WATER POVERTY STATUS IN SELECTED SMALL-SCALE WATER RESOURCES PROJECTS IN BANGLADESH

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

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DEDICATION

This research is dedicated to the poor and deprived farmers of Bangladesh who is trying their best to keep us sufficient in food supply but their contribution is neglected.

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ABSTRACT

Water plays an important role in socio-economic development and ecosystem sustenance. At the same time, water-related adversities, hazards and inequity deter the development of the vulnerable communities, mostly the poor. In many developing countries, the development is hindered and poverty reduction efforts are unsuccessful since the importance of water is not effectively addressed in policy and decision making. The conventional human development or poverty indicators do not adequately reflect this water-related poverty or 'water poverty'. This study used a 'Water Poverty Index (WPI)' to assess the changes in different aspects of water poverty resulting from implementation of water resources development projects. In Bangladesh, structural and non-structural interventions for water sector development are being attempted to resolve local water-related problems with a view to reducing poverty. However, these interventions have been observed to have both positive and negative socio-economic impacts. The actual impacts in terms of the individual water poverty components are unknown. In this study, two small-scale Water Conservation (WC) and Flood Control and Drainage (FCD) projects were selected to assess their water poverty status. Two control sites were also selected to evaluate the impact of project interventions. The WPI is composed of five components: Resource, Access, Capacity, Use and Environment. Subcomponents of these five components were identified based on literature studies and FGDs. These subcomponents represent the physical availability of water, and major socio-economic and environmental conditions at the study sites. The WPIs for the project and control sites were evaluated from the weighted average values of the subcomponents obtained through field investigations and secondary data analysis. Comparison of the WPIs of the project and control sites indicate that 'Capacity' and 'Use', particularly for irrigation purposes, have improved due to structural interventions of the projects while 'Resources' have not changed significantly. The overall WPI has improved by about 30% and 9% in the Narayankhali FCD and Boronurpur WC subprojects, respectively. The study also indicates that there is scope to improve the water poverty status by giving attention to education, farmers' training, safe water and sanitation access, increased participation of the women in Water Management Cooperative Associations (WMCA), and water use conflict reduction.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BIDS	Bangladesh Institute of Development Studies
BUET	Bangladesh University of Engineering and Technology
HDI	Human Development Index
HH	Household
HPI	Human Poverty Index
IWRM	Integrated Water Resources Management
IWMI	International Water Management Institute
LGED	Local Government Engineering Department
MDG	Millennium Development Goal
NWMP	National Water Management Plan
NWP	National Water Policy
O&M	Operation and Maintenance
PDO	Project Development Office
SSWRDSP	Small Scale Water Resources Development Sector Projects
UNDP	United Nation Development Program
WMA	Water Management Association
WMCA	Water Management Cooperative Association
WPI	Water Poverty Index
WSS	Water Supply and Sanitation

Chapter One
INTRODUCTION

1.1 Background of the Study

Water is one of the most important entry points for poverty reduction. Water not only provides opportunities for increased agricultural production and food security, but also maintains ecological integrity that is essential for livelihood support and healthy living conditions. Millions of people around the world fail to overcome poverty because of the lack of water in adequate quantity and quality to sustain their livelihoods. This 'water poverty' may also cause conflicts among water users and hinder efficient and equitable allocation of water resources required for sustainable development. Water poverty may occur even when there is an abundance of water, because this water may not be a useful resource due to timing of the availability, lack of socio-economic capacity or access to the resource, or inferior quality for use. UNESCO (2003) asserts that better access to better managed water can significantly reduce poverty. Sullivan (2002) argues that existence of water poverty is likely to fail any measure to reduce income poverty. Realizing the importance of water, the UN millennium development goals also set the target of halving the people who are lacking safe drinking water and sanitation by the year 2015 (ADB, 2004). The risk of water poverty in absence of clean and safe water has been also emphasized by IMF (2005).

Sullivan (2002) shows that water scarcity can happen in two ways. First order scarcity is the shortage of the water itself and second order scarcity results from the lack of social adaptive capacity. The poor lack social adaptive capacity and this suggests that this aspect of development in the water sector is mostly related with poverty alleviation. ADB (2004) shows that water is important to the poor in four key ways: a) for food production, b) for sound health and sanitation, especially for vulnerable groups: children, women and old people, c) for maintaining ecological integrity on which most of the world poor depend for their survival, and d) even when any water related hazard like flood, drought, storm surge or pollution occurs poor are the most vulnerable to it. Osmani (2003) states vulnerability can push some people who are not poor to poverty because of their inability to recover from it. So there lies a strong relationship between water and poverty which is shaped by the physical factors limiting water availability and various social, economic and institutional constraints.

Conflicts over water use have been increasing in recent years, and it is increasingly recognized as being a possible source of conflict in the future, especially in areas of high population density and decreasing water resources in shared water courses. Another potential source of conflict in the future is that concerning water for food. A 'Virtual Water' concept is developed which means water will be treated as an economic good and countries will import water in the form of food grain. In this context Water Poverty Index may provide opportunities for developing a more transparent and equitable framework for water management decisions and reducing potential conflicts over water use. Another important issue. the gender issue, is also included in the WPI structure. This issue is addressed by taking into account the proportions of water carried by women and the time required for domestic use.

Water shortages do not determine the poverty or the prosperity enjoyed by a community. However, communities that endure poverty will in almost in all circumstances face problems in accessing sufficient safe water, both for domestic purposes and for their livelihood generation. Thus assessment of water poverty requires a holistic approach to consider all these characteristics that link water and poverty (Heidecke, 2006). Rahman (2004) proposes a set of water poverty indicators for monitoring the performance of macro-scale water sector interventions in Bangladesh. The 'Water Poverty Index' (WPI) representing quantitative measurement of water poverty (Sullivan, 2002) provides a basis for an assessment that integrates a variety of issues in water management and planning and helps in prioritization of development needs. Thus, WPI measures water poverty in relation to water availability. WPI can be also used as a tool to monitor the progress in the water sector (CEH, 2007; Lawrence *et al.*, 2002).

Poverty reduction was one of the overall goals of the Small-Scale Water Resources Development Sector Project, Phase I (SSWRDSP-I) implemented in 300 subprojects in the western part of Bangladesh. Different water resource projects like flood control, drainage improvement, water conservation and command area development schemes are implemented in these subprojects, and poverty has been monitored from a broader perspective of 'human poverty' rather than 'water poverty' using a set of socio-economic indicators (LGED, 2004). BUET-BIDS-Delft Hydraulics (2003) evaluated the socio-economic outcome including poverty reduction in 30 selected subprojects and in these projects poverty reduction is measured only by employment opportunities. However, no quantitative assessment was carried out for this evaluation. Valuations were based on theoretical relations between direct outcomes such as agriculture, fisheries and employment, and expected distribution of benefits.

1.2 Objective of the Study

The objectives of the proposed study were to:

i) assess water poverty status in the different types of small-scale water resources subprojects of SSWRDSP-I; and

ii) determine issues within the subprojects that need further attention from water management perspective.

1.3 Outline of Methodology

Two SSWRDSP-I subprojects, one 'more successful' and one 'less successful', were selected on the basis of their performance as evaluated by BUET-BIDS-Delft Hydraulics (2003). One control site with each subproject having similar demographic and hydrologic characteristics was also selected for the study. Location and accessibility for convenience in research execution was considered during selection of these subprojects. WPI in each site was calculated from the average score of its 5 components: Resource, Access, Capacity, Use and Environment, on a 0-100 scale. The subcomponents composing the WPI components were evaluated through questionnaire survey, focus group discussion and secondary data analysis.

The subcomponents or variables used to evaluate the WPI components include: surface and groundwater availability, variability or reliability of resources for 'Resource'; percentage of water collected by women, access to clean water and sanitation, access to irrigation coverage, conflicts over water use, etc., for 'Access'; household expenditure, educational level, membership of water user association, illness related with water, percentage of irrigated land to total cultivable land, etc., for 'Capacity'; domestic water consumption, agricultural water use, livestock water use, etc., for 'Use'; and loss of wetland and fish area, soil quality, water quality, fertilizer and pesticide use, etc., for 'Environment'. The compiled information was then presented on a 'WPI pentagram' so that the attributes of water sector that need to be further developed can be easily identified.

1.4 Scope and Limitations of the Study

This study conducted an evaluation of the water poverty status and different components of water poverty in the selected subprojects only to propose a methodology for evaluation and monitoring of water poverty status in small-scale water resources projects in Bangladesh. This methodology may be followed in other subprojects. The research was conducted within the following limitations:

1) Only two subprojects along with their control sites have been selected for this study. However, two different types of subprojects - a more successful and a less successful subproject in the same geographical and hydrologic conditions could not be located.

2) Study sites and control sites having exactly the same problems and issues could not be located.

It is found that in both project sites the Water Poverty Index (WPI) has improved due to project implementation but there is scope to further improve the water poverty status.

Chapter Two
LITERATURE REVIEW

2.1 Conceptual and Theoretical Basis for Poverty Assessment

The world with its growing population is facing serious water crisis day by day. UNESCO (2003) warns that this situation will be continuing unless any corrective action is taken for its management. The crisis lies mainly behind the mismanagement of water but mainly affects the poor who are fighting everyday to get their minimum requirement for their survival and suffering from various infectious diseases mainly borne by water.

The Water Poverty Index (WPI) is a way of measuring water poverty status focusing on poverty and livelihood assets of the poor. The WPI is a new concept first developed in 2000 (Sullivan, 2000; Sullivan, 2002; Sullivan et al., 2003). For application of WPI at the local, national or international level, the WPI components need to be rearranged. WPI can be best used for better representation of water issues. Despite the positive results, there is scope for further development of the WPI.

The five key components of the WPI: Resource, Access, Capacity, Use and Environment, are closely analogous to the livelihood capitals (Sullivan et al., 2003). Currently, monitoring access to safe water and sanitation is carried out at the international level by WHO and UNICEF joint monitoring program for water supply and sanitation. WHO and UNICEF joint monitoring program deals only with domestic water supply. However, it is widely recognized that food production is also an important use of water.

In many parts of the world. small-scale irrigation and livestock watering can help people to lift out of poverty and these require an adequate water supply. Since the amount of water required for irrigation is larger than domestic use, a conflict can arise there. Pollution of domestic water by agricultural and industrial water use can also create conflict. So a tool is needed to include all these water related issues in a holistic way. The Water Poverty Index, since its main purpose is monitoring, can be also used to select the areas where development is urgently needed. WPI has several advantages like it is easily understood by both policy makers and decision makers, its transparent process. reflects empowerment of local communities and has the adaptability to a variety of local situations. The primary focus of WPI is on the poor people who suffer most from inadequate access to water. Ohlsson (2002) mentions that WPI demonstrates not only the amount of water resources available but also how effectively the resource is used and the poverty level of that community. The links between poverty, social deprivation, environmental integrity, water availability and health becomes clear in the WPI.

Comparatively, IWMI (2004) shows 'Poverty' as a multidimensional concept extending from low levels of income and expenditures due to lack of education and poor health and includes other social dimensions such as powerlessness, insecurity, vulnerability, isolation, social exclusion and gender disparity. Most empirical work on poverty measurement is based on income or consumption expenditure, and poverty is defined as a situation where a household's or a person's income or consumption level falls below some minimum necessity to meet basic needs. Osmani (2003) states that 'Poverty' is intrinsically multidimensional in nature, it consists of the failure of several kinds of basic capabilities including being educated, living a life of dignity and security, participate in the life of a community. Different approaches have been developed to assess the nature of poverty like income based poverty assessment which is quantitative. Other capability approaches measure poverty as multidimensional in a qualitative way. Another approach, called Participatory Poverty Assessment (PPA), is developed from the approach of Rapid Rural Appraisal (RRA) but it is a qualitative method of poverty assessment which draws the life experiences of people as perceived by them. IWMI (2001) shows that there is a strong link between water and poverty. Rural people are mostly dependent on agriculture so their poverty is mostly related with irrigation water shortages. Around 80-90% of annual water supply is consumed in agriculture sector and provides livelihood for most of the world's poor.

Mujeri (1998) measures the poverty status of urban and rural areas by a set of indicators which include income, nutrition, health, education, housing, access to community services, access to land, people's participation, crisis coping capacity, economic diversification, employment and public expenditure. It finds that people who are educated enough and have access to large lands are in a better position than the poor. People engaged in non-farm sectors are less poor than landless farm workers. Female-headed households are poorer than male headed households.

Agriculture represents about 70% of all water use and per capita food production is rising steadily over last generation in almost all regions. So there is an urgent need to assess the amount of water which can contribute to our food production. This multidimensional consideration for poverty provides a basis for development of integrated approach for poverty reduction (ADB, 2004).

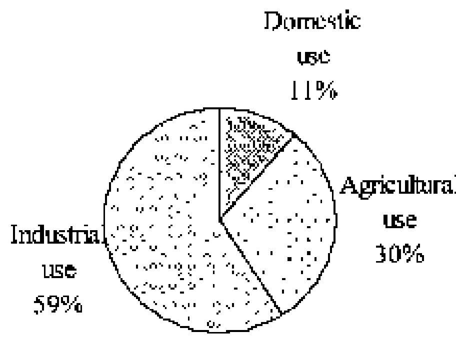
Another concept related to poverty assessment is the Human Development Index (HDI) which gives a measure of economic and social progress (Sullivan et al., 2002). HDI is the average of three separate indicators first, life expectancy at birth, educational attainment, and GDP per capita at purchasing power parity (PPP). However, it combines two different elements with no common measure, most of its components are highly correlated with each other, thus reducing the usefulness of the separate sub-indices. Therefore, WPI may provide a better basis for water-related poverty.

ADB (2003) shows that the issue of access to water resource is more complex than the issue of access to safe drinking water. A few criteria are set out which we can identify people who are 'water poor'. These people are: a) those whose livelihood is always threatened by flood or drought, b) those whose livelihood depends on cultivation of food or natural products whose water source is not dependable, c) those whose livelihood base is subject to erosion, degradation or confiscation without due compensation, d) those living more than one km away from a year round supply of safe drinking water, e) those obliged to expend a high percentage (more than 5%) of household income on water and slum dwellers obliged to pay for water at above market rates, f) those whose water supply is contaminated bacteriologically or chemically and they are either unable to use it or lacking alternative source, g) women, girls who daily spend hours to collect water and whose security, education, productivity and nutritional status is thereby at risk, and h) those living in areas of high levels of water related diseases like malaria, cholera, typhoid without any means of protection.

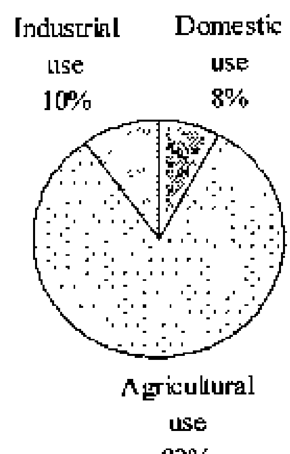
Rahman (2004) developed a strategy to achieve poverty alleviation goals by various changes in the water sector for a flood-prone country like Bangladesh. A set of criteria representative of poverty alleviation potential, management and environmental issues of different interventions has been defined. Strategies were formulated for each hydrological region separately because firstly water resources issues vary greatly from one hydrological region to another. Secondly, since the regions are hydrologically independent, integrated water resource management is appropriate in regional scale. The outcome indicators proposed in the study are: i) % of population with access to safe water and sanitation, ii) number of persons with access to arsenic free water in arsenic contaminated area, iii) flooded area. iv) monsoon crop production, v) crop damage, vi) flood / cyclone death, vii) flood damage, viii) dry season crop production. ix) rural-urban migration, x) dry season flow, xi) dry season water body area, and xii) dissolved oxygen. These indicators are suggested for monitoring the performance of water sector interventions from poverty alleviation perspective.

UNESCO (2003) represents after World Bank (2001) a comparison among different water uses in Figure 2.1. The figures show competing water uses for the main income group countries. These figures also show that high income countries use water for industrial purposes and low and middle income countries use more water in the agriculture sector. So it is clear that the people of the middle and low income countries depend directly on water for their food supply and livelihood generation. Hence water is vital for their survival.

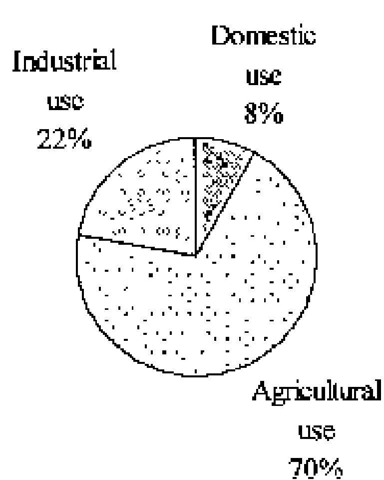
IMF (2005) found a number of gaps during the post-document reviews of the Poverty Reduction Strategy Paper (PRSP) of Bangladesh. Strategy for water resources management was identified as one of the major gaps which were not fully addressed in the PRSP preparation.



(a) Competing water uses (world).



(b) Competing water uses (High income countries).



(c) Competing water uses (low and middle income countries).

