Table 5.18: Comparative matrix of social perception and technical evaluation for Duber beel drainage check structure

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS	NS	Not done
Location	S	S	Not done
Invert level	S	S	Not done
Crest level	NS	NS	Not done

Note: S= Sufficient, NS= Not sufficient

Beneficiary farmers claim that Duber beel drainage check structure is insufficient in terms of opening size and crest level. On-field observation has justified their claims. Combined summary appraisal report and summary EIA report of Madhurgaera subproject prepared by House of Consultants Ltd (January 2006) proposed 1 vent regulator at the mouth of the Madhurgaera khal and 1.2 m diameter pipe sluice at about 2.2 km upstream of the khal. LGED claims that farmers are informed of the proposed structures in the consultation meeting prior to construction. They have chosen rectangular check structure instead of pipe sluice and demanded 2-vents regulator instead of 1-vent.

5.2.6 Seapagla regulator

Beneficiary farmers are familiar with this regulator for last 10 years and so they are confident in assessing the performance parameters. Parameter-wise social ranking of this regulator is converted into sufficiency/not sufficiency of hydrologic parameters in the following way (Table 5.19).

Table 5.19: Checklist matrix of Seapagla regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	2	NS			
Flushing	3	S		S	
Water logging	3		S	S	
Salinity	3				
Water retention	-		-	-	
Flood Protection	3				S

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

During field observation, it is realized that the catchment of this subproject is relatively large and a long canal is found running across the field. It is not possible to observe spatial and temporal extent of drainage congestion and water logging. Because, this year (2009), during field visits, amount of rainfall and runoff is relatively low although it is monsoon.

During field visit, the vent size of this 2-vents regulator is found standard and width of the regulator seems to be best fitted with the width of the canal.

A union connecting road between Maijpara and Tularampur runs across this subproject. This road certainly retards flow of water and make the water congestion longer. It seems that invert level is quite good.

There are lifting gates and flap gates which are found well during field visit. Canal is found full of water, which is potential for irrigation. Crest level of the regulator is found 1 foot higher than the existing dike.

Desk evaluation

Form FGD, it is found that farmers are mainly dissatisfied due to water congestion and long time of water removal from the crop field. Simple mathematical equations, flood record, rainfall runoff, drainage modulus etc has been used in this regard.

Desk evaluation of opening size

As Debipur and Seapagla shares same catchment, it may be assumed from experiences and secondary data that about 60% of the total design discharge flows through Seapagla regulator. Inflow to this catchment is about 30% from other adjacent catchments.

Data used are

Benefited area = 975 ha

Gross catchment area = 1275 ha

Allowable velocity of flow = 1 m/s (assuming)

Free flow of 9 hours with blockage of 3 hours (tidal river consideration)

Drainage modulus = 43.5 mm/day (assuming similar for the whole Narail district)

Tidal factor = 1.33 and Drainage time factor = 0.000116

Therefore, design discharge = 1275×43.5×0.000116×1.33×0.6×1.3 = 6.54 m^3/sec

(Assuming 60% of the total discharge and 30% inflow)

Required vent = 6.54/(1.52×1.83) = 3 vents (standard vent size 1.52 × 1.83 m^2)

Hence, technically the existing opening size of the regulator (2-vent, 1.5 m ×1.8 m) is not sufficient for proper drainage subject to assumption. Gross catchment area is larger than the benefited area. There may be inflow from the other adjacent catchments. So, erroneous consideration of the catchments area may results in fewer vents than the requirement.

Comparative analysis

Social perception about performance of Seapagla regulator has been found quite similar for opening size. Simple technical check verifies social perceptions of the regulator (Table 5.20).

Table 5.20: Comparative matrix of social perception and technical evaluation for Seapagla regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS	NS	NS
Location	S	-	Not done
Invert level	S	-	Not done
Crest level	S	-	Not done

Note: S= Sufficient, NS= Not sufficient

Beneficiary of Seapagla regulator has identified drainage congestion and hence insufficiency of the opening size. Opening size of this regulator seems unsatisfactory from technical check. Improper canal network increases drainage congestion. Union connecting road between Tularampur and Maijpara might cause obstruction to water drainage.

5.2.7 Debipur regulator

Beneficiary stakeholders of the Debipur regulator have identified their problems related to this regulator and measured performance level according to their feeling towards satisfaction in the following way (Table 5.21).