Figure 2.1: Comparison among different water uses.
(Source: World Bank, 2001)

On the other hand, sustainable livelihood frameworks are used by donor agencies to assess development effectiveness (UNESCO, 2003). These frameworks assess development impacts in terms of variety of attributes referred to as livelihood capitals identified as natural, physical, financial, social and human assets. To sustain our lives we use a combination of some or all of these. Impoverished communities are by definition short of some or all of these livelihood capitals. To redress any kind of poverty, access to these capitals must be redistributed more equitably.

In this framework Access refers to social and financial capitals, Use include physical and financial capitals, Capacity includes human capital, Resource includes natural capital and water resources, and Environment includes natural capital. Figure 2.2 shows how development processes can result in changes in the availability of different capital types from period 1 to period 2. It is realized that a tool is necessary to quantify the capital changes, distribution of impacts and for better understanding. WPI is developed according to this concept.

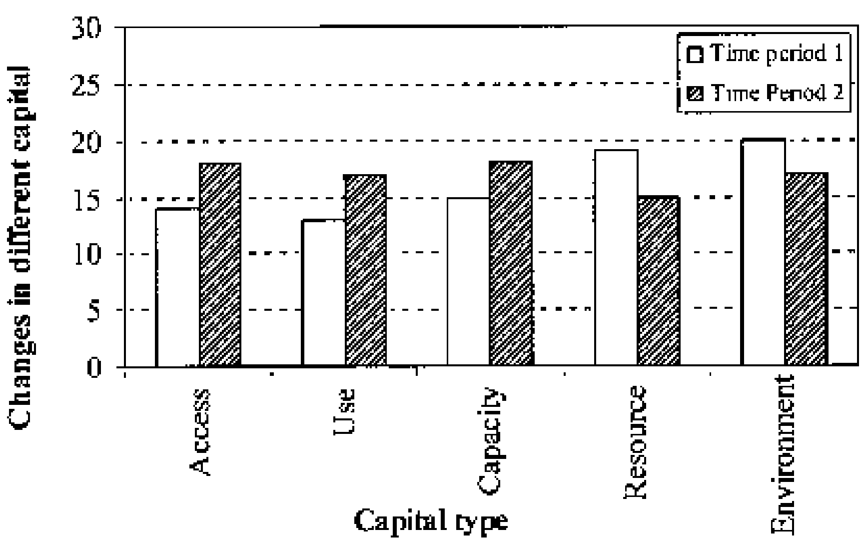


Figure 2.2: Impact of development on livelihood capitals.

2.2 Theoretical Formulation of WPI

Indicators are used to measure the performance or achievement of any project. Indicators which are used to measure WPI are called sub-components and they are carefully selected so that information under each indicator is separate from each other and are not correlated.

All water used by the human in consumption and production are extracted from the natural environment which were served the nature before. And it is found that natural environment used mainly by the poor people, so for maintaining the integrity of the natural environment it is important to sustain the livelihood of the poor as well as the nature itself. One of the important aspects of WPI is that it takes into account the key issues of the users so the decision makers can feel confidence of their decisions in water development. So WPI can also provide community empowerment because local people become more aware of their resource obstructions which will make them to bring pressure to decision makers for equitable distribution and effective management of water. At local levels water conflicts are increasing and through development of a transparent decision making this conflict can be reduced.

Sullivan (2002) develops some approaches to calculate "Water Poverty Index": a) the conventional composite index approach: In which WPI comprises various elements like water availability, access to safe water, clean sanitation and time taken to collect domestic water, b) an alternative approach – the gap method: which measures the gap between the actual amount of water available and standard amount of water. in case of ecosystem health, community well-being, human health, ecosystem welfare, c) a matrix approach, where a two dimensional matrix is developed based on water stress and human welfare, and d) a simple time- analysis approach, which measure only the required time to collect a fixed amount of water for domestic purpose. In the composite index approach, the WPI comprises a wide range of variables. The score of the index varies from 1 to 100. The score of the WPI is the weighted average of five major components. Each of the 5 components is also scored on a scale of 0 to 100. These components are: Resource, Access, Capacity, Use and Environment. The produced score can help local mangers to monitor their progress and also to identify areas where development is urgent. At national level it helps policy makers to assess how the water sector is progressing at national level.

2.3 Applications of WPI

2.3.1 Application of WPI at the international level

An index structure is developed by Lawrence et al. (2002) to measure WPI at the international level. This index (WPI) measures the country's position relative to each other in the provision of water. In order to do this, an index is constructed consisting of five major components which are Resources, Access, Capacity, Use and Environment. For Resource component data like internal freshwater flows, external inflows, population used as sub-indices; for Access percentage of population with access to clean water, percentage of population with access to sanitation, percentage of population with access to irrigation (measured by the ratio of arable land to internal water resource); for Capacity per capita income, under five mortality rate (per 1000), education enrolment rates, Gini coefficient of income distribution; For Use domestic water use (Liter/day), share of water use by industry and agriculture adjusted by the sector's share of GDP; for Environment component indices of water quality, water stress, environmental regulation and management, informational capacity, biodiversity based on threatened species. Using these sub-indices WPI of 147 countries is presented in rank order with the highest scoring country first. Most of the countries are either developed or richer developing. There are few notable exceptions: Guyana scores highly on Resource, Access and Use to get into fifth position, while Belgium is 56th in the list, having scored low on resources and on environment. The US and New Zealand though, they score relatively highly on Environment, score very low on Use. South Africa, low on the Resources index, is relatively high on the other sub-indices reflecting its progressive policies on Access and management. The index as presented does suggest areas of current or future policy concentration with the overall performance. It is found that there is a positive correlation between the Human Poverty Index (HPI) and WPI and strong positive correlation between the sub-indices of WPI and the Human Development Index (HDI). Thus the WPI can be used to establish an international measure comparing performance in the water sector across countries in a holistic way.

2.3.2 Local application of the composite index approach

For applying WPI at the community level, a scoping study was done to find what data are available from national or other institutions (Lawrence et al., 2002 and CEH, 2007). After the scoping study, key data were selected matching with the data sets suggested in the WPI framework. Data which are unavailable were collected by field survey. In this way, WPI score was generated for a specific site. In case of local scale of WPI in Tanzania, Sri Lanka and South Africa, it was found that the WPI score represent the real picture, but in case of environmental indicator it represents the real picture for rural areas but it does not represent the real picture in urban areas because sub-indicators may be different in rural and urban areas. The value of the WPI varies seasonally. In case of access component it is found that the score on access increases in wet season and decreases in dry season.

2.4 Uses of WPI to Monitor Progress in the Water Sector

The WPI methodology has been carried out for pilot sites in South Africa, Sri Lanka and Tanzania to monitor progress in water resources projects (CEH, 2007). In case of Sri Lanka, the values of WPI in four pilot sites and its components are presented in Table 2.1. In Awarakotuwa though the capacity is high, the use is low because of low access. In case of Tharawaththa, though the resource is comparatively low and capacity is comparatively high, due to low access resource use is limited in these areas, but the environmental score is good.

Table 2.1: Calculated WPI values from pilot sites in Sri Lanka.

Community	Resources	Access	Capacity	Use	Environment	WPI
Awarakotuwa	10.0	35.2	79.6	21.2	28.1	34.8
Tharawaththa	20.0	26.5	50.6	16.2	42.2	31.1
Agarauda	20.0	38.3	64.7	74.9	34.2	46.4
Tissawa	20.0	47.3	52.0	50.0	38.5	41.6

To understand more explicitly which attributes of the water sector need to be developed more, a WPI pentagram shown in Figure 2.3 is used. The pentagram can be also used to examine the strength and weakness of the water management components.

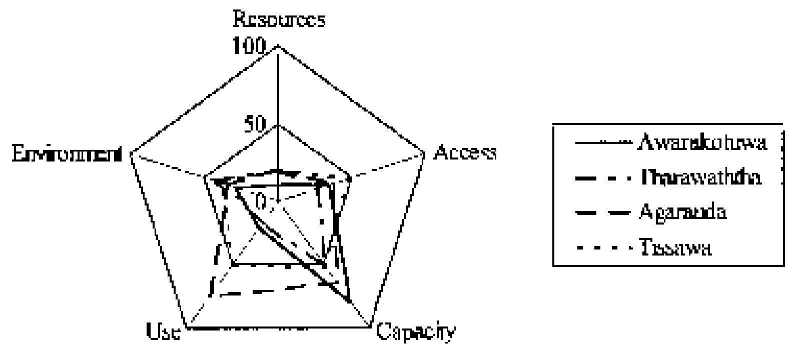


Figure 2.3: A WPI pentagram for pilot sites in Sri Lanka.

Water Poverty Index has been also used to monitor the progress in the water sector at different regions of Benin (Heidecke, 2006). Internal renewable water resources are relatively high compared to Benin's neighboring countries. The WPI as suggested by Sullivan (2000, 2001, and 2002) comprising 5 different components (resources, access, use, capacity and environment) to capture the complexity of the water situation of a country is used. Each of these components consists of a several elements. For the calculation of the WPI at the regional scale, the choice of variables was adjusted according to data availability.

To display the components in a more visible way, a pentagram showing all five components in Figure 2.4 was used. Although only a few regions are shown, the strengths

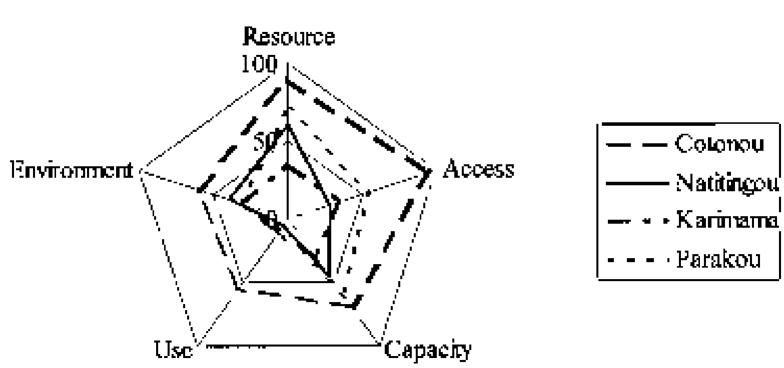


Figure 2.4: Results for the WPI for selected communes.

and weaknesses of these regions can be clearly distinguished. In Figure 2.4, Cotonou, the largest city in Benin, has the highest WPI value. However, the water situation can still be improved focusing on environmental aspects, particularly wastewater treatment, which is hardly developed in Benin. In contrast, Karimana is the commune with the lowest WPI value. Although all sub-components show low values, special attention should be given to the access and use components. Parakou, the second largest city in Benin, does well in human capacity but is weak on environmental issues.

2.5 Evaluation of SSWRDSP Subprojects

LGED contributes to the millennium development goals of poverty reduction by implementing Small-Scale Water Resources Development Sector Projects in Bangladesh. Two hundred and eighty small-scale water resources projects Figure 2.5 were implemented in the western part of Bangladesh (LGED, 2004) to achieve the objective of poverty reduction by removing different water related problems and forming Water Managements Associations. Before implementation in an area, first general information of the households in that area is collected. Then of these household a classification is done based on their poverty. Then a Water Management Association is formed among the people. A clear plan is prepared on the capital information and investment aspects of the WMA. An agreement is signed between the WMA and LGED about the implementation of the project and its operation and maintenance. After implementation of the project, LGED hand over the project to the WMAs. After implementation of the project some indicators are used for monitoring and evaluation of the project every year on the basis of: (1) poor people participation, (2) creating opportunities for the poor, (3) rate of employment and increase of income, (4) creating leadership among the poor, and (5) impact of the project on income, education, health, sanitation, nutrition and house structure.

An evaluation of 30 Small Scale Water Resources Development Sector Projects implemented by LGED was conducted by BUET-BIDS-DELFT Hydraulics (2003). This evaluation is expected to represent the two hundred and eighty subprojects in Western Bangladesh. The methodology of this evaluation was as follows. First, secondary information was collected on these thirty subprojects. Then desk studies of the data were done. Based on this information a field study was then carried out in the subprojects. Analysis of these data was done to complete the final report. The subprojects have been selected randomly proportional to the completion of the subprojects. The field data have been collected by interviews with local LGED officials, WMCA members, beneficiaries and stakeholders. For these interviews different sets of questionnaires have been prepared in line with the Logical Framework for the external evaluation.

The findings of the evaluation work on 30 sub-projects are as follows: About 47% of the subprojects score above 70% on technical issues and 17% of the sub-projects scored below the accepted standard. In case of environmental impacts, it was observed that the quality of the environment (water quality, soil quality, species response, vegetation) in the 30 subprojects is deteriorating because of increased use of fertilizer and pesticides in crop fields and destruction of the natural water flow regimes. In case of socio-economic out come it was observed that cropping intensity is increased in winter due to drainage improvement. Crop diversification occurs in some cases because losses caused by flood have been reduced by flood protection. Increased use of mechanized equipment has shown in the project areas. Percentage of irrigated land has increased due to FCD and WCS projects. Value of the agricultural land has increased in the project area due to project. Culture fish production has been increased but natural fish production has been declined. Some employment opportunities has been created in the project site for construction, operation and maintenance activities in the project but fishermen and boatman have faced negative impacts. Wage rates in the subproject areas have increased. In case of poverty reduction, creating employment opportunities for the poor as day labor in project activities has benefited the poor, especially the hard core poor. For women empowerment, women are participating in different Water Management Co-operative Associations (WMCA) and water groups so they get chance in decision making and in some case they can also work there. So their decision-making power and social mobility have increased. In case of institutional capacity, only one of the 30 subprojects scored above 70% and 20% of the subprojects scored above 60%. In case of training, it was investigated to what extent local people have access to and use the training program.

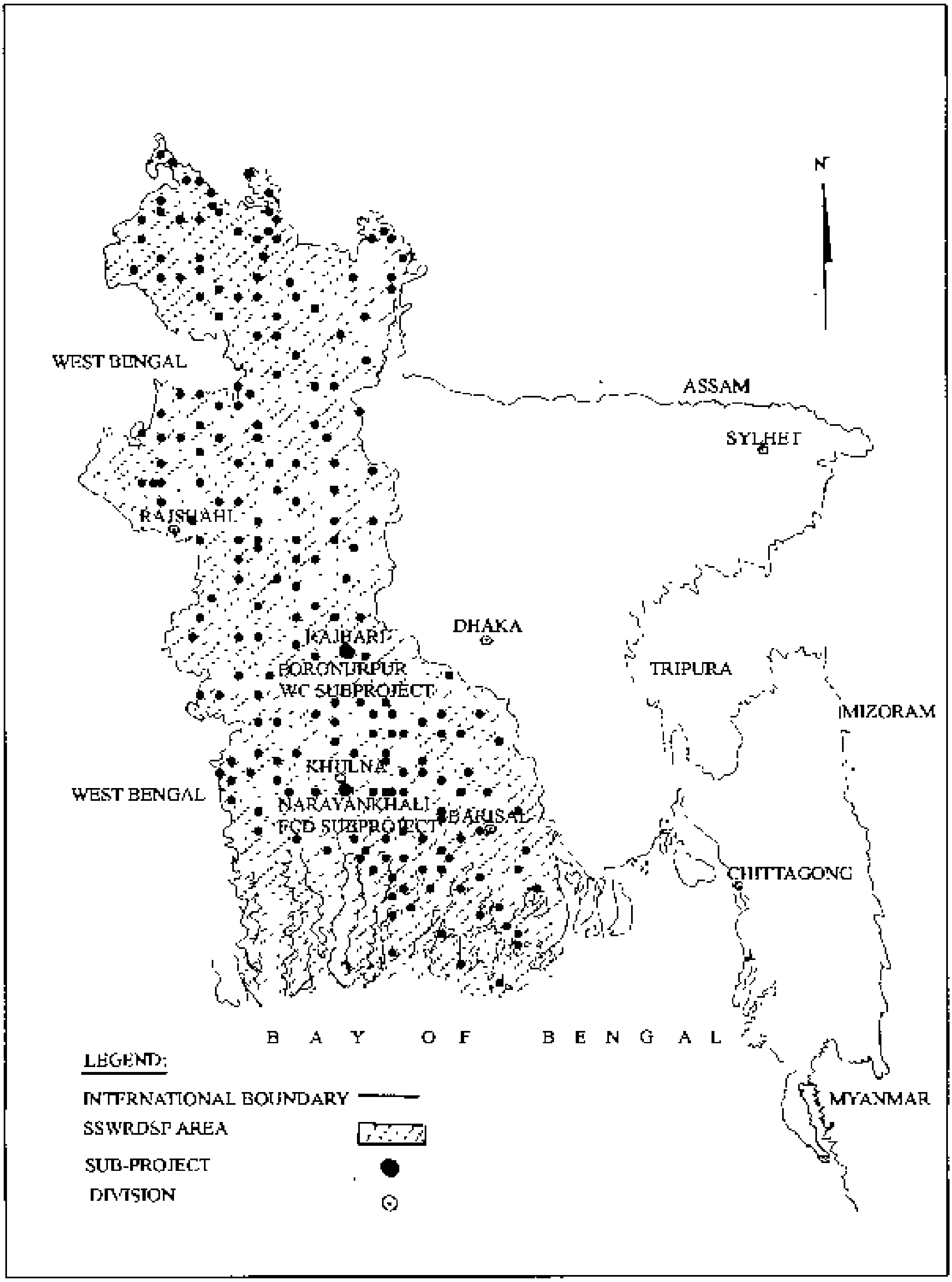


Figure 2.5: Location map of SSWRDSP subprojects.