Table 5.21: Checklist matrix of Debipur regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance level	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	2	NS			
Flushing	2	NS		S	
Water logging	3		S	S	
Salinity	3				
Water retention	0		S	NS	
Flood Protection	2				NS

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

A field visit have been paid to the Debipur regulator immediately after FGD conducted at Char Peruly.

Debipur regulator shares part of the same catchment with Seapagla regulator. Peruly, Malidanga, Bakshadanga and Debipur are common villages in the same catchment of the regulators. The catchment is nearly flat with no perennial low land and wetland.

Desk evaluation

Simple empirical mathematical equations, flood record, topographic contour, drainage modulus etc has been used in this regard to check the sufficiency of opening size, invert level and crest level of the regulator.

Desk evaluation of opening size

As Debipur and Seapagla shares same catchment, it may be assumed from experiences and secondary data that about 40% of the total design discharge flows through Debipur regulator. Inflow to this catchment is about 20% from other adjacent catchments.

Data used are

Benefited area = 975 ha

Gross catchment area = 1275 ha

Allowable velocity of flow = 1 m/s (assuming)

Free flow of 9 hours with blockage of 3 hours (tidal river consideration)

Drainage modulus = 43.5 mm/day (assuming similar for the whole Narail district)

Tidal factor = 1.33 and Drainage time factor = 0.000116

Therefore, design discharge = 1275×43.5×0.000116×1.33×0.4×1.2 = 4.12 m^3/sec

(Assuming 40% of the total discharge and 20% inflow)

Required vent = 4.12/(1.52×1.83) = 2 vents (standard vent size 1.52 × 1.83 m^2)

Hence, technically the existing opening size of the regulator (1-vent, 1.5 m ×1.8 m) is not sufficient for proper drainage subject to assumptions. So, erroneous consideration of the catchments area results in fewer vents than the requirement.

Desk evaluation of invert level

From the tidal data of the Afra khal

Lowest tide level is -0.06 m PWD (in March)

And minimum mean tide level is 0.021 m PWD (in February)

Considering contours of the area, 0.0 m PWD level and tidal water level data, the present invert level of the regulator (0.5 m PWD) seems to be properly fixed.

Desk evaluation of crest level

From analysis and interpolation of water level data of 22 years (1981-2002) of Khatur station, Chitra and Afra ghat station, Bhairab.

Annual average (2.33 years) monsoon flood level = 3.34 m PWD

1: 20 years monsoon flood level = 4.23 m PWD

(Source: LGED subproject feasibility study reports)

Hence, the present crest level of the regulator (4.5 m PWD) is technically feasible considering 1 in 20 years flood level.

Comparative analysis

Social perceptions for performance parameters of Debipur regulator are quite similar for opening size (Table 5.22).

Table 5.22: Comparative matrix of social perception and technical evaluation for Debipur regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS	-	NS
Location	S	-	-
Invert level	NS	-	S
Crest level	NS	-	S

Note: S= Sufficient, NS= Not sufficient

Analysis of social perceptions indicates that hydrologic parameters of this regulator are not sufficient. But technical check do not find major problem in the design of the invert level and crest level. Opening size of the regulator is not satisfactory to people and technical check verify their claim. People identify invert level is higher and hence water cannot flow in during dry season. But it is not expected in the design that water will flow during dry period of the year especially when the river water becomes saline. However invert level could be fixed at 0.0 m PWD and it would not be technically unviable. Although crest level is not dissatisfactory and technically it is not faulty, 5.0 m PWD crest level could be designed instead of 4.5 m PWD considering long term benefit. Here although social perceptions do not coincide with technical check, the difference is negligible. Although technical check does not verify social perceptions, it is impractical to say that social perceptions are invalid. Moreover consideration of social perceptions in the regulator design might increase people's participation in the project.