Chapter Three
METHODOLOGY

3.1 Selection of the Study Area

To identify the changes of water poverty status in the Small-Scale Water Resources Development Sector Project (SSWRDSP) two different types of subprojects were selected on the basis of their performance evaluated by BUET-BIDS-Delft Hydraulics (2003). One relatively successful subproject in Rajbari District and one less successful subproject in Khulna were selected on the basis of accessibility and availability of secondary data. Two control sites having geographical, demographic and hydrological characteristics similar to those of the subproject site were also selected. Study area selection was finalized after reconnaissance visits to the sites, preliminary assessment and questionnaire pre-testing. Baranurpur WC subproject (SP-66) in Rajbari District was selected as the 'more successful' subproject and Narayankhali FCD subproject was selected as the 'less successful' subproject.

3.2 Data Collection Method

Primary and secondary data were used in this study to evaluate the WPI from its five components: Resource, Access, Capacity, Use and Environment. The following sections describe the data collection method.

3.2.1 Primary data collection

Primary data were collected from the field through household questionnaire survey and Focus Group Discussion (FGD). Data collection was carried out from January 2008 to March 2008 during two visits to each site. Simple random sampling technique was adopted for household survey. A questionnaire (Appendix A) was prepared before the household survey and the questionnaire was pre-tested during reconnaissance visit to the study area. The households were selected from the villages where people are directly benefited from the subproject. In Narayankhali subproject, 80 beneficiary households were selected randomly from three villages: 51 from Kharabadh, 15 from Kismat Kurighata and 14 from Talapara among 621 benefited households of eight villages. The sample size in village

Kharabadh is big because the number of beneficiaries in this village is relatively large. Twenty households were surveyed from the village Talbunia as the control site among about 100 households. In Boronurpur Subproject, 50 households were selected randomly among 317 total benefited households. From the control site village Borovobanipur, 28 households were surveyed among 150 households. According to the following formula (Moore and McCabe, 1999):

$$n = \left(\frac{z}{m}\right)^2 p(1-p) \tag{3.1}$$

where n = sample size, z = 1.645 for 90% confidence level, m = margin of error, and p = the proportion of a sample that will respond in a given way to a survey question (e.g., ratio of number of surveyed villages to the total number of subproject villages), the selected sample sizes are within 90% confidence level and 9% margin of error.

A checklist was prepared for the FGDs (Appendix B). In each FGD, 8-10 members were selected for discussion. The discussants included WMCA members, farmers and women members of the WMCA. For FGDs, topics on resource availability, water quality, different uses of water, conflicts regarding water use, amount of land erosion, people's dependency on wildlife and change in total vegetation were included.

3.2.2 Secondary data collection

Secondary data were collected from project appraisal reports of LGED, and maps and reports on SSWRDSP. Secondary data from Bangladesh Water Development Board were used for hydrological analysis. To identify the people who get direct benefit from the project, data from local LGED officials in Khulna and Rajbari were used. To understand the project performance status, the external evaluation report prepared by the BUET-BIDS-Delft Hydraulics (2003) was used.

3.3 Methods for Evaluating the Water Poverty Index

3.3.1 Basis for sub-component selection

The WPI is calculated from the scores of a set of sub-components of each of its components. Different sets of sub-components under the five components are used by different users. The sub-components used by CEH (2005) after Sullivan (2002) to evaluate the WPI of the water sector at the community or small-scale municipality level are given in Appendix C. For this study, the five components are further divided into sub-components which are selected from the list in Appendix C. A list of the selected sub-components is given in Table 3.1.

Table 3.1: List of sub-components selected for the study.

Component	Sub-components
Resource	• surface water availability • groundwater availability • rainfall availability
Access	• access to clean water as a percentage of households having a piped or safe tubewell water supply • conflict over water use • access to sanitation as a percentage of population • % of water carried by woman • access to irrigation coverage adjusted by climate characteristics
Capacity	• household wealth status • household educational level • membership of water management associations • % of households reporting illness due to water supplies • % of household receiving pension, remittance, wage, etc.
Use	• domestic water consumption • agricultural water use • livestock water use
Environment	• % of households depending on fish or wildlife • % of households reporting crop loss during last 5 years • % of households reporting erosion of their land in last five years

For the 'Resource' component, quantitative and qualitative evaluation of the variability or reliability of resources has been used but quantitative and qualitative assessment of water quality is not included because of lack of data. For 'Access', time spent in water collection including waiting is excluded because of time limitation. For 'Capacity', child mortality under five years has been excluded because diarrhea and other water-borne disease related information are unavailable at the community level. For 'Use', industrial water use (based on people reporting that they used water for purposes other than domestic and agricultural) was not significant at the community level.

3.3.2 Calculation of Water Poverty Index

These variables or sub-components are represented by numerical scores. Average score of these sub-components is the score of the respective WPI component. The WPI is then calculated from the weighted average of the five component scores using the formula:

$$WPI = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i} \tag{3.2}$$

where X_i = score of component i, w_i = weight of component i, and n = total number of components. Weights can be used in this index to assign the relative importance of various components. This is usually done to identify issues which are considered the most important for policy goals, etc. A hypothetical look-up table of how weights may be applied is shown in Appendix D. However, for this study all the weights are set to 1 to give equal importance to all the components. Therefore the final formula is:

$$WPI = \frac{R + A + C + U + E}{5} \tag{3.3}$$

where R, A, C, U and E are the respective component scores, providing a weighted average of the five components: Resource (R), Access (A), Capacity (C), Use (U), and Environment (E). Each of the component is first standardized so that it falls in the range 0 to 100, thus the resulting WPI value is also between 0 and 100. A low score on the WPI indicates a more extreme case of water poverty. The data used to calculate the WPI using this composite index approach at the community level are mainly derived from field surveys carried out in six villages of the study areas.

3.4 Converting scores to indices

As mentioned before each of the five WPI components has been obtained by aggregating a set of sub-components by using the composite approach. In other words, each of the five components forming the WPI is itself an index. Scores for each sub-component are calculated by the formula:

$$\text{Sub-component Score} = \frac{X_i - X_{min}}{X_{max} - X_{min}} \text{x}100 \qquad (3.4)$$

where X_i , X_{max} and X_{min} are the original values for location i, for the highest value, and for the lowest value, respectively. The score for any one sub-component indicator lies between 0 and 100, where 0 is the worst, 100 is the best. When these are combined to make a composite index, then each component is on the same basis.

Chapter Four
DESCRIPTION OF THE STUDY AREA

4.1 Narayankhali FCD Subproject

4.1.1 Location

The Narayankhali FCD subproject is located in Amirpur Union of Batiaghata Thana in Khulna District as shown in Figure 4.1. It is a Flood Control and Drainage improvement Subproject bounded by Narayankhali khal and Rupsha river in the North Rupsha river and Nalua river in the West, Jabusa-Nijgram GCC road in the East and Nijgram-Dadhua village road in the South-east.

4.1.2 Demography

The subproject area consists of 16 villages in 2 unions. From the field survey it is estimated that the subproject has a population of 6155 living in 1105 households giving the average household size of 5.57 which is higher than the national average of 5.32. Number of land holdings less than 1 ha land is 939 (85% of the total 1105 households). The beneficiaries are primarily farmers. Their distribution by farm size is given in Table 4.1. The total number of benefited households in the subproject is 621. The total members of the WMCA are 450, out of them 352 are male and 98 are female.

Table 4.1: List of beneficiaries of Narayankhali subproject by farm size.

Category of farmers	% of household by category as a whole	% of land owned by category of farmers
Landless (up to - 0.2 ha)	43	11
Marginal farmers (0.2 - 0.6 ha)	25	18
Small farmers (0.6 - 1 ha)	17	23
Medium farmers (1- 2 ha)	9	22
Medium large farmers (2 - 4 ha)	4	15
Large farmers (4 ha & above)	2	11

(Source: LGED, 1997)

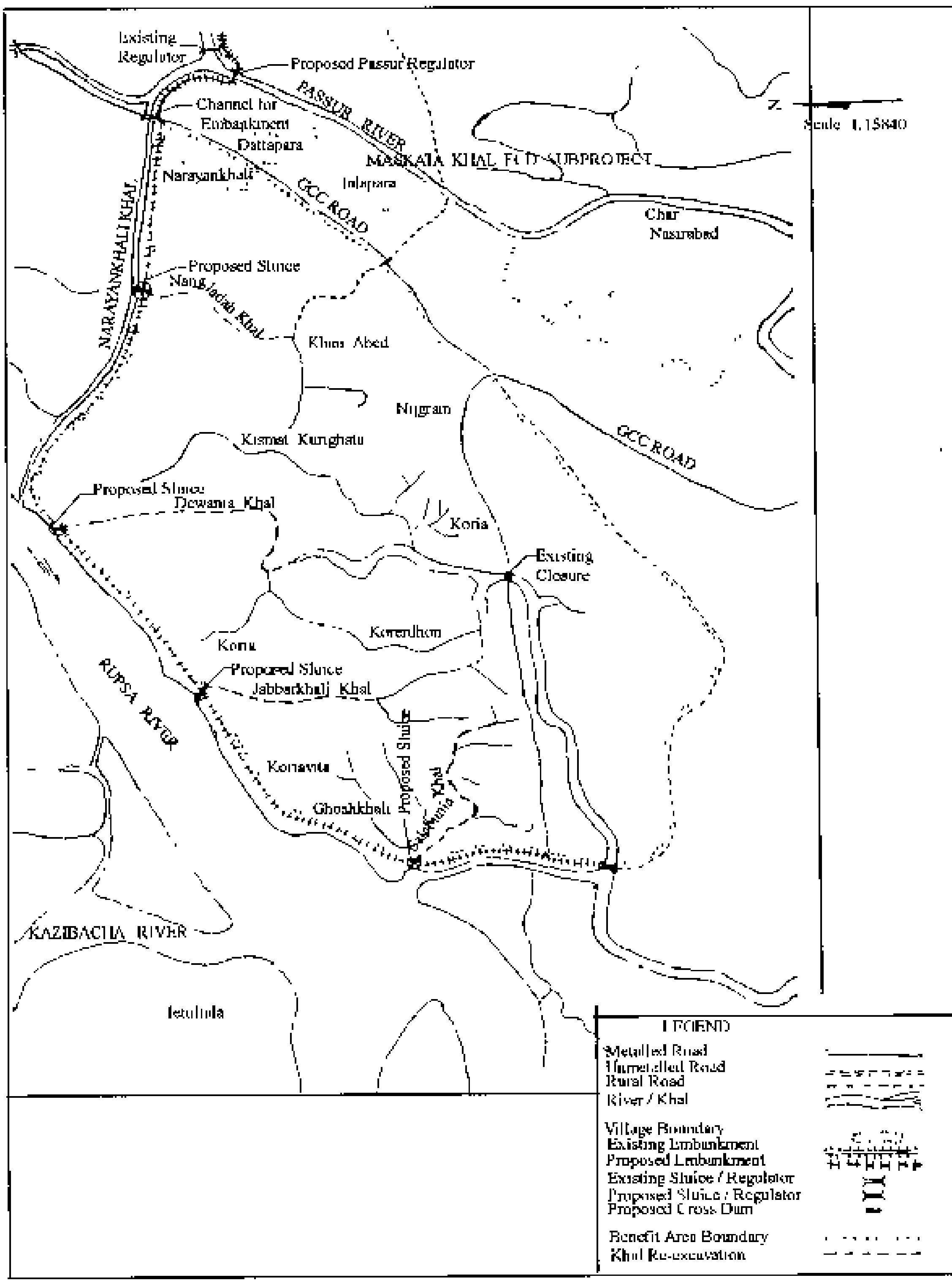


Figure 4.1: Map of Narayankhali FCD subproject.
(Source: LGED, 1997)

4.1.3 Hydrology

River water level

The subproject is about 7 km downstream from Khulna and is situated on the river bank. The water regime of the subproject area is directly influenced by the Rupsha river. Therefore, WL records of Khulna (Station 241) have been directly used for assessment and analysis for the subproject. A summary of statistical analysis of WL and Tidal Range records of Khulna WL station is given in Table 4.2. The mean tide level of pre-monsoon, post-monsoon and winter periods, and annual HWL in the subproject area are given in the table.

Table 4.2: Water level and Tidal range records of Khulna station.

		Annual HFL (m PWD)	Monthly WL (m PWD)					
			MAY	JUN	OCT	NOV	FEB	MAR
Mean	HWL	2.87m						
	HTL		2.30	2.42	2.63	2.20	1.95	2.15
	LTL		(-)0.31	(-)0.06	0.31	(-)0.00	(-)0.59	(-)0.60
	Max R		2.53	2.35	2.09	2.04	2.45	2.70
	Min R		1.35	1.40	1.13	1.39	1.23	1.24
1:20-yr	HWL	3.35						
1:50-yr		3.48						

(Source: LGED, 1997)

Rainfall

The nearest rainfall station from the subproject is in Khulna (Station R510), about 7 km from the subproject site. The rainfall records of Khulna have been used for the study. For small-scale subprojects, rain-storms of 3 to 5 days duration are generally taken as the design storm for drainage analysis. Daily and cumulative rainfall during a 5-day storm in Khulna is given in Table 4.3. This design storm for the subproject is a 5-day 10-year storm.

4.1.4 Flood control

The mean and 1 in 10-yr High Water Levels in the subproject are 2.87 m and 3.35 m, respectively, which inundate 850 ha (83%) and 970 ha (94%) of the gross 1030 ha area of the subproject. Depth of flooding extends up to a maximum of 1.77m in average floods and 2.25m in 1:10-Yr floods.

Table 4.3: Five days cumulative rainfall of Khulna.

Day	Daily rainfall (mm)	Cumulative rainfall (mm)
1	145.20	145.20
2	134.90	196.70
3	83.40	229.90
4	50.20	258.80
5	21.30	280.10

(Source: LGED, 1997)

Average HTL in pre-monsoon and post-monsoon periods are about the same, and is approximately 2.40 m PWD. This water level inundates 490 ha (47%) land. The winter average HTL of 2.00 m PWD inundates 350 ha (34%) land. Tidal inundations, particularly inundations in winter and summer months, are by waters of higher salinity which affect productivity of soil.

4.1.5 Waterlogging and drainage congestion

As usual in tidal plain lands, the subproject area has a high density of khals: 4 main khals with several branches to drain 1030 ha area. The khals have the following features:

Dewania khal: Bed level of the khal at the outlet in Rupsha river is higher than the bed level along its length. The bed level at the outlet has become high due to repeated closing and cutting of the earthen dam by the local people. The outlet is closed by the earthen dam in the dry season to prevent intrusion of saline tidal water. In the rainy season, the dams are cut to allow fresh tidal water. Also, the khal has a bed level near its mid reach about 0.5m higher than the lowest level of the drainage area. Therefore, drainage of the catchments through this khal remains always incomplete.

Nangladah khal: Bed level of the khal at the outlet in Rupsha river is higher than the bed level along its length. The bed level has become high due to repeated closing and cutting by the locals to prevent entry of tide. Also, the khal has humped bed profile near its mid length.

Jabbarkhali khal: Outfall of the khal is open and active. However, bed level in mid-length region of the khal is about 0.5m higher than the ground level in the beel area. The khal lets in water at every high tide but drainage is incomplete which results in water logging.

Salabunia khal: Outfall of the khal is open and active. However existing bed level near the outfall is about 1.0m higher than the beel area ground level. Thus, incomplete drainage leads to water logging.

Cross sections of the khals at different locations show that active khals are very narrow due to siltation at the sides.

4.1.6 Water retention

Retaining fresh water in the re-excavated and other khals, and in low lands to harmless depths is an operational activity. Water retention is also of additional advantage for fisheries activities and domestic or social use. Volume of stored water is relatively small and therefore, irrigation using stored water is not significant. However, retention of fresh water for longer period reduces soil salinity through leaching.

4.1.7 Resources and livelihoods

The two major occupations in the subproject area are farming and farm labor. Business, service and fishing are the other occupations practiced. Primary and secondary education is available. Agriculture is the main source of income in the subproject area. The rates of hired labor are Tk. 65 per day and Tk. 35 per day, during the peak and lean seasons respectively.

An estimated total of 84406 employment days (estimated) as shown in Table 4.4 is created through the subproject implementation, which include both skilled and unskilled laborers. The estimated employment is 841 people-days annually for O & M activities. There is ample scope of generation of employment and economic activity through WMCA's Program.

Table 4.4: People employment status of Narayankhali subproject.

Period	Subproject components	Skilled (No.)	Unskilled (No.)	Total
During construction	Earth work	-	34406	34406
	Structure	6000		50000
	Total	6000		84406
During O & M (Annual)		0	258	258
		400	183	583
	Total	400	441	841

(Source: LGED, 1997)

4.1.8 Poverty status

About 31-37 % people in the subproject villages are below the lower poverty line (BBS and WFP, 2004).

4.1.9 Project interventions

Structural interventions: Different structural interventions have taken place in the subproject area to improve its water management situation by draining out the excess rain water, re-excavating of existing drainage khal, re-sectioning flood protection embankment, constructing or rehabilitating sluices, and constructing infrastructure for fisheries development.

Non-structural interventions: Non-structural interventions include a Water Management Association (WMA) is formulated in the subproject area which has a vision and target to generate their own capital through regular small savings and purchase of shares by its members. There are four sub-committees in the WMA: O & M sub-committee, Agriculture sub-committee, Fisheries sub-committee and Loan sub-committee. These sub-committees meet separately once in a month or week. Tree plantation is done along the embankment slopes which is maintained by the poor people creating employment opportunity for them.

4.1.10 Water management institutions

Before implementation of the subproject there was no water management association at the local level. Only different NGOs like BRAC, ASHA, PROSHIKA took some initiatives to improve their livelihood status by micro-credit activities or other socio-economic activities. LGED at thana level maintains the structural activities to manage the water.

4.2 Boronurpur WC Subproject

4.2.1 Location

The Boronurpur Water Conservation subproject (SP-66) is located in Rajbari Sadar Thana, Rajbari District. A map of the sub-project area is shown in Figure 4.2. It is a water conservation subproject.

4.2.2 Demography

Total benefited households in the subproject area are 317. WMCA is composed of 343 members of which 216 are male and 127 are female. Most of the villagers in the subproject area are farmers. Some are day laborers some depend on trade and transport services, and very few depend on fisheries and navigation.

4.2.3 Hydrology

The subproject is bounded to the North by an unmetalled road, to the North-east by a railway line and the Rajbari-Faridpur highway, and to the East, South and West by rural roads. With no interventions, drainage of the area takes place relatively early following the cessation of the monsoon rainfall. The impact is that Kharif II (Aman) paddy yields are reduced and the options for winter season cropping are limited. In response, farmers constructed an earthen cross-dam in August almost every year to retain water in the Boronurpur and Moragang Khals. However, late and post-monsoon rainfall results either overtopping or collapsing, and the stored water is lost.

4.2.4 Resources and livelihoods

Farming practice is the main occupation in the subproject area. The soil type is sandy loam, suitable for all types of crops so the farmers cultivate different type of crops in different cropping seasons. Crops like Aus, HYV Aman, Wheat are the main crops. Other crops include jute, pulses, oilseed, sugarcane, vegetables, spices, etc.

4.2.5 Poverty status

BBS and WFP (2004) indicate that 25% of the villagers live below the poverty line in Bangladesh. The households' farm size distribution within the subproject is given in Table 4.5.

Table 4.5: Household farm size distribution of Boronurpur subproject.

Farm area	Percent of farmer (%)
0.0 to 0.5 acres	31
0.51 to 1.5 acres	26
1.51 to 2.50 acres	23
2.51 to 5.0 acres	15
5.01+ acres	5

(Source: LGED, 1998)

4.2.6 Project interventions

Structural interventions: Structural interventions have taken place for drainage improvement and water retention within the subproject area of 850 ha to (i) retain rainfall-run-off for supplementary irrigation of Kharif II crops, and (ii) improve post-monsoon drainage to promote production of winter season crops. The major physical works include structures, vent regulators and channel re-excavation.

Non-structural interventions: Non-structural interventions include formulation of a Water Management Association (WMA). Four Power tillers are supplied to the farmers and a fixed amount of money is given to the WMCA as a donation. The WMA can generate its own capital through regular small savings and purchase of shares by its members of the WMA can take loan from the WMA.

4.2.7 Water management institutions

LGED at thana level maintains the structural activities to help the WMCA in its management.

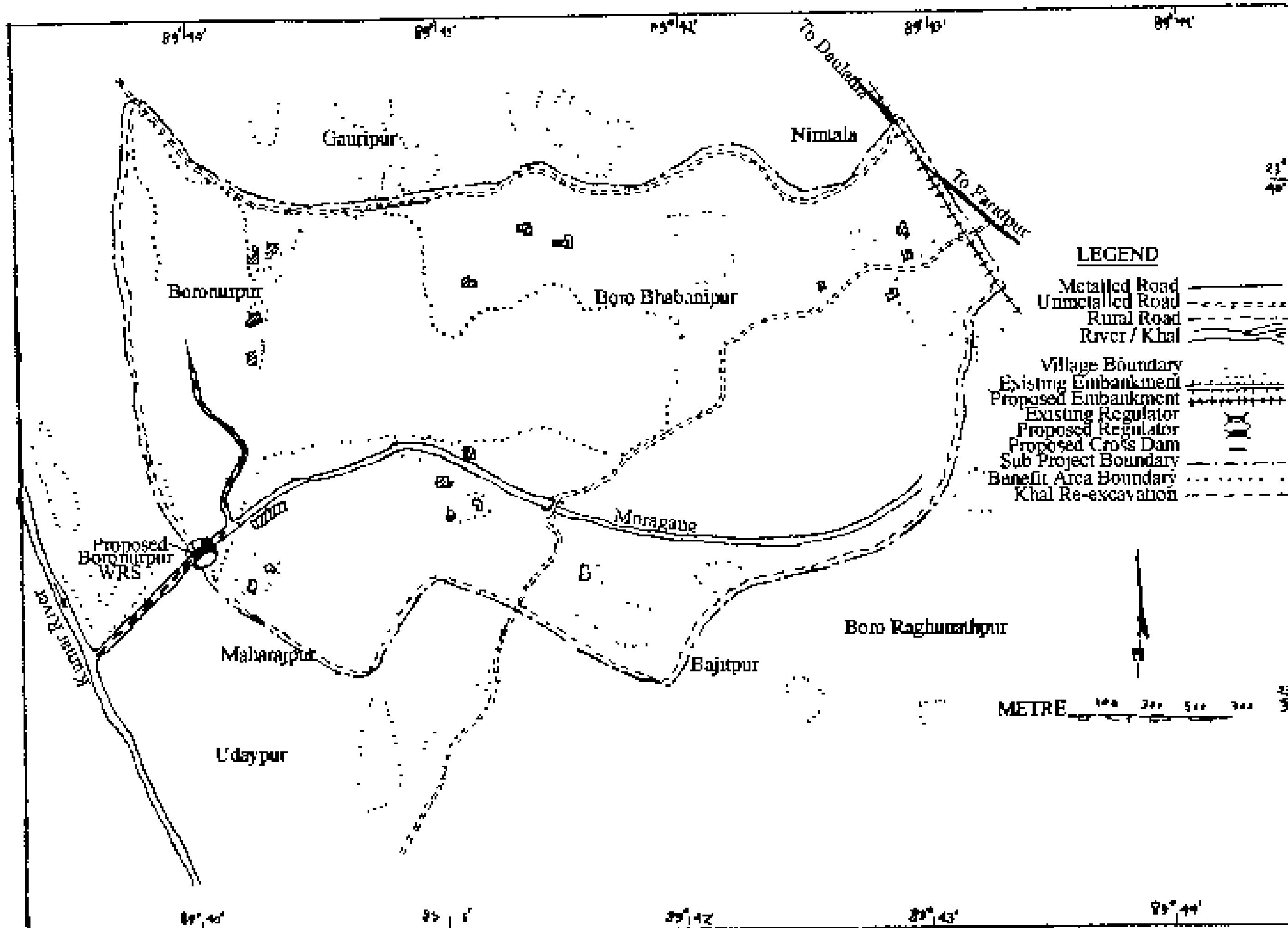


Figure 4.2: Map of Boronurpur WC Subproject.
(Source: LGED, 1998)

Chapter Five
RESULTS AND DISCUSSION

5.1 Introduction

The water poverty status in a subproject depends largely on the local demographic characteristics and performance of the water management institutions. Before implementation of a SSWRDSP subproject a Water Management Cooperative Association (WMCA) is constituted for successful implementation, operation and maintenance of the subproject at the local level. The WMCA generates a fund with the contribution from its members and LGED for various activities including repairing of the project infrastructure and equipment after its implementation. The WMCA members can take loan from this fund. Although the general activities of the WMCA are almost the same in all subprojects, these activities and the cooperation of LGED in these activities vary in different subprojects. In the study area subprojects, 'soil health cards' are given to a limited number of farmers based on soil analysis. These cards indicate the levels of different nutrients existing in the soil. Based on the information on the soil health card, the farmers can buy fertilizers to meet the requirements in their fields.

The WMCA members elect an effective committee of twelve members for three years headed by Secretary. Other members include Assistant Secretary, Editor, Treasurer and general members of which four are female members to represent them. All projects beneficiaries are members of different subcommittee of the WMCA, like operation and maintenance subcommittee, agriculture subcommittee, fish subcommittee, loan subcommittee. Members of this subcommittee including the effective committee of the WMCA meet once or twice in a month with the LGED field officials including the socio-economist and agriculturist to share their problems and ideas.

Most people living in the project and control sites are dependent on agriculture. However, many people are also dependent on other occupations. Table 5.1 shows occupational diversity in the study areas. In addition to farmers and fishermen there are a few day laborers, service holders, businessmen, etc., at the project and control site. In Narayankhali subproject on an average fifty six percent of the households are mainly engaged in agricultural activities at Kharabadh, Kismat Kurigahat and Talapara. At the control site, about forty five percent of households are dependent on agriculture. In Boronurpur subproject about sixty two percent of the households are mainly dependent on agriculture and at the control site Borovobanipur about seventy five percent households are dependent on agriculture.

Table 5.1: Percentage of households dependent on different occupation.

Subproject		Village	Occupation by %		
			Farmer	Fishermen	Other
Narayankhali	Project Site	Kharabadh	51	2	47
		Kismat Kurighata	67	0	33
		Talapara	50	0	50
	Control Site	Talbunia	45	25	40
Boronurpur	Project Site	Boronupur	62	2	34
	Control Site	Borovobanipur	75	0	25

5.2 Evaluation of WPI Components

The WPI is evaluated from five components: Resource, Access, Capacity, Use and Environment. These components are evaluated at the study and control sites from data collected from secondary sources and primary field investigation. The following sections discuss different features of these components.

5.2.1 Resource

The 'Resource' component is evaluated using data from secondary sources. Three types of water resources are considered: available rainfall, groundwater and surface water. A score is assigned for each resource based on its availability for a particular use during different months of the year. For example, rainfall may not be useful throughout the year for agriculture, but may be useful for rainwater harvesting. Therefore a score of 100 is assigned to the maximum rainfall amount. However, for surface water, the maximum water level may have negative impacts like flooding and consequently the corresponding resource score would be low. The score derived from these three sources are averaged to calculate the resource component score.

During the field survey most of the respondents in the project site said that they get enough water for household purposes throughout the year because they mainly use groundwater. For agricultural purposes they get adequate water for irrigation in wet season but in dry season the availability is low. In case of Narayankhali subproject, the respondents use groundwater from shallow tubewell. However in control site they cannot irrigate by shallow tubewell in dry season because of salinity in water. Irrigation by deep tubewells is not affordable by the respondents. Some respondents mentioned that they cultivate sesame in dry season because it does not require irrigation. Figure 5.1 shows the monthly average rainfall distribution in Narayankhali subproject and the control site from 1995-2002 (Khulna Sadar Station).

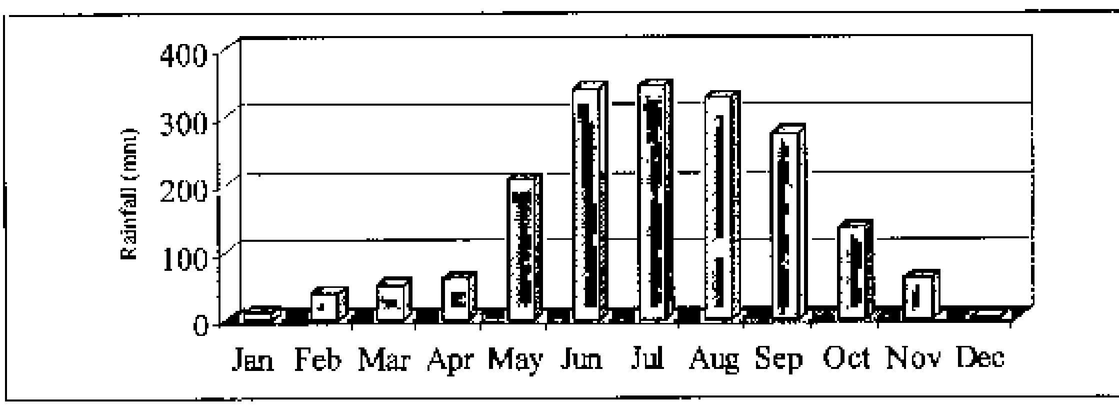


Figure 5.1: Average monthly rainfall in Narayankhali subproject and control site (Khulna Sadar Station).

It is found that availability of the resource is the highest in July. Based on a 0-100 scale, 100 being the maximum available resource, the average monthly rainfall resource scores are given in Table 5.2.

In Narayankhali subproject, the respondents did not have useable agricultural land before implementation of the project during the dry season because of salinity intrusion. The embankment and sluice gates constructed to protect their agricultural land have increased land availability.

Table 5.2: Average monthly rainfall and score in Narayankhali subproject and control site (Khulna Sadar Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul
Rainfall (mm)	11.66	39.79	50.83	62.16	207.8	339.7	344
Score	3	12	15	18	60	99	100

Month	Aug	Sep	Oct	Nov	Dec	Average
Rainfall (mm)	326.8	274.8	136.7	62.16	2.46	45
Score	95	80	40	18	1	

In Boronurpur subproject, the respondents said that they need to store rain water in Kharif II season for jute decomposition. This has been a traditional practice in the area. However, breaching of the earthen dam causes damage to their crops. LGED constructed a regulator for retaining rainfall runoff and drainage of excess water for dry season cultivation. This increases their access to and use of water in Kharif II season which is mainly used for jute decomposition. In control site, respondents have access to irrigation but they do not have water storage capacity for irrigation in Kharif II season. In dry season in both project and control site mainly Rabi crops are cultivated which need little irrigation. However Boro is not cultivated since groundwater is not easily available.

The average monthly rainfall distribution in Boronurpur subproject and control site from 1996-2002 (Faridpur Sadar Station) is shown in Figure 5.2. Rainfall resource is the highest in August, which is scored as 100. Rainfall resources in other months are calculated on a 0-100 scale as shown in Table 5.3.

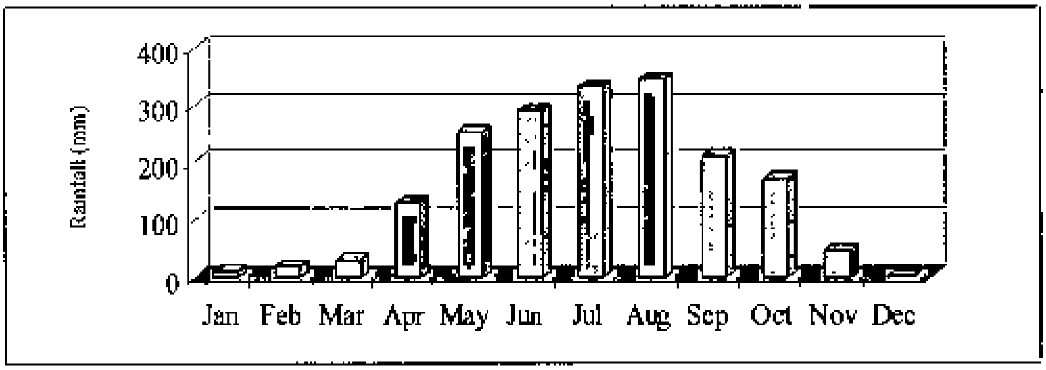


Figure 5.2: Average monthly rainfall in Boronurpur subproject and control site (Faridpur Sadar Station).

Table 5.3: Average monthly rainfall and score in Boronurpur subproject and control site (Faridpur Sadar Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul
Rainfall (mm)	11.9	19.33	30.94	130.1	251.7	289.4	332.3
Score	3	6	9	38	73	84	96

Month	Aug	Sep	Oct	Nov	Dec	Average
Rainfall (mm)	345.2	210.4	171.2	46.61	2.59	45
Score	100	61	50	14	1	

Figure 5.3 shows the average monthly groundwater level in Narayankhali subproject and control site during 1995-2005 (Khulna Sadar Station). Although the groundwater level varies monthly it is always above the suction limit of the shallow tubewell. The water level is generally the highest in September. Based on a 0-100 scale for the groundwater resource, between the suction limit and the maximum groundwater level, the monthly scores are calculated (Table 5.4).

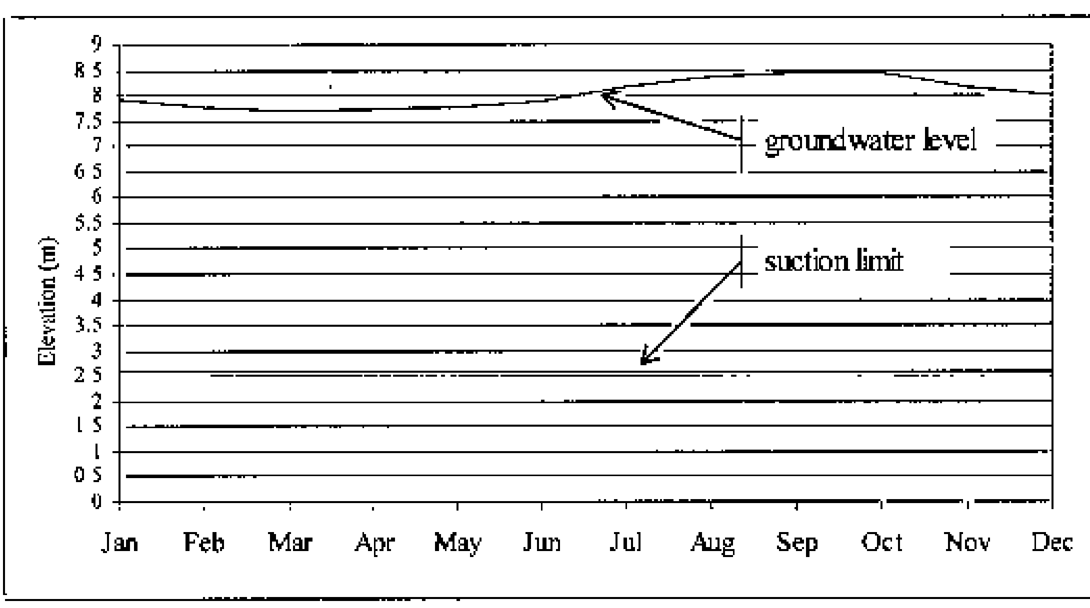


Figure 5.3: Average monthly groundwater level and suction limit at Narayankhali subproject and control site (Khulna Sadar Station).