5.2.8 Chamrul regulator

Beneficiary farmers have recalled the situations while the regulator was workable during late 1980s and early 1990s and projected the situations in terms of drainage, flushing, water logging, salinity, water retention and flood protection. They have ranked their assessments for each performance parameters, which can be made related with hydrologic parameters in the following way (Table 5.23):

Table 5.23: Checklist matrix of Chamrul regulator for technical evaluation (source: FGD result)

Parameter used for FGD	Performance	Hydrologic parameters of regulator			
		Opening size	Location	Invert level	Crest level
Drainage	1	NS			
Flushing	2	NS		NS	
Water logging	1		-	-	
Salinity	4				
Water retention	0		-	-	
Flood Protection	2				NS

Note: S= Sufficient, NS= Not sufficient

On-field observation and evaluation

Catchment of this regulator is relatively large. This regulator covers the whole catchment of the Compartment 1 (about 5000 ha) of the Narail subproject. Chamrul canal runs parallel to the Jessore-Narail connecting road and then changes direction towards north into the beels. Gates of the regulator are not found during field visits. A small cross dike has been constructed down side of the regulator to prevent water entrance from the river and to facilitate culture fishery. Water is found entering through small opening of the cross dike into the canal during flood tide.

It is 2-vent regulator with measured width of 2 × 1.52 meters. The crest is about 3.5 meters high above the water level during field visit. The crest of the approach dike here is about 16 feet wide and 7 feet height in the countryside. The water level is found close to the crest of the dike during high tide.

As the regulator is closed with cross dam, no flow has been observed in the canal water. Eventually canal water is stagnant. The land is meandering and flat. No water logging has been noticed during field visit. Salinity of the canal water is found moderate. No irrigation facilities with the canal water are found during field visits. The crest of the regulator is slightly lower than the crest of the embankment.

Desk evaluation

Simple empirical mathematical equations, flood record, topographic contours, drainage modulus etc has been used to check the sufficiency of opening size, invert level and crest level of the regulator.

Desk evaluation of opening size

The catchment of the Chamrul regulator is relatively large and presently it shares the whole catchment with other regulators such as Poradanga, Panu, Boramara, Seapagla, Debipur, Madhugaera etc. It will share more with the proposed regulators in nearest future as well. Some rainfall runoff also flows to the south into Compartment 2 through the bridges and culverts. So it may be assumed that about 30% of the rainfall runoff will flow through this regulator.

Data used are

Catchment area = 0.3 × 5000 ha (estimated with assumption)

Allowable velocity of flow = 1 m/s (assuming)

Free flow of 9 hours with blockage of 3 hours (tidal river consideration)

Drainage modulus = 43.5 mm/day (assuming similar for the whole Narail district)

Tidal factor = 1.33 and Drainage time factor = 0.000116

Therefore, design discharge = 0.3×5000×43.5×0.000116×1.33 = 10.1 m^3/sec

Required vent = 10.1/ (1.52×1.83) = 4 vents (standard vent size 1.52 × 1.83 m^2)

Hence, technically the existing opening size of the regulator (2-vents, 1.5 m ×1.8 m) is not sufficient for proper drainage subject to assumptions.

Desk evaluation of invert level

From the tidal data of the Afra khal

Lowest tide level is -0.06 m PWD (in March)

And Minimum Mean tide level is 0.021 m PWD (in February)

Considering contours of the area, 0.0 m PWD and tidal water level data, the present invert level of the regulator (0.0 m PWD) seems sufficient and good.

Desk evaluation of crest level

From analysis and interpolation of water level data of 22 years (1981-2002) of Khatur station, Chitra and Afra ghat station, Bhairab.

Annual average (2.33 years) monsoon flood level = 3.34 m PWD

1: 20 years monsoon flood level = 4.23 m PWD

(Source: LGED subproject feasibility study reports)

Hence, the present crest level of the regulator (5.0 m PWD) is technically feasible and sufficient considering 1 in 20 years flood level.

Comparative analysis

Similar implication has been drawn between beneficiary assessment and technical evaluation of the hydrologic parameters of the Chamrul regulator (Table 5.24).

Table 5.24: Comparative matrix of social perception and technical evaluation for Chamrul regulator

Hydrologic parameter	Beneficiary assessment	On-field evaluation	Desk evaluation
Opening size	NS	NS	NS
Location	S	S	-
Invert level	NS	-	S
Crest level	NS	-	S

Note: S= Sufficient, NS= Not sufficient

Chamrul regulator has been constructed as drainage cum flushing regulator alone for the whole Compartment 1. It is clear that Chamrul regulator is not sufficient alone for the whole catchment from both social perceptions and technical point of view. Still it is not sufficient, although there are now about 9-12 regulator (approx. 15 vents) for the same catchment. Hence, social perceptions reflects technical drawback of the regulator for opening size. In case of both invert and crest level, social perceptions show dissatisfaction, but it is not extreme. Technical check shows that both invert and crest level fixation are good. Hence a similarity might be drawn between social perceptions and technical evaluation. Consideration of social perception in the design of invert level and crest level might increase people's participation in the project.

5.3 Composite comparative study

Based on the detail study of the selected regulators of Compartment 1 of Narail subproject, social perceptions and its usefulness about performance of water control structures can be discussed as follows:

5.3.1 Social perceptions of regulator performance

In case of regulators, beneficiary stakeholders have good sense of perceptions about performance parameters. They have capabilities to find out the faults in hydrologic parameters of the water control structures (regulators) from their experiences of drainage congestion, flooding, salinity intrusion, irrigation etc. Performance of six regulators (Poradanga, Panu, Boramara, Debipur, Seapagla and Chamrul) has been measured and evaluated considering six parameters. Madhurgaera regulator and Duberbeel check structure are considered for composite comparative study as they are under construction and implementation only. Social perceptions about performance of these regulators are summarized in the following Table 5.25.

Table 5.25: Social perceptions of performance parameters

Performance parameter	Social perceptions		
	No of regulators	Satisfactory	Unsatisfactory
Drainage	6	1	5
Flushing	5	2	3
Water logging	6	3	3
Salinity	5	4	1
Water retention	6	2	4
Flood protection	6	4	2

Drainage

One regulator out of six regulators scores satisfactory in drainage performance. This perception simply denotes unsatisfactory opening size in the hydrologic design of the regulator.

Flushing

Three out of five regulators score unsatisfactory in flushing performance. These perceptions denote unsatisfactory opening size again and invert level of the regulator as well.

Water logging

Out of six regulators, three score satisfactory and three score unsatisfactory in water logging performance. Unsatisfactory water logging means faulty location and/or invert level of the regulator.

Salinity

Regulator performance is satisfactory in preventing salinity intrusion during the dry seasons. Out of five regulators, four score satisfactory. Unsatisfactory performance in salinity causes mostly due to management problems.

Water retention

Out of six regulators, five score unsatisfactory for water retention. Unsatisfactory performance for water retention means fixation of faulty invert level along with inadequate depth of canal and temporal availability and reliability of river water.

Flood protection

Two out of six regulators score unsatisfactory perception for flood protection parameter. In this case, perceptions of unsatisfactory performance denote insufficient crest level of the regulator.

Regulator wise social perceptions for the selected performance parameters are shown in the Table 5.26.

Table 5.26: Regulator wise social perceptions about performance parameters

Regulator	Performance parameters		
	No	Satisfactory	Unsatisfactory
Poradanga	6	4	2
Panu	6	1	5
Boramara	6	5	1
Seapagla	6	4	2
Debipur	6	2	4
Chamrul	5	1	4

Social perceptions have been obtained about performance parameters and converted into sufficiency/insufficiency of four relevant hydrologic parameters of each regulator. Technical cross check has not been conducted on the satisfactory performance parameters of the regulators. Results of the comparative analysis of social perceptions and technical assessment have been given below in the Table 5.27:

Table 5.27: Comparison of social perceptions and technical assessment

Hydrologic parameters	Social perceptions			Technical assessment		
	Nos	Satisfactory	Unsatisfactory	Nos	Satisfactory	Unsatisfactory
Opening size	6	1	5	5	-	5
Location	6	5	1	1	1	-
Invert level	6	4	2	2	2	-
Crest level	6	3	3	3	2	1

In the above Table, Social perceptions are very good in determination of the adequacy of the opening size. People express dissatisfactory opening size of five regulators out of six. Technical assessment for opening size of the regulator indicates correctness of the social perception.

Location of the regulators is satisfactory to the beneficiary farmers for all cases except Poradanga regulator. Invert levels and crest levels are in most cases found satisfactory to the beneficiary farmers. Unsatisfactory perceptions are found for invert level of two regulators and crest level of three regulators out of six regulators whereas technical assessment shows satisfactory except Panu regulator. Slight adjustment in the crest level and invert level might be possible in the technical design to reflect social perceptions.

5.3.2 Social perceptions and technical design

From study of eight regulators, it is seen that social perceptions about the design requirements of hydrologic parameters are good. Social perceptions comply with the technical cross check and on-field observation in this study. Normally local people do not disagree with the Location of the regulators.