Table 5.4: Average monthly groundwater level and score at Narayankhali subproject and control site (Khulna Sadar Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul
Groundwater level (m)	7.91	7.78	7.71	7.73	7.76	7.88	8.17
Score	93	92	91	92	92	93	97

Month	Aug	Sep	Oct	Nov	Dec	Average Score
Groundwater level (m)	8.36	8.44	8.42	8.16	8.02	95
Score	99	100	100	97	95	

Figure 5.4, shows the average monthly groundwater level variation in Boronurpur subproject and control site (Rajbari Sadar Station). The groundwater level generally remains above the suction limit of the shallow tube wells. The water level is the highest and the lowest in September and April, respectively. Farmers within the project site cultivate mainly wheat, jute, pulses, vegetables, coriander, mustard, onion, sugarcane, pepper, etc., and jute. The monthly average groundwater resource scores calculated based on a 0-100 scale are given in Table 5.5.

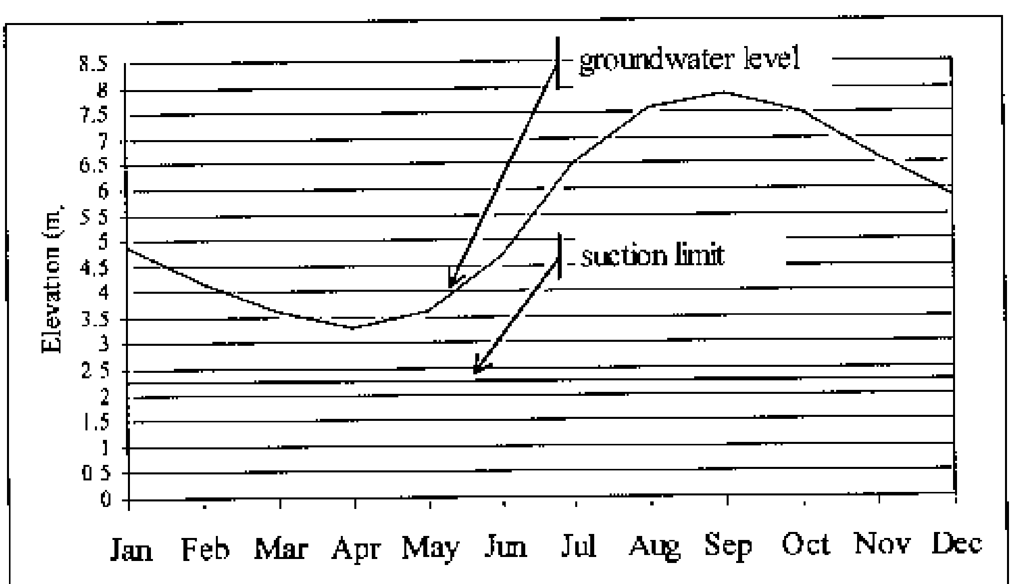


Figure 5.4: Average monthly groundwater level and suction limit at Boronurpur subproject and control site (Rajbari Sadar Station).

Table 5.5: Average monthly groundwater level and resource score at Boronurpur subproject and control site (Rajbari Sadar Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul
Groundwater level (m)	4.87	4.18	3.63	3.3	3.6	4.68	6.53
Score	61	53	46	41	45	59	83

Month	Aug	Sep	Oct	Nov	Dec	Average Score
Groundwater level (m)	7.6	7.86	7.51	6.65	5.83	53
Score	96	100	95	84	74	

There are four khals in Narayankhali subproject which are Dewania khal, Nangladaha khal, Salbunia khal, and Jabbarkhali khal. The average bed level of these four khals is approximately 0.25 m PWD. This means that water may enter in these khals from the river round the year, but in the dry season the water is unusable for irrigation mainly because of salinity. Figure 5.5 shows the average monthly tidal range in the Narayankhali subproject and control site (Passur River at Mongla). The tide level generally remains the highest in August. The scores are calculated on a 0-100 scale based on the availability of useable water in canals in each month for irrigation and other purposes. In Table 5.6 score 0 is given in dry periods from December to April when water is not useable because of salinity.

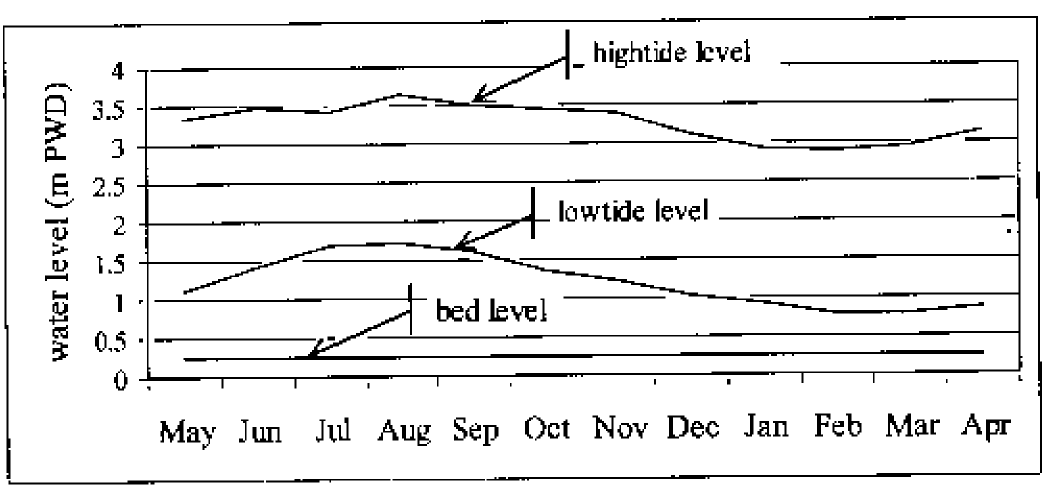


Figure 5.5: Average monthly tidal range at Narayankhali subproject and control site (Passur River, Mongla).

For other months the score is calculated based on availability of water during low tide. Score is not given based on high tide level. Because it is assumed that during high tide water availability is sufficient.

Table 5.6: Average monthly tide level and score at Narayankhali subproject and control site (Passur River, Mongla, 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul
High tide level	2.93	2.9	2.94	3.13	3.33	3.46	3.43
Low tide level	0.92	0.77	0.78	0.85	1.1	1.43	1.69
Score	0	0	0	0	64	83	98

	Aug	Sep	Oct	Nov	Dec	Average
High tide level	3.63	3.5	3.44	3.39	3.1	49
Low tide level	1.73	1.61	1.37	1.21	1.04	
Score	100	93	79	70	00	

From the field survey it is found that the surface water availability in Khulna subproject is gradually increasing. Respondents at the project site said that the canal depth has been reduced because of sedimentation. The canal needs regular re-excavation. They said that the flood control and drainage project protects their land from saline water intrusion in dry season. They mention that now they can cultivate round the year, which was not possible without the subproject intervention since the land would be flooded during wet season and the soil salinity would increase during the dry season.

Figure 5.6 shows the average monthly surface water level in Boronurpur subproject and control site (Goalando Station) during 1988-2004. The level remains the highest in August. Table 5.7 gives the monthly surface water levels and resource scores based on a 0-100 scale. It is found from field survey in Boronurpur subproject that the farmers mainly cultivate wheat in dry season because it is becoming profitable and it requires relatively less irrigation.

Table 5.8 gives the average score of the resource component in Khulna and Rajbari Sadar subprojects. From field surveys conducted in February and March, 2008, it is found that in

Narayankhali subproject farmers cultivate HYV Boro by applying groundwater irrigation. In the control site, there was no crop in the field and a few shrimp farms were found.

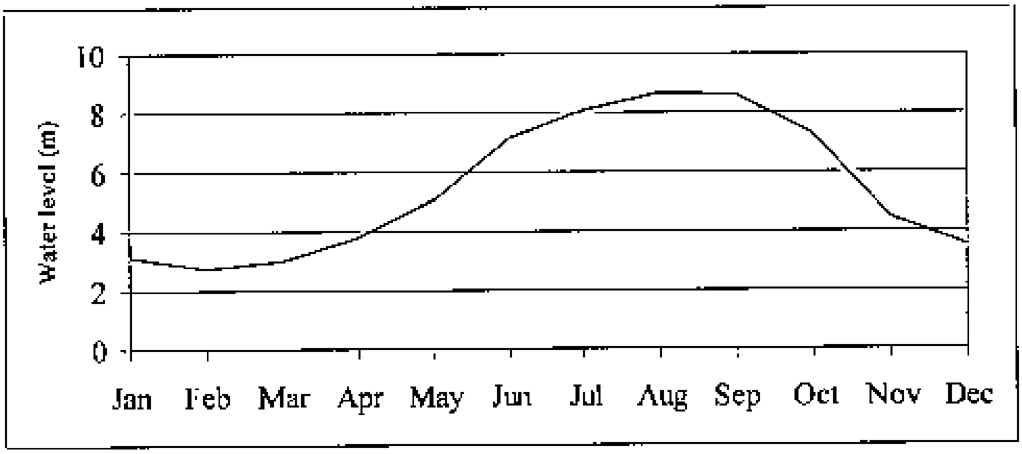


Figure 5.6: Average monthly surface water level at Boronurpur subproject and control site (Goalando Station).

Table 5.7: Average surface water level and resource score at Boronurpur subproject and control site (Goalando Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul
Water level (m)	3.10	2.74	3.00	3.84	5.04	7.15	8.09
Score	36	32	35	44	58	82	93

Month	Aug	Sep	Oct	Nov	Dec	Average score
Water level (m)	8.68	8.61	7.27	4.44	3.53	63
Score	100	99	84	51	41	

In Boronurpur subproject farmers cultivate mainly wheat. Some farmers produce pulses, coriander, pepper, vegetables, etc., which need less irrigation. In the control site, the

Table 5.8: Average Resource scores at the project and the control sites.

Location	Groundwater	Surface water	Rainfall	Average Resource
Khulna Sadar	95	70.83	45	70
Rajbari Sadar	53	63	45	54

farmers cultivate mainly vegetables with some pulses, sugarcane, etc. Quality of drinking water in the subproject and control sites is good. However, arsenic contamination of groundwater has restricted use of tube well water for drinking. During field survey in Boronurpur. it is found that one household is using arsenic affected tube well water for drinking purposes.

5.2.2 Access

Scores of the access component are calculated based on women's access to water (Table 5.9), access to irrigation (Table 5.10), access to tube wells (Table 5.11), households having sanitation (Table 5.12), and reported water use conflict (Table 5.13). The score for access is found from the average scores for the sub-components (Table 5.14). Details of the calculations are shown in Appendix E.

Table 5.9: Percentage of water collected by woman.

Subproject		Village	Water Collected by Women	Total Households	% of water collected by others than women
Narayankhali	Project Site	Kharabadh	34	51	33.3
		Kismat Kurighata	9	15	40
		Talapara	5	14	64.3
	Control Site	Talbunia	13	20	35
Boronurpur	Project Site	Boronupur	17	50	66
	Control Site	Borovobanipur	10	28	64.3

Table 5.10: Access to irrigation adjusted by climatic characteristics.

Subproject		Village	Access to irrigation
Narayankhali	Project Site	Kharabadh	14
		Kismat Kurighata	32
		Talapara	30
	Control Site	Talbunia	0
Boronurpur	Project Site	Boronupur	27
	Control Site	Borovobanipur	26

Table 5.11: Households having access to tube well.

Subproject		Village	Households having tube well	Total households	% of Households having tube well
Narayankhali	Project Site	Kharabadh	45	51	88.2
		Kismat Kurighata	12	15	80
		Talapara	12	14	85.7
	Control Site	Talbunia	10	20	50
Boronurpur	Project Site	Boronupur	44	50	88
	Control Site	Borovobanipur	22	28	78.6

Table 5.12: Percentage of households having sanitation.

Subproject		Village	Households having sanitation	Total Households	% of Households having sanitation
Narayankhali	Project Site	Kharabadh	40	51	78.4
		Kismat Kurighata	12	15	80
		Talapara	11	14	78.6
	Control Site	Talbunia	14	20	70
Boronurpur	Project Site	Boronupur	43	50	86
	Control Site	Borovobanipur	21	28	75

One of the main objectives of the Narayankhali flood control and drainage subproject was to increase irrigation coverage by protecting the agricultural land from saline river water in Boro season. Accordingly, after the project implementation, irrigation coverage has increased, which supports mainly HYV Boro. In case of access to drinking water, it is found that most of the households either have their own tube wells or have easy access to a nearby tube well. However in the control site, very few households have their own tube wells and they have to walk quite a long distance to fetch water. In Boronurpur subproject, most of the households have access to tube wells in both project and control sites.

The aim of Boronurpur water conservation subproject was to retain rainfall runoff during monsoon for Kharif II cultivation and drain out water for post-monsoon cultivation. During the field survey conducted in Rabi/Boro season, it is found that farmers cultivate crops like wheat, pulses, vegetables, corundum, sesame and pepper, which cannot tolerate water logging and need relatively less irrigation. Field survey results indicate that irrigation coverage has not increased significantly at this project site. In the control site village, there is no reported conflict among water users because they do not store rainwater during monsoon for agricultural purposes. Their access to irrigation is similar to that in the project site village.

In Narayankhali subproject, there are still some reported conflicts among water users (Table 5.13). These conflicts mainly result from head-tail water distribution inequity.

Table 5.13: Percentage of households reporting conflict in water use.

Subproject		Village	% of Households experiencing conflict in water use	Total Households	% of Households not experiencing conflict in water use
Narayankhali	Project Site	Kharabadh	14	51	86
		Kismat Kurighata	0	15	100
		Talapara	21	14	79
	Control Site	Talbunia	0	20	100
Boronurpur	Project Site	Boronupur	10	50	90
	Control Site	Borovobanipur	0	28	100

During field survey, some farmers in Kharabadh and Talapara stated that they cannot irrigate their land since it is high. Conflicts among the water users are also found in Boronurpur subproject. Some farmers who cultivate Aman stated that they do not want to retain the rainfall runoff during monsoon. However, other farmers who cultivate jute say that they want the water for jute decomposition.

Table 5.14: Average scores on access.

		Village	% of water collected by others than women	% of Households having access to sanitation	% of Households not experiencing conflict in water use	% of Households having Tube Well	Access to irrigation coverage	Access
Narayankhali	Project Site	Kharabadh	33.3	78.4	86	88.2	13.7	60
		Kismat Kurighata	40	80	100	80	31.7	66
		Talapara	64.3	78.6	79	85.7	29.5	67
	Control Site	Talbunia	35	70	100	50	0	51
Boronurpur	Project Site	Boronupur	66	86	90	88	26.5	71
	Control Site	Borovobanipur	64.3	75	100	78.6	26.2	68

5.2.3 Capacity

Scores for the capacity component are calculated based on education level (Table 5.15), score on wealth status (Table 5.16), health status (Table 5.17), income (Table 5.18), and household membership in WMCA (Table 5.19). The overall score of the capacity component is found from the average scores of the subcomponents (Table 5.20). It is

Table 5.15: Household education level.

Subproject		Village	Total Households	Households having at least one member SSC passed
Narayankhali	Project Site	Kharabadh	51	11 (22%)
		Kismat Kurighata	15	3 (20%)
		Talapara	14	4 (29%)
	Control Site	Talbunia	20	4 (20%)
Boronurpur	Project Site	Boronupur	50	9 (18%)
	Control Site	Borovobanipur	28	4 (14%)

assumed that household education level would indicate their awareness about sanitation and hygiene. In Narayankhali, education level is found to be higher in both project and control sites than that in Boronurpur. Because in Narayankhali people are more aware about the need for education and few children assist in the agricultural field, whereas in Boronurpur the awareness about education is low and many children are engaged in agricultural activities.

The wealth status of a household is measured in terms of items like television, refrigerator, bicycle, furniture, livestock holdings, etc. A score is assigned to the household on the basis of the total price of the items belonging to the household. The details of the calculation are shown in Appendix F. It is found that the wealth status is better in the subproject village Talapara in Narayankhali than that in the control site. This is because the people of Talapara own more livestock than other villages. Also, the number of households dependent on occupations other than agriculture is higher. The wealth status of other two villages is similar to that of the conttol site. In Boronurpur subproject the wealth status is better in the control site village Borovobanipur than that of the project site village Boronurpur. The wealth status score is high because households of this village depend on agriculture and most of them are earning from their agricultural products and they also have more livestock.

Table 5.16: Score on household wealth status.

Subproject		Village	Score on wealth status
Narayankhali	Project Site	Kharabadh	11
		Kismat Kurighata	12
		Talapara	17
	Control Site	Talbunia	12
Boronurpur	Project Site	Boronupur	15
	Control Site	Borovobanipur	21

The illness related to water reported by households is mainly skin diseases, gastric problems and arsenic contamination effects. Water related diseases are more reported in Narayankhali project and control sites than in Boronurpur project and control sites.

Income status of the households in Boronurpur project and control sites is better than that of Narayankhali project and control sites. Field survey results show that in Boronurpur most of the farmers earn from their farm products also. Whereas in Narayankhali farmers only produce crops for their own consumption and sometimes they even have to buy food

Table 5.17: Households reporting illness related to water.

Subproject		Village	Households experiencing illness related to water	Total Households	% of households not experiencing illness related to water
Narayankhali	Project Site	Kharabadh	11	51	78.4
		Kismat Kurighata	0	15	100
		Talapara	0	14	100
	Control Site	Talbunia	5	20	75
Boronurpur	Project Site	Boronupur	1	50	98
	Control Site	Borovobanipur	2	28	92.9

when the production is insufficient. In Narayankhali subproject, farmers are also engaged in non-farming activities during the dry season when they cannot afford to buy sufficient agricultural inputs. Membership in the WMCA also indicates the capacity of the people. In general, membership in the WMCA is higher in Narayanhkali subproject than that in Boronurpur subproject.

Table 5.18: Household income status.

Subproject		Village	Total Households	Households employment/earning from pension/ wage/farm products (%)
Narayankhali	Project Site	Kharabadh	51	24 (47)
		Kismat Kurighata	15	9 (60)
		Talapara	14	7 (50)
	Control Site	Talbunia	20	6 (30)
Boronurpur	Project Site	Boronupur	50	37 (74)
	Control Site	Borovobanipur	28	14 (50)

Household membership status (Table 5.19) in the WMCA is better in Boronurpur subproject than that in the Narayankhali subproject. Since in Boronurpur more people are dependent on agriculture their participation in the WMCA is also higher.

Table 5.19: Membership status of WMCA in project sites.

Subproject		Village	Total	Member of WMCA	% of membership
Narayankhali	Project Site	Kharabadh	51	23	45
		Kismat Kurighata	15	3	20
		Talapara	14	8	57
Boronurpur	Project Site	Boronupur	50	34	68

Table 5.20: Average scores of Capacity component.

Subproject		Village	% of Households matriculated	% of Households not experiencing illness related to water	Score on wealth status	% of Households receiving Income	% of WMCA membership	Capacity
Narayankhali	Project Site	Kharabadh	22	78	11	47	45	41
		Kismat Kurighata	20	100	12	60	20	42
		Talapara	29	100	17	50	57	51
	Control Site	Talbunia	20	75	12	30	0	27
Boronurpur	Project Site	Boronupur	18	98	15	74	68	55
	Control Site	Borovobanipur	14	93	21	50	0	36

The average score of the capacity component is higher in both subproject villages than that of the control site villages.

5.2.4 Use

Scores for the use component are calculated based on average water use per household per day (lpd) (Table 5.21), percentage of irrigated land in dry season (Table 5.22), and average livestock water use per household per day (lpd) (Table 5.23). For calculating average water use for domestic purposes, estimates provided by Ahmed and Rahman (2003) for per capita water use for distant tube wells are used. Households having tube wells in their yards use 40 lpcd, at <50 m distance use 35 lpcd, at 50-250 m distance use 25 lpcd, at 250-500 m use 15 lpcd. and at >1000 m distance use 7 lpcd. The water use score is then

Table 5.21: Score on households' water use in project and control sites.

Subproject		Village	Score on water use (lpd)
Narayankhali	Project Site	Kharabadh	27
		Kismat Kurighata	24
		Talapara	26
	Control Site	Talbunia	33
Boronurpur	Project Site	Boronupur	41
	Control Site	Borovobanipur	50

calculated using Eqn. 3.4 as shown in Appendix E. A score 100 is assigned to the highest water use by a household in that subproject area and a score 0 is assigned when water use is zero. Since water consumption depends on the family size, the score for water use is higher in the control site village where the average family size is bigger.

Table 5.22: Irrigated land in project and control sites.

Subproject		Village	Total cultivated land of surveyed households (acre)	Irrigated land of surveyed households (acre)	% of irrigated land of surveyed households
Narayankhali	Project Site	Kharabadh	88	49	56
		Kismat Kurighata	33	16	48
		Talapara	36	17	46
	Control Site	Talbunia	26	0	0
Boronurpur	Project Site	Boronupur	92	78	85
	Control Site	Borovobanipur	80	46	57

For calculating agricultural water use, percentage of irrigated land with respect to cultivable land per household is used. In Narayankhali subproject, about 50 percent of the cultivable land is irrigated in dry season mainly for HYV Boro. In Boronurpur subproject, about 85 percent of the cultivable land is irrigated in dry season mainly by minor irrigation for Rabi crops.

For calculating livestock water consumption, average livestock holdings per household and standard water use per livestock estimates are used. A score is calculated for the households using Eqn. 3.4 as shown in Appendix E. It is assumed that water consumption by cattle is 20 liter/day, and that by goat and sheep is 5 liter/day (Heidecke, 2006).

Table 5.23: Score of livestock water use per household in project and control sites.

Subproject		Village	Livestock water use in (lpd)
Narayankhali	Project Site	Kharabadh	16
		Kismat Kurighata	20
		Talapara	23
	Control Site	Talbunia	19
Boronurpur	Project Site	Boronupur	21
	Control Site	Borovobanipur	36

In Narayankhali subproject site the score of livestock water is higher in the two subproject site villages. However, the score is lower in one project site village than that of the control site village. In Boronurpur subproject the score of livestock water use is higher in the control site village than that of the project site village.

The average value of the 'Use' component is calculated in Table 5.25. In Boronurpur subproject, a water conservation subproject, the aim is to retain rainfall run-off for use in dry period. The score in the project site is almost 1 point higher than that in the control site. In Narayanlhali subproject, a flood control and drainage project, the score in the project site is about 15 point higher than that in the control site. Major water uses in the project and control sites of Narayankhali and Boronurpur subprojects were ranked by the users during FGDs. Table 5.24 gives the percentage of water use for different purposes.

Table 5.24: Average scores of Use component.

Subproject		Village	Average water use (lpd)	% of irrigated land	Livestock water use in (lpd)	Average Score
Narayankhali	Project Site	Kharabadh	27	56	16	33
		Kismat Kurighata	24	48	20	31
		Talapara	26	46	23	32
	Control Site	Talbunia	33	0	19	17
Boronurpur	Project Site	Boronupur	41	85	21	49
	Control Site	Borovobanipur	50	57	36	48

Table 5.25: Ranking of water use in different sectors.

	Sector	Percentage of use
Narayankhali subproject	Agriculture	60
	Livestock	15
	Domestic	10
	Other	15
Narayankhali control site	Fisheries	40
	Agriculture	40
	Livestock	5
	Domestic	10
	Other	5
Boronurpur subproject	Agriculture	60
	Livestock	20
	Domestic	10
	Other	10
Boronurpur control site	Agriculture	50
	Livestock	30
	Domestic	10
	Other	10

5.2.5 Environment

The 'Environment' component is calculated by three sub-components: percentage of households dependent on wildlife or fish (Table 5.26), percentage of households reporting crop loss in last five years (Table 5.27), and percentage of households reporting erosion on their land (Table 5.28). In Narayankhali subproject, the percentage of households dependent on fish is calculated by households reporting use of fish for their own consumption. This indicates a positive return from the environment. In Narayankhali subproject, the number of households dependent on natural fish is more than that of the control site. This is because the subproject site has more ponds (Table 5.30) and wetland areas than those of the control site, although the numbers are decreasing. In the control site of Narayankhali, due to presence of shrimp farms, open water fisheries and agriculture are both adversely affected, especially in dry season, because of high water salinity.

Table 5.26: Households dependent on fish.

Subproject		Village	Total HHs	HHs using fish (%)
Narayankhali	Project Site	Kharabadh	51	16 (31)
		Kismat Kurighata	15	4 (27)
		Talapara	14	3 (21)
	Control Site	Talbunia	20	1 (5)
Boronurpur	Project Site	Boronupur	50	18 (36)
	Control Site	Borovobanipur	28	7 (25)

Table 5.27: Households report crop loss in last five years.

Subproject		Village	Total HHs	HHs reporting crop loss (%)	% HHs reporting no crop loss
Narayankhali	Project Site	Kharabadh	51	6 (12)	88
		Kismat Kurighata	15	3 (20)	80
		Talapara	14	0 (0)	100
	Control Site	Talbunia	20	7 (35)	65
Boronurpur	Project Site	Boronupur	50	5 (10)	90
	Control Site	Borovobanipur	28	4 (14)	86

In Narayankhali subproject households reporting crop loss in last five years is more in the control site than that in the project site. In control site, crop loss results from loss of soil fertility due to saline water logging for shrimp cultivation. In project site, crop loss mainly occurs due to insect attack, conflict in irrigation water use, and changes in the pattern and intensity of rainfall. In Boronurpur, farmers in both the project and control sites reported loss of crop mainly due to insect attack and loss of soil fertility.

Table 5.28: Households reporting erosion of their land.

Subproject		Village	Total HHs	HHs reporting soil erosion (%)	% HHs reporting no erosion
Narayankhali	Project Site	Kharabadh	51	2 (4)	96
		Kismat Kurighata	15	1 (7)	93
		Talapara	14	1 (7)	93
	Control Site	Talbunia	20	5 (25)	75
Boronurpur	Project Site	Boronupur	50	3 (6)	94
	Control Site	Borovobanipur	28	1 (4)	96

In Narayankhali subproject, number of households reporting erosion of their land is more in the control site. This is because the fields are not covered with vegetation. So the soil is eroded. The soil is also eroded due to shrimp cultivation. In project site villages, the erosion is caused mainly by excessive rainfall and flood water. In Boronurpur subproject, in both control and project sites, some households reported erosion of their land which occurs mainly due to conversion of forest land to crop land.

The values of the above three sub-components are averaged to calculate the average score on 'Environment' (Table 5.29). In Narayankhali subproject site, the average scores of the 'Environment' component in the project site villages is more than that of the control site village. Similarly, in Boronurpur subproject the average score on 'Environment' is more in the project site than that in the control site.

Table 5.29: Environment component score for project and control sites.

Subproject		Village	% HHs dependent on fish	% HHs no crop loss	% HHs reporting no soil erosion	Average
Narayankhali	Project Site	Kharabadh	31	88	96	72
		Kismat Kurighata	27	80	93	67
		Talapara	21	100	93	71
	Control Site	Talbunia	5	65	75	48
Boronurpur	Project Site	Boronupur	36	90	94	73
	Control Site	Borovobanipur	25	86	96	69

In the subproject sites, the farmers reported during FGD that project interventions have adversely affected the fisheries in the study area. Open water fisheries has been affected since the floodplain connectivity to the rivers and canals have been disrupted. Although the subproject interventions protect the land from saline water intrusion and help increase rice production, the internal canals are gradually silting up causing reduction in water holding capacity, and will need frequent re-excavation.

It is also found that for high yield varieties farmers use more fertilizer and pesticide than those for local varieties. Excessive use of fertilizer and pesticide causes gradual reduction in soil fertility. The subproject interventions protect the area from flooding and erosion in wet season, and from tidal flooding and salinity intrusion in dry season. The flood water contains sediment and increases the soil fertility. Since the agricultural field is not flooded, fertility is not increased naturally. As a result the land needs more fertilizer for agricultural production.

It is also found that households depend largely on the local ponds for fish (Table 5.29). However most of these ponds dry up in dry season due to shortage of water. This also affects the drinking water availability in Narayankhali. Since the groundwater is contaminated by arsenic.

Table 5.30: Households having pond in project and control sites.

Subproject		Village	No. of Pond	Total Household	% having pond
Narayankhali	Project Site	Kharabadh	32	51	62.8
		Kismat Kurighata	6	15	40
		Talapara	0	14	0
	Control Site	Talbunia	0	20	0
Boronurpur	Project Site	Boronupur	18	50	36
	Control Site	Borovobanipur	7	28	25

The FGDs indicate that the forest area has decreased and natural fish production has reduced in last five years. In Boronurpur subproject, since the farmers cultivate high yield varieties of rice, fertilizer and pesticide requirement is gradually increasing. During jute cultivation farmers decompose the jute in open water bodies which causes water pollution and local odor problem. Arsenic contamination of the groundwater has made drinking water scarce. It is found on one occasion that people drink water from tube wells contaminated with arsenic.

5.3 Calculated Water Poverty Index Values in Study Area

The Water Poverty Index (WPI) is finally calculated based on the five components: Resource, Access, Capacity, Use and Environment, and their 17 subcomponents (Table 5.31).

Table 5.32 gives the average WPI component scores in the project and control sites of the Narayankhali subproject. The overall WPI has improved by about 30% due to project implementation. The 'Resource' component scores in three project sites Kharabadh, Talapara, Kismat Kurighata, and that in control site Talbunia is the same. The 'Access' component score have increased in Kharabadh, Kismat Kurighata and Talapara. However there are some conflicts in irrigation water use due to differences in land elevation. Also in some cases farmers having their plots farther from the pump are deprived of irrigation. In the control site Talbunia, there is no irrigation access in dry season. The 'Capacity' component score is higher in the project site than in the control site. Farmers produce more crops in the project sites than the control site. Therefore their living standard is better. For project operation and maintenance a 'Water Management Cooperative Association' is formed in the local community which takes initiatives to improve their capacity. In the control site, very few people are employed, and they mostly depend on agriculture. Most of them remain jobless in dry season. In the project site, the 'Use' component score is higher than that in the control site.

There is no irrigation water use in dry season in the control site and the water use for livestock is also relatively low. Some households rear sheep and goat because their water consumption is low. The 'Environment' component score is higher in the project site than that in the control site because the total crop production has increased due to project implementation and the soil salinity has decreased.

Table 5.31: Scores of different components of WPI at project and control sites.

	Resource			Access					Capacity					Use			Environment		
Village	GW	SW	Rain	% Other	% San	% No Conflict	% TW	Irr Cov.	% SSC	% no ill	Wealth	% Wage	% of WMCA member	lpd	% AU	Liv U	% Wildlife	% No LC	% No Erosion
Narayankhali FCD subproject																			
Kharabadh	95	70.8	45	33.3	78.4	86.3	88.2	13.7	21.6	78.4	53	47.1	49	38	56	25	16	88	96
Kismat Kurighata	95	70.8	45	40	80	100	80	31.7	20	100	55	60	51	35	47.6	40	20	80	93
Talapara	95	70.8	45	64.3	78.6	78.6	85.7	29.5	28.6	100	54	50	58	35	45.7	40	14	100	93
Talbunia (Control site)	95	70.8	45	35	70	100	50	0	20	75	45	30	34	30	0	20	10	65	75
Boronurpur WC subproject																			
Boronupur	53	63	45	66	86	90	88	26.5	18	98	73	74	66.2	40	85	55	14	90	94
Borovobani Pur (Control site)	53	63	45	64.3	75	100	78.6	26.2	14.3	92.9	66	50	44.6	40	57	55	21	86	96

GW groundwater availability
SW surface water availability
Rain Rainfall availability
% Other % of Water carried by others than women
% San % of HHs with access to sanitation
No Conflict % of HHs that do not experience conflicts over use of water
% TW % of HHs that have got a TW near their house
Irr cov. Access to irrigation coverage with climatic characteristics
% SSC % of HHs that have got at least one of their members matriculated
% no ill % of HHs that have not experienced illness that they perceive to be related with water
Wealth this score has been derived by using the number of items like television, refrigerator, bicycle, etc. belonging to a HH
% wages this score has been derived using both the % of HHs with at least a member earning a wage or perceiving a pension and % of HHs earning income by selling farm products or craft products
% of member % of households having membership of WMCA Committee
lpd Score derived using the average liter per day per household.
Au score derived using the proportion of HHs irrigating their crops and the average size of the cultivated land.
LivU score derived using the average number of livestock own by a HH and the minimum amount of water required per type of livestock in liter per day
% Wildlife % of HHs use wildlife or fish for their consumption.
% No LC % of HHs reporting no loss of crop during last five years.
% No erosion % of HHs reporting no erosion of their land

Table 5.32: WPI and scores of its components in project and control sites of Narayankhali subproject.

Subproject		Village	Resource	Access	Capacity	Use	Enviro-nment	WPI
Narayan-khali	Project Site	Kharabadh	70	60	41	33	72	55
		Kismat Kurighata	70	66	42	31	67	55
		Talapara	70	67	51	32	71	58
	Control site	Talbunia	70	51	27	17	48	43

The average WPI for the project site is higher than that in the control site. This indicates that the water poverty status in the three project sites Kharabadh, Talapara and Kismat Kurighata, is better than that in Talbunia which is outside the SSWRDSP project. Since the other external factors are similar in the project and control sites, implementation of SSWRDSP project has most likely improved the water poverty status in the project site.