In some cases, beneficiaries show dissatisfaction about invert level (Chamrul and Debipur regulator) and crest level (Panu and Debipur regulator) of the regulator. Although invert level and crest level of these regulators are technically satisfactory, it is impractical to say that social perceptions about invert level and crest level are not right. It might be better if the invert level and crest level are designed with the congruence of the beneficiary opinion for better management. Similar opinion might be made for all hydrologic parameters of the regulator.

In most cases, social perceptions indicate dissatisfactory about opening size of the regulators. Technical evaluations show that Poadanga, Panu, Duber beel, Seapagla, Debipur and Chamrul regulators have smaller opening size than the requirement, while Madhurgaera and Boramara have technically satisfactory opening size. Technical design might have several alternatives and social perceptions may be incorporated in the technical design of water control structures. Social perceptions about opening size, location, invert level and crest level might be collected and considered during technical design of regulator to maximize outputs and to involve beneficiaries into the project planning, design and implementation.

In some cases, dissatisfactory opinion size comes due to lack of proper maintenance of the structures. Drainage congestion and water logging (Seapagla and Debipur regulator) are results of improper canal network. In all the problematic regulators, it is observed that management faults are severe rather than any design fault.

5.3.3 Usefulness of social perceptions

From analysis, social perceptions are good for all the four selected hydrologic parameters especially in the opening size of the regulators. On the other hand, technical design of water control structures, sometimes, show faults and does not work up to expectation level.

Under the condition above, it might be beneficial when technical design of hydrologic parameters of water control structures is cross checked and verified with local knowledge and skill before going into implementation.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

From analysis of the study, the following conclusions can be made:

1. Beneficiaries are competent to measure performance of hydrologic parameters of water control structures.

2. They are also capable to identify the faults in the design of hydrologic parameters since they are experienced of natural events like drainage congestion, draught, flood, water logging, salinity etc.

3. Most of the regulators score unsatisfactory performance for drainage and flushing parameters. Out of six regulators, five regulators score unsatisfactory for drainage performance.

4. Technical cross check of unsatisfactory regulators proves that they have smaller opening size than that of the requirement.

5. Three out of six regulators score unsatisfactory in performance of water logging parameter. Similarly four regulators score unsatisfactory in performance of water retention parameter. Only two regulators score unsatisfactory in performance of flood protection parameter.

6. Location, invert level and crest level are relevant hydrologic parameters of regulator. Technical cross check of the relevant hydrologic parameters verifies social perceptions.

7. Most of the regulators score satisfactory (four out of five) in performance of preventing salinity intrusion. It is a management parameter; better management might ensure better salinity free condition in the project.

8. All regulators have few unsatisfactory performance parameters. Panu regulator has five unsatisfactory parameters, whereas Boramara has one unsatisfactory parameter out of total six performance parameters. Technical cross check verifies design faults in hydrologic parameters of Panu regulator.

9. Beneficiaries express opinion in performance of few hydrologic parameters of regulator differently from technical design. Technical design may vary within ranges and both social perceptions and technical design might be acceptable.

10. Social perceptions are well in identifying the type of structure they require. Social perceptions might be incorporated in the design of water control structures to make it socially more acceptable.

6.2 Recommendations for future projects

Bangladesh is an agro-based country. Crop production must be increased to meet the increasing food demand of the increasing population by implementing more FCD/I projects. The following findings and recommendations should be considered in project formulation, planning and design of various water control structures:

- Water resources project is complex in nature and requires lots of experiences and technical capability. Hence, water resources project and structure should be constructed through consultations with beneficiary stakeholders and using technical cross check. This interaction will increase performance efficiency of the project.

- It may be noted that beneficiary participation in water resources project becomes essential for better outcomes and success. Participation in all phases of water resources project will grow better understanding and sense of ownership, which ultimately results in better management and delivery of services.

- Social perceptions and technical design might be complementary to one another. It is recommended that technical design of hydrologic parameters of water control structures should be cross checked with social perceptions of the beneficiaries before going into implementation of FCD/I projects.

6.3 Recommendation for further study

- A case study project may be taken to finding out the extent of social perceptions in the design of hydrologic parameters of water control structures. For the purpose of study, hydrologic parameters of a water control structure can be designed in accordance with social perceptions of the beneficiaries. After few years (about 5 years) of construction, social perceptions of performance parameters of the selected structure can be collected and analyzed again to check the differences between the two perceptions.