Figure 5.7 shows the WPI component scores in the project and control sites. Scores of the five components are indicated along the five axes of the pentagram. For both the project

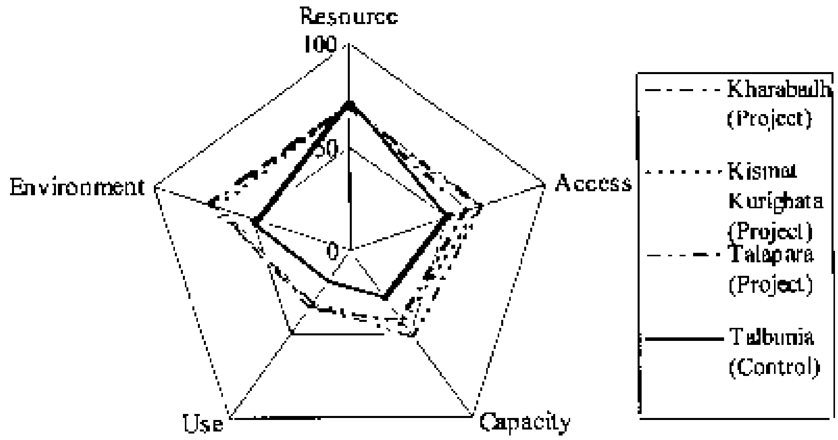


Figure 5.7: Pentagram representing the scores of WPI components in project and control sites of Narayankhali subproject.

and control sites, the pentagram is skewed more toward the 'Resource' component, indicating that the resource is higher in both project and control sites. Thus 'Access' component scores are higher in the project sites. The Narayankhali subproject is a Flood Control and Drainage improvement (FCD) project, and its main purpose is to prevent the saline water intrusion in dry season and protect the land from excess flooding during wet season by constructing embankments with sluice gates surrounding the project area.

Primarily the aim of the project is to maximize the access to of land and irrigation resource. In Talbunia, the 'Access' component score is lower than that in the project site, mainly because of the relatively low access to irrigation and drinking water. The 'Capacity' component score is lower in the control site than that in the project site. Most people in the control site remain jobless in dry season and have to depend on alternative livelihood. The 'Use' component score is also higher in the project site than that in the control site. With the increase in available resources due to project interventions, the use of irrigation has also increased. The 'Environment' component score is higher in the project site than that in the control site.

Table 5.33 gives the average WPI component scores in the project and control sites of the Boronurpur subproject. The overall WPI has improved by about 9% due to project implementation. The 'Access' component score is higher in the project site than that in the control site. However, there are still conflicts in water use between agriculture and fisheries. In the project site, conflict in water use exists among the farmers. Jute farmers

Table 5.33: WPI and scores of its components in project and control sites of Bronurpur subproject.

Subproject		Village	Resource	Access	Capacity	Use	Environment	WPI
Boronurpur	Project Site	Boronupur	54	71	55	49	73	60
	Control Site	Borovobanipur	54	69	36	48	69	55

want to conserve water for jute fermentation, while some farmers who cultivate Aman do not want to conserve the water. In the control site there is no conflict in water use. A Water Management Cooperative Association (WMCA) is formed in the project site for operation and maintenance of the project at the local level. This WMCA takes initiatives to improve their socio-economic status in the project site. Hence the 'Capacity' component score is higher in the project site than that in the control site. The 'Use' component score is almost similar in the project site and control site. Because in Boronurpur more water is used for agriculture while in control site more water is used for livestock. The 'Environment' component score is higher in the project site than that in the control site. This is because in the project site, more households depend on natural fish for their own consumption and are more aware about different agricultural problems through their WMCA activities.

Figure 5.8 shows the WPI component scores in the project and control sites. The score of 'Capacity' component is higher in the project site. The 'Access', 'Use', and, 'Environment' component scores have increased moderately in the project site because of better access to conserved water. Since this is a Water Conservation project, its main purpose is to conserve water. Water users in the project reached a mutual agreement to conserve water. Although there are conflicts among water users in the project site, there is no water use conflict in the control site.

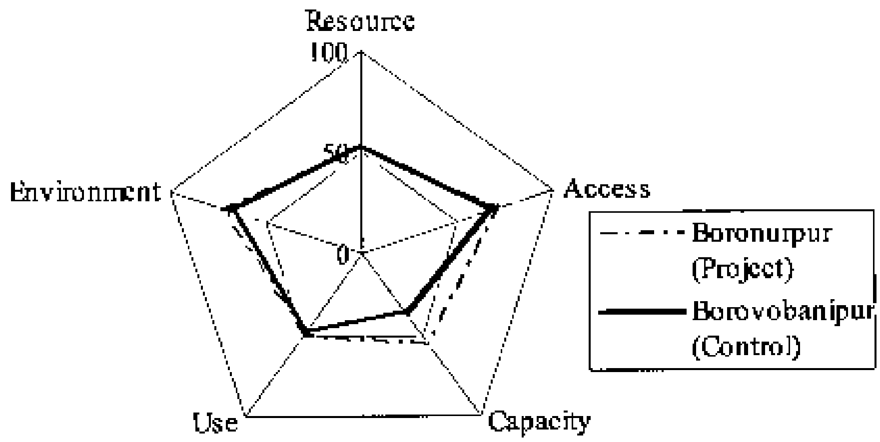


Figure 5.8: Pentagram representing the scores of WPI components in project and control sites of Boronurpur subproject.

5.4 Comparison of WPI in Different Sites

WPI and its component scores for different sites of the study area were compared. These are also compared with the overall country index and component scores for Bangladesh estimated by Sullivan (2002). The 'Resource' component score is higher in all the sites than the overall 'Resource' score of the country estimated by Sillivan (2002) (Table 5.34).

Table 5.34: WPI component scores in project sites and the overall values for the country.

	Resource	Access	Capacity	Use	Environment	WPI
Bangladesh	45	69	51	62	45	54
Kharabadh	70	60	41	33	72	55
Kismat Kurighata	70	66	42	31	67	55
Talapara	70	67	51	32	71	58
Talbunia	70	51	27	17	48	43
Boronupur	54	71	55	49	73	60
Borovobanipur	54	69	36	48	69	55

The 'Access' is the lowest in Narayankhali control site Talbunia. In other sites, except Kharabadh the scores are approximately equal to that estimated by Sullivan (2002). The 'Capacity' component score is higher in project site village Boronurpur than the national score. The score is the same in project site village Talapara, while in the other project site villages and the control site villages the score is lower than the overall score for the country. The 'Use' component score is lower in both subproject sites and control sites. The 'Environment' component score is higher in both the control and project sites than the overall score for the country.

The WPI in project sites of Khulna and Boronurpur are higher than the country's overall index (Figure 5.9) except the control site village Talbunia in Narayankhali subproject. It is reasonable to assume that this has happened due to project implementation for solving water-related problems. The WPI is also higher in Boronurpur control site, possibly because relatively low level of conflict in water uses, fertile soil, crop diversity, absence of salinity problem, and higher water use for livestock.

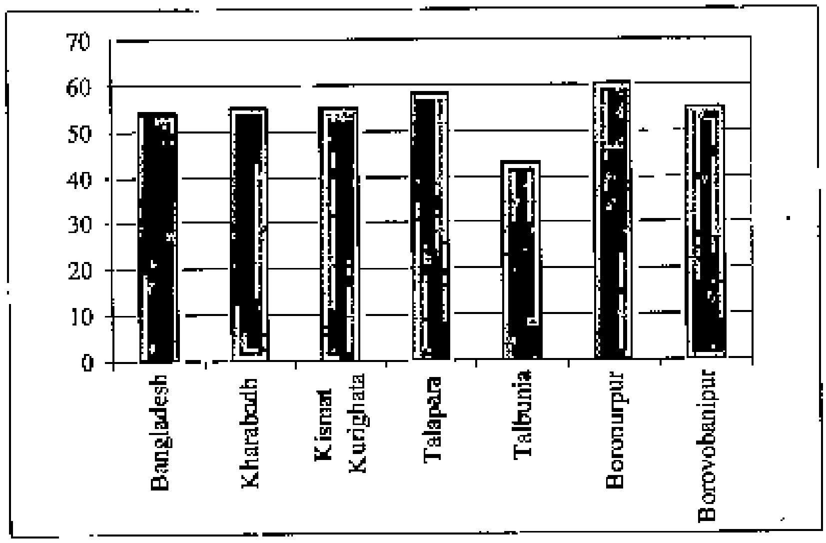


Figure 5.9: WPI for project and control sites with overall country index.

Table 5.35 gives a comparison of WPI for the project sites with those for small communities of South Africa, Sri Lanka and Tanzania. The WPI for the projects sites are

Table 5.35: Comparison between small communities in South Africa, Sri Lanka and Tanzania with the project sites in Bangladesh.

Village	Resource	Access	Capacity	Use	Environment	WPI
Kharabadh	70	60	41	33	72	55
Kismat Kurighata	70	66	42	31	67	55
Talapara	70	67	51	32	71	58
Boronupur	54	71	55	49	73	60
Ethembeni	50	36.6	59.8	41.5	27.7	43.1
Latha	20	17	42.1	24.5	28.9	26.5
Wembezi(informal)	50	48.8	46.1	18	39.1	40.4
Wembezi(formal)	50	86.5	78	38.1		63.2
Nkoaranga	30	39.5	59.4	65.3	69.9	52.8
Samaria	20	20.9	44.7	37.7	56.1	35.9
Majengo	10	32.7	62.9	15	98.4	43.8
Kijenge	20	53.9	68.3	21.6		41
Agarauda	20	38.3	64.7	74.9	34.2	46.4
Awarakotuwa	10	35.2	79.6	21.2	28.1	34.8
Tharawaththa	20	26.5	50.6	16.2	42.2	31.1
Tissawa	20.0	47.3	52.0	50.0	38.5	41.6

relatively higher in generals. The 'Resource', 'Access' and 'Environment' component scores in the project site of Bangladesh are higher than those in the small communities in South Africa, Sri Lanka and Tanzania. The 'Capacity' and 'Use' component scores are approximately the same.

Table 5.36 gives the project evaluation scores for the Narayankhali and Boronurpur subprojects given by BUET-BIDS-Delft Hydraulics (2003) depending on four different issues. The evaluation scores generally agree with the WPI determined by the present study where the situation in the Boronurpur subproject is found to be relatively good.

Table 5.36: Evaluation of subprojects by BUET-BIDS-Delft Hydraulics.

Subbproject	Technical Issues	Socioeconomic Issues	Institutional Issues	Training	Total Score
Narayankhali FCD	66	47	46	0	46
Bromurpur WC	97	65	76	67	79

Narayankhali is a FCD subproject, and its aim is to increase cultivable land and irrigation coverage mainly in dry season. Table 5.37 shows that the irrigated land and access to irrigation in the project sites are both more than those in the control site.

Table 5.37: Impact of project interventions on irrigation.

Subproject		Village	Access to irrigation	% of irrigated land
Narayankhali	Project Site	Kharabadh	13.7	56
		Kismat Kurighata	31.7	47.6
		Talapara	29.5	45.7
	Control Site	Talbunia	0	0
Boronurpur	Project Site	Boronupur	26.5	85
	Control Site	Borvobanipur	26.2	57

Figure 5.10 schematically shows that access to irrigation coverage in dry season is more in the project sites than that in the control sites.

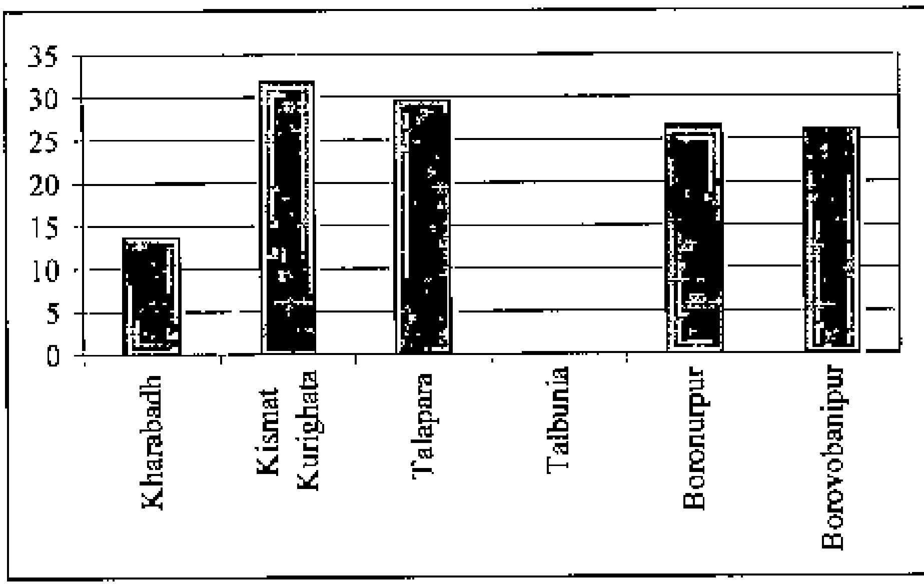


Figure 5.10: Access to irrigation in project and control sites.

The aim of the Boronurpur subproject is to conserve water for irrigation purposes in Kharif II season. Figure 5.11 shows that water use in terms of percentage of irrigated land to total cultivable land is more in the project sites than those in the control sites.

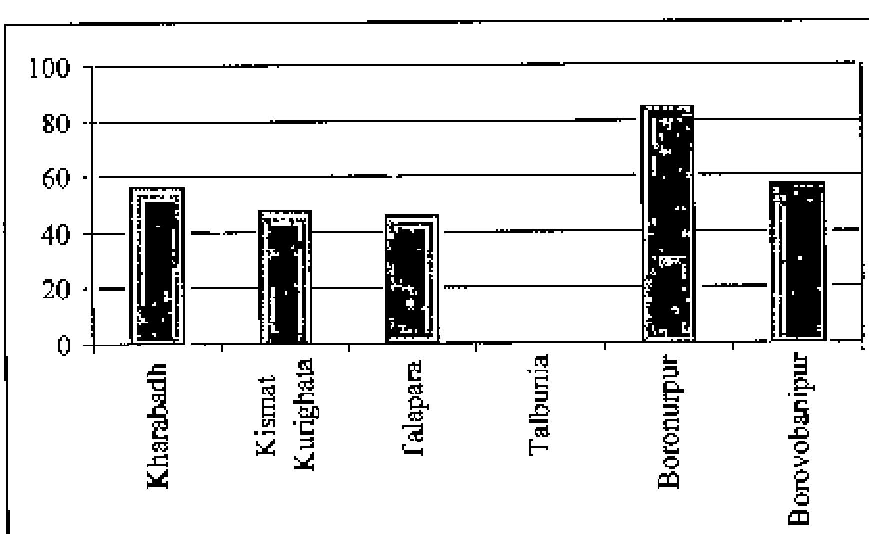


Figure 5.11: Irrigated land in project and control sites.

Although it is very difficult to draw a correlation between water poverty and poverty, the regional poverty indicators may be briefly discussed. Two different approaches are usually used to measure poverty: (i) the Direct Calorie Intake (DCI) method, and (ii) the Cost of Basic Needs (CBN) method. The DCI method measures the calorie intake per capita per day. If this is below 2,122 kcal, it is defined as 'absolute poverty', while 'hard core poverty' refers to a calorie intake less than 1,805 kcal. In the CBN method, poverty lines are calculated based on the per capita expenditure required to meet the basic needs plus an allowance for non-food consumption. The 'lower poverty line' adds an amount equal to the typical non-food expenditure of households whose total expenditure is equal to the food poverty line. The 'upper poverty line' adds an amount equal to the typical non-food expenditure of households whose food expenditure is equal to the food poverty line. BBS and WFP (2004) report that in Khulna 31-37 % people in the subproject live below poverty line and in Rajbari 0-25% people in the subproject live below poverty line. This poverty situation is shown in the following Table 5.38. Comparison of the poverty situation with WPI in Table 5.39 shows that people in the Narayankhali subproject are better in terms of WPI although their poverty level is lower. On the other hand in Boronurpur subproject, WPI is lower than the poverty score.

Table 5.38: Scores on poverty status.

Percentage of people live below poverty Line	Score
0-25%	100
25-31%	75
31-37%	50
37-55%	25

(Source: BBS and WFP, 2004).

Table 5.39: Poverty status and WPI in different subprojects.

	WPI	Average WPI	Poverty Score
Khulna		-	50
Kharabadh	55		
Kismat Kurighata	55	56	-
Talapara	58		
Rajbari		-	100
Boronupur	60	60	-

5.5 Issues Within the Sub-projects that Need Attention

The pentagram in Figure 5.12 shows that 'Resource' remained unchanged whereas 'Access', 'Capacity', 'Use' and 'Environment' has changed because of implementation of the Narayankhali subproject.

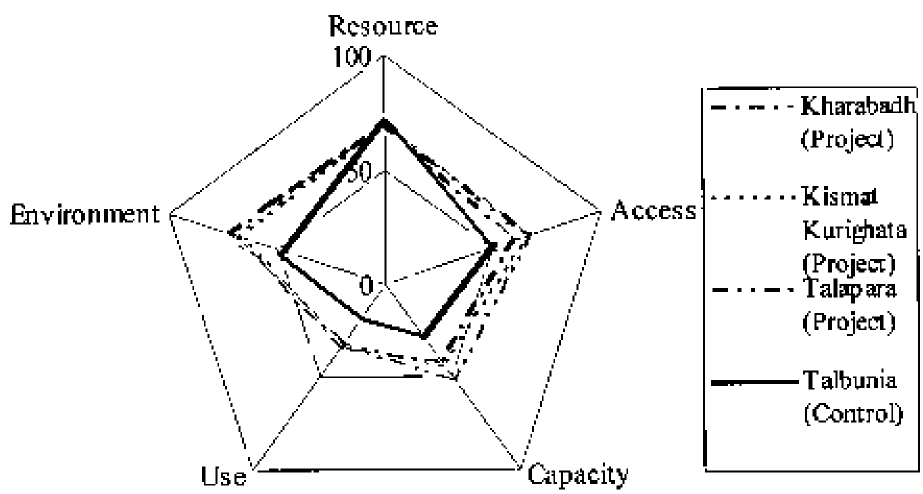


Figure 5.12: WPI component scores in Narayankhali subproject.