References

Abernethy C. L., Jinapal K. and Makin I. W. (2001), *Assessing the opinions of user of water projects,* The Journal of the International Commission on Irrigation and Drainage, Vol-50(3), 2001

BWDB (2005), Development Project Proposal for Southwest Area Integrated Water Resources Planning and Management Project, Bangladesh Water Development Board, Government of the people's Republic of Bangladesh, December 2005

BWDB and CIDA (1991), Design Workshop: Small Scale Water Control Structures, Vol.-1, Sponsored by BWDB and CIDA and Organized by Northwest Hydraulic Consultants, 1991

BWDB (2008), Guidelines for Integrated Planning for Sustainable Water Resources Management, Bangladesh Water Development Board, Ministry of Water Resources, Govt. of Bangladesh, September 2008

BWDB (2009), Southwest Area Integrated Water Resources Planning and Management Project, Institutional Strengthening and Project Management, Technical Report no. 6, Subunit Implementation Plan SWN-8 Tularampur, Bangladesh Water Development Board, March 2009

BWDB (Undated), Standard Design Manual, Vol.-1, Standard Design Criteria, Standard Design Manual Committee, Bangladesh Water Development Board, Office of the Chief Engineer (Design), BWDB Dhaka

Banglapedia (2009), Maps: Narial, www.banglapedia.com, downloaded on August 23, 2009

Duyne, J. E. (1998) Community Partnership for Sustainable Water Management: Experiences of the BWDB Systems Rehabilitation Project, Vol. VI, Local Initiatives for Sustainable Water Resources Management, The Universal Press Limited, June 1998.

DFID and others, Water Resources Management in Bangladesh: A Policy Review, Livelihood-Policy Relationships in South Asia, Working Paper 1

FAP-13 (1992), Operation and Maintenance Study: Appraisal of Operation and Maintenance in FCD/I projects, Vol-I&II, Flood Action Plan, FPCO, Govt. of Bangladesh, March 1992

FPCO (1993), Guidelines for People's Participation, Flood Plan Coordination Organization, Ministry of Irrigation, Water Development and Flood Control, Government of the people's Republic of Bangladesh, March 1993

Google earth (2009), Narail, www.googleearth.com, downloaded on August 23, 2009

Halcrow and others (2004), Southwest Area Integrated Water Resources Planning and Management Project, Main Report, Asian Development Board, Bangladesh Water Development Board and Water Resources Planning Organization, 2004.

Hunting Technical Services Limited, Flood Hazard Research Centre and Technoconsult International Limited (1992), FAP-12 FCD/I Agricultural Study, Flood Plan Coordination Organization, Ministry of Irrigation, Water Development and Flood Control, Government of the people's Republic of Bangladesh, March 1992

House of Consultants Ltd, (2006), Madhurgaera Subproject Combined Summary Appraisal Report and Summary EIA Report, House of consultants Ltd, Prepared for Local Government Engineering Department, PMO-SSWRDSP-2, LGED, Dhaka, January 2006

House of consultants Ltd, (1998), Seapagla Subproject Combined Summary Appraisal Report and Summary EIA report, House of consultants Ltd, Prepared for Local Government Engineering Department, PMO-SSWRDSP-2, LGED, Dhaka, 1998

LGED (2003), External Evaluation: Small Scale Water Resources Development Sector Project-I, Final report, Local Government Engineering Department, Govt. of Bangladesh, June 2003

MoWR (1999), National Water Policy, Ministry of Water Resources, Government of the people's Republic of Bangladesh, Dhaka, 1999.

Nishat, A., Mirjahan, M. and Saleh, A. F. M. (1998) Community Partnership for Sustainable Water Management: Experiences of the BWDB Systems Rehabilitation Project, Vol. III, Engineering Evaluation, The Universal Press Limited, June 1998

Nahar, N. (2009), Cumulative Environmental Impact Assessment of Narail Subproject, M.Sc. thesis, Institute of Water and Flood management, Bangladesh University of Engineering and Technology (BUET), June 2009

Subramanya, K. (2009) Engineering Hydrology, Third edition, Tata MacGraw-Hill, New Delhi, 2009

Technical Advisory Committee (2000), Integrated Water Resources Management, TAC Background Papers no. 4, Global Water Partnership, Sweden, March 2000

Wikipedia (2008a), Social perception, http:// en.wikipedia.org/wiki/Social_perception, downloaded on July 2, 2008

Wikipedia (2008b), Social design, http:// en.wikipedia.org/wiki/Social_design, downloaded on July 2, 2008

Wikipedia (2008c), Traditional knowledge, http:// en.wikipedia.org/wiki/Traditional_knowledge, downloaded on July 2, 2008

Wikipedia (2008d), Likert scale, http:// en.wikipedia.org/wiki/Likert_scale, downloaded on October 13, 2008

Appendix A

Checklist for FGD

“Social perceptions and technical evaluation of performance of selected water control structures in Narail district”

Name of the regulator:-

Date, Time and Place:-

No of participant:-

Drainage

1. **Spatial extent:** Average (last five years) maximum extent of water congested area (in percentage of the project area) during yearly peak rainfall (usually in monsoon).
2. **Temporal extent:** Average (last five years) maximum drain out time (in days) of the congested water after yearly peak rainfall (during non flooding condition in the river).

Average spatial extent					
Average drain out time					
Performance	0	1	2	3	4

Reasons of the above Performance:

On field assessment:

Flushing

3. **Bed type:** The type of bed (silting/eroding/neutral) in the approach canal of the regulator.

(Please turn over)

Bed type					
Performance	0	1	2	3	4

Reasons of the above Performance:

On field assessment:

Water logging

4. **Water logging:** Maximum extent of waterlogged area in the project area (permanent water bodies like beels, ponds, wetlands etc are not considered as water logged area).

Water logged area					
Performance	0	1	2	3	4

Reasons of the above Performance:

On field assessment:

Salinity

5. **Concentration:** Present salinity level (in percentage) within the project area compared to river water during dry season (February-April) and beneficiary assessment of salinity level for crop production.

River water	100				
Water within project					
Performance	0	1	2	3	4

Reasons of the above Performance:

(Please turn over)

On field assessment:

Water retention

6. Irrigation coverage: Irrigation coverage in the project area with the retained water in the canal by regulator.

Irrigation Coverage					
Performance	0	1	2	3	4

Reasons of the above Performance:

On field assessment:

Flood protection

7. Freeboard: Average freeboard (last five years) remained during yearly peak flood in the river and assessment of the prevailing freeboard.

Freeboard					
Performance	0	1	2	3	4

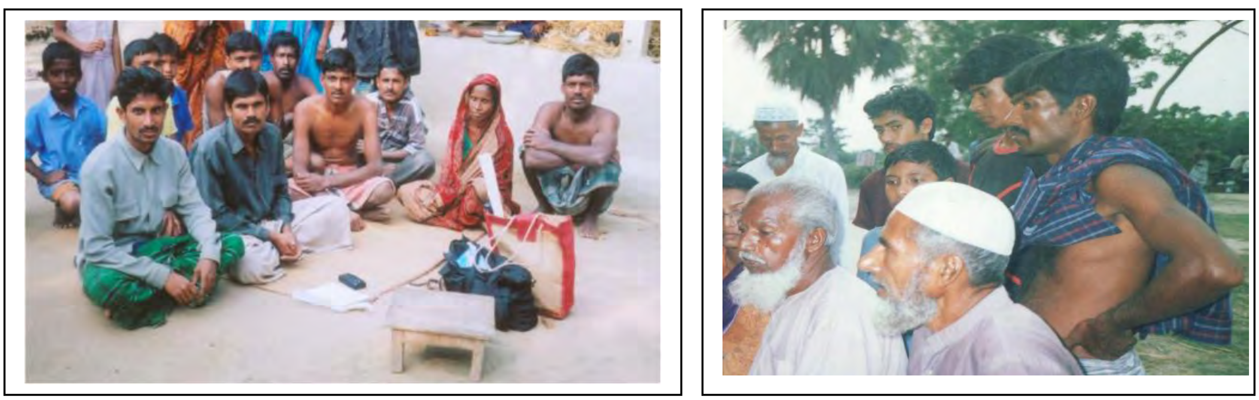
Reasons of the above Performance:

On field assessment:

Appendix B

Photographs

Photographs: Seapagla Regulator across the Embankment



Photographs: FGD with Beneficiaries

Photographs: Study Area (Canal and Paddy fields)