Although irrigation was not the main focus of the FCD subproject, irrigation has increased due to salinity protection. However. the 'Access' component score did not change much because of the lack of access to safe water and sanitation and, existing conflicts in water use. 'Capacity' score has increased more than 'Access' but it can be increased more by giving more attention to education. The 'Use' score has increased less than the other component scores of WPI. So, there is scope for improvement in homestead gardening and livestock water use. The 'Environment' score has also improved due to project implementation. Environment component can be further improved. Farmers can be trained up on environmental impact of excessive use of chemical fertilizer and pesticides, manufacturing of organic fertilizer, and integrated pesticides management. The demographic pattern in the project and control sites in (Table 5.37) indicates that about half of the villagers are women, but their participation in WMCA is low so their participation in WMCA should be increased. Because women play a major role in our domestic water use and homestead irrigation. Their involvement in the WMCA will improve the access of water for homestead gardening and other problems which women face to collect drinking water. In WMCA households who are not farming can also be involved. It will encourage them in agricultural activities and they can also suggest how they can be benefited from the project. For Households who are negatively affected by the project can also include in the WMCA to create alternative employment opportunities for them.

Table 5.40: Demographic characteristics in the project and control sites.

Subproject		Village	Men	Women	Total	% of Women
Narayankhali	Project Site	Kharabadh	143	138	281	49
		Kismat Kurighata	45	26	72	36
		Talapara	35	34	69	49
	Control Site	Talbunia	72	64	136	47
Boronurpur	Project Site	Boronupur	109	117	226	52
	Control Site	Borovobanipur	76	75	151	50

So to increase their capacity they should be trained up about effective use of water and to increase their agricultural activities some steps can be taken to provide them loan for agricultural and livestock use. Conflicts in water use and the head-tail inequity can be resolved to improve the 'Use' component.

In case of Boronurpur subproject also the 'Resource' component has not changed significantly. While the 'Access' component has changed slightly. The 'Capacity' component has changed more than the other components. The 'Use' and 'Environment' components have changed moderately. This indicates that further attention needs to be given to 'Capacity' and 'Environment' components. There is a scope to increase the capacity by improving education. Some steps can also be taken to improve the environmental condition. Farmers' capacity particularly needs to develop in efficient use of water in dry season.

To improve 'Capacity' component, educational programs and skill development trainings can be arranged to generate income and employment opportunities. Some work can be done on the 'Access' component can be improved by resolving conflict among water users.

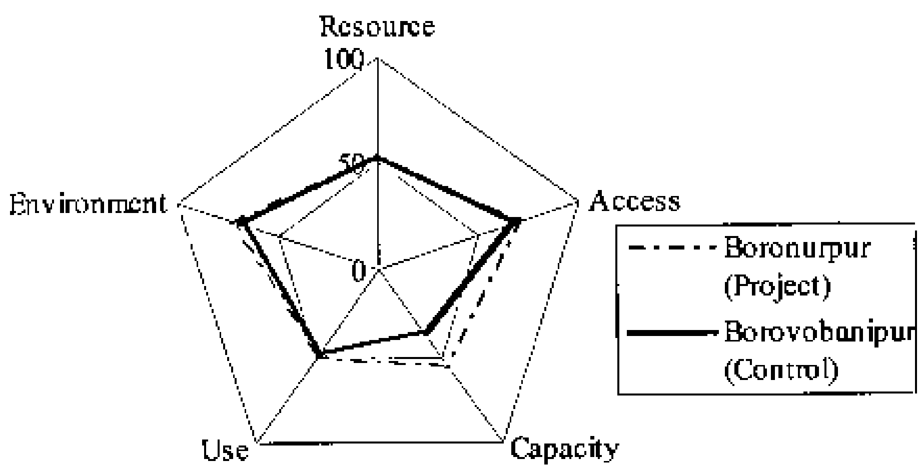


Figure 5.13: WPI component scores in the Boronurpur subproject.

Generating alternative livelihood opportunities for those who are losing during the process of conflict resolution may improve the 'Capacity' component. To improve the 'Environment' component, steps should be taken to solve water quality problems with both irrigation and drinking water. Farmers can be trained up for using organic fertilizer and integrated pesticide management.

Chapter Six
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study assessed the water poverty status in two selected small-scale water resources development subproject of LGED based on a Water Poverty Index. Five components: Resource, Access, Capacity, Use and Environment, were scored based on evaluation of their sub- components from field investigation and secondary data. Specific conclusions of the study are summarized below:

In both study sites, the 'Resource' component score at the project site is similar to that at the control sites, indicating insignificant impact of project implementation on the resources. The most important impacts of project implementation are found to be on 'Capacity' and 'Use' components. In Narayankhali FCD subproject, the Access, Capacity, Use and Environment component scores have improved more than those in the Boronurpur WC subproject, indicating better improvement in water poverty in Narayankhali subproject. The overall WPI has improved by about 30% and 9% in the Narayankhali and Boronurpur subprojects, respectively. The overall 'Capacity' has improved due to increased agricultural productivity and employment opportunities for the poor and marginal farmers, although the capacity of the fisher folks have been reduced because of livelihood losses. The 'Environment' has increased indicating households' more dependence on fish.

The WPI provides a means to identify the areas where more attention is needed from water management perspective. This study indicates that more attention is needed to improve the access to safe water and sanitation, reduce existing conflicts in water use, and increase homestead gardening. The 'Capacity' can be improved by giving more attention to education, and increasing women's participation in WMCA. There is a potential to increase the livestock water use in both subproject sites. The 'Environment' component can be improved by training farmers on environmental impact of excessive use of chemical fertilizer and pesticides, manufacturing of organic fertilizer, and integrated pesticides management.

6.2 Recommendations

Based on the present study, the following recommendations are made:

- Further study should be conducted on other types of small-scale water resources subprojects. Also, a research can be conducted to determine the ways in which the WPI components can be improved.
- WPI structure may be considered for feasibility study and project monitoring of LGED.
- Component or sub-component selection should be field oriented or participatory.
- Weightage selection of WPI components can be done by FGD, etc.

REFERENCES

ADB (2004), "Poverty and Water Security Understanding How Water Affects the Poor", Asian Development Bank.

Ahmed, M.F. and Rahman, M.M. (2003), "Water Supply and Sanitation", ITN-Bangladesh, Centre for Water Supply and Waste Management, BUET, Dhaka. Page 327.

BBS and WFP (2004), 'Poverty Map - Proportion of population below the lower poverty line', Bangladesh Bureau of Statistics, Dhaka.

BUET-BIDS-Delft Hydraulics (2003), "Small-Scale Water Resources Development Sector Project-I, External Evaluation", Final Report, Local Govt. Engineering Department, Govt. of the People's Republic of Bangladesh.

CEH (2007), "Using the Water Poverty Index to Monitor Progress in the Water Sector", http://www.ceh.ac.uk, Centre for Ecology and Hydrology, Wallingford, UK.

Heidecke, C. (2006), "Development and Evaluation of a Regional Water Poverty Index for Benin", EPT Discussion Paper 145, Environment and Production Technology Division, International Food Policy Research Institute, Washington DC, USA.

Hussain, I., Giordano, M., and Hanjra, M.A. (2004), "Agricultural water and poverty linkages: case studies on large and small systems", Water and Poverty: The Realities, Water for All Publication Series No. 5, Asian Development Bank.

IMF (2005), "Bangladesh: Unlocking the Potential, National Strategy for Accelerated Poverty Reduction", General Economics Division, Planning Commission, Government of People's Republic of Bangladesh, IMF Country Report No. 05/410,International Monetary Fund, Washington, D.C.

Lawrence, P., Meigh. J., and Sullivan, C.A. (2002), "The Water Poverty Index: An International Comparison", Keele Economic Research Papers, Department of Economics, Keele University, Staffordshire, UK.

LGED (2004), "Pani Shampad Unnayan O Daridra Hrashkoron" (In Bangla), Local Govt. Engineering Department, Govt. of the People's Republic of Bangladesh.

LGED (1997), "Appraisal Report", Small Scale Water Resources Development Sector Project, Narayankhali FCD Sub-project (SP-26), Project Management Office, SSWRDSP, LGED, LGED Bhaban, Sher-E-Bangla Nagar, Agargaon, Dhaka.

LGED (1998), Combined Summary Appraisal Report and Summary IEE Report", Small Scale Water Resources Development Sector Project, Boronurpur Subproject (SP-66), Project Management Office, SSWRDSP, LGED, LGED Bhaban, Sher-E-Bangla Nagar, Agargaon, Dhaka.

Moore, D. and McCabe, G. (1999), "Introduction to the Practice of Statistics (3rd Edition)", New York: W.H. Freeman and Company.

Mujeri, M.K. (1998), "Monitoring Poverty in Bangladesh: Experiences of the Monitoring Adjustment and Poverty (MAP) Project", Paper presented at the Third Annual Meeting on Micro Impacts of Macroeconomic and Adjustment Policies (MIMAP), November 2-6, 1998, Kathmandu, Nepal, International Development Research Centre.

Osmani, S.R. (2003), "Evolving Views on Poverty: Concept, Assessment and Strategy", Poverty and Social Development Paper No. 7/July 2003, Regional and Sustainable Development Department, Asian Development Bank.

Rahman, R. (2004), "Formulation of a Pro-poor Water Sector Strategy", Final Report, Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Dhaka.

Sullivan, C.A., Meigh, J.R., Giocomello, A.M., Fediw, T., Lawrence, P., Samad, M., Mlote, S., Hutton, C., Allan, J.A., Schulze, R.E., Dlamini, D.J.M., Cosgrove, W., Priscoli, J.D., Gleick, P., Smout, I., Cobbling, J., Calow, R., Hunt, C., Hussain, A., Acreman, M.C., King, J., Malomo, S., Tate, E.L., Regan, D.O., Milner, S., and Steyl, I. (2003), "The Water Poverty Index: Development and Application at the Community Scale", Natural Resources Forum 27, Blackwell Publishing, UK.

Sullivan, C.A. (2005), "Method to Develop and Describe Community Level Water Poverty Index Scores", Centre for Ecology and Hydrology (CEH), Wallingford, UK.

Sullivan, C.A. (2002), "Calculating a Water Poverty Index", World Development, Elsevier Science Ltd., Vol. 30, No. 7, pp. 1195-1210.

Sullivan, C.A., Meigh, J., and Fediw, T.S. (2002), "Derivation and Testing of the Water Poverty Index, Phase 1, Volume 1", Centre for Ecology and Hydrology (CEH),

Suphaphiphat, P. (2000), "An Assessment of Poverty Reduction Objective of ADB's Operations in Bangladesh", Report prepared by Bangladesh Resident Mission of the Asian Development Bank as part of its Economic and Sector Work Program, Dhaka.

Thapa, G. (2004). "Rural Poverty Reduction Strategy for South Asia", Paper presented at the International Conference on 'Ten Years of Australian South Asia Research Centre', Australian National University Canberra, 27-28 April 2004, International Fund for Agricultural Development, Rome.

UNESCO (2003), "The UN World Water Development Report: Water for people, water for life". World Water Assessment Programme, UNESCO.

World Bank (2001), "World Development Indicators". World Bank.

World Bank (1992), "World Development Report", Oxford University Press, New York.

World Resouces Institute (1996), "World Resources", Oxford University Press, New York.

APPENDIX A
Questionnaire for Household Survey

Water Poverty Status in Selected Small Scale Water Resources Development Sector Projects in Bangladesh

Sl. No. Name of the subproject:

Date:

Sec-A. General Information

1. Identification of the respondent:

Sl. No.		
Name of the Head of the Household		
Gender	Male	
	Female	
Name of Father/Husband		
Occupation	Primary	
	Secondary	
Total HH member		
Total earner		
Land Ownership(Acre)	Own land	
	Borrowed land	
	Within sub-project	
	Outside subproject	
Waterbody(Khal/Beel/ Haor/Baor in Acre))	Own	
	Not Own but Use it	
Address	Holding No.	
	Village	
	Union	
	Upazila	
	District	
Comments		

2. Are you a member of Water Management Cooperative Association in your locality?
   a. Yes b. No

Sec – B. Resource Component

3. Do you get water available for all purposes?
   a. Worst (1) b. Bad (2) c. Average (3) d. Good (4) e. Best (5)
4. If the supply vary-
   a. No variation b. Vary seasonally
5. What about the variation?
   a. Worst (1) b. Bad (2) c. Average (3) d. Good (4) e. Best (5)
6. What is the quality of drinking water?
   a. Worst (1) b. Bad (2) c. Average (3) d. Good (4) e. Best (5)

Sec – C. Access Component

7. Who collect water?
   a. Man b. Woman c. Children d. Other e. N/A
8. Have you access to sanitation?
   a. Yes b. No
9. Amount of land irrigated to total arable land (in acre)
   ....
10. Do you irrigate your gardens (even with buckets)?
    a. Yes b. No
11. Are there any conflict regarding water use?
    a. Never (1) b. Sometimes (2) c. Many (3) d. Daily (4)
12. Do you have access to tube well (deep tube-well / safe shallow tube-well / Govt. Tube well)
    a. Yes b. No

Sec – D. Capacity Component

13. Household member (number) completing education up to
    b) Primary level .... c) Secondary level ....
    d) Higher Secondary level....................................
14. Number of children dying aged under five in your household?
    ....
15. Did you face any type of illness related with water?
    a. Yes b. No
16. Financial status of household in terms of
    a. livestock holdings (..)
    b. Land...c.Tree......................
    d.House................. e.Pond.......... f.Bamboo cluster........
    c. ownership of key items: like radio, bicycle, television, freeze, non-thatched roof, watch, factory made furniture, etc.
    others..
17. Any member of your family employed more than 6 months per year.
    a. Yes ....(Number) b. No
18. Any member of your family earning with wage or pensions or income by selling farm products or craft products.
    a. Yes ....(Number) b. No

Sec – E. Use Component

19. How much average water you use for domestic purposes and total number of household in your family (liter/day).
    Amount and person………………………………………………
20. How much water you use for industrial purposes other than domestic, agriculture or livestock.
    Amount…………………………………………….(liter)
21. How much water you use for irrigation purposes [area x irrigation depth x time]
    Amount…………………………………………….(liter)

Sec – F. Environment Component

22. Do you face erosion on your land?
    a) Yes b) No

23. Household report using wildlife (and or fish) for their own use and their opinion
    a) Yes b) No

If the availability of these has decreased over the last 5 years
    a) Increased b) Decreased

24. Have you lost crop during last 5 years?
    a) Yes b) No

APPENDIX B
Checklist for Focus Group Discussion

Water Poverty Status in Selected Small Scale Water Resources Development Sector Projects in Bangladesh

1. Name of the WMCA:
2. Address:
   Vill..................Union...............Upazilla..............District..................
3. Occupation: How many of you are:

Farmer	Fisherman	Farming & Others	Service	Others

4. Do you think that water resource that you get from surface and ground water is sufficient and available all time?
5. If it vary then discuss about the variation in different season?
6. What is the quality of Drinking water?
7. What is the status about access to drinking (time spent to collect) water and sanitation and who collect drinking water?
8. What is the capacity status regarding financial, educational, child health status of your community?
9. Different uses of water and rank them on use basis?
10. Are there any conflict among the water users and occupational groups and if it exists all time?
13. State some changes in last five years:
    a. Erosion: % of HHs reporting erosion on their land – from key informants in village, e.g. village leader, extension officer, teacher, sample of farmers
    b. % of households which report using wildlife (and or fish) for their own use and their opinion if the availability of these has decreased over the last 5 years
    c. % of households reporting crop loss during last 5 years

14. State some impact of the water resource project.

APPENDIX C
Community Level Data Requirements for Calculation of Water Poverty Index

C.1 Data Requirement at Community and Small-scale Municipality Level

The WPI is based on a calculation which requires data on water resources, access, capacity to manage, use and environmental impact. Data required depends on the scale of application. According to CEH (2005) the data requirements for application at a community or small scale municipal level are listed below:

RESOURCE

- Amount of water available
- Measure of reliability / variability
- Measure of water quality

ACCESS

- Total Time taken to collect domestic water per household per day (in mins)
- % of water collected by women
- % of households with access to sanitation
- Irrigated agriculture (take total arable area and indicate % irrigated)
- Garden irrigation per household - give % households in community which irrigate their gardens, even with buckets, etc)
- Conflicts reported over water use or access (never = 1, sometimes =2, many = 3, daily = 4)
- % of households with pipe in the house/yard
- % with access to protected water well, borehole with wall or concrete apron, tap, standpipe, etc

CAPACITY

- Education % of household heads completing primary education, % attending any level of secondary schooling, % having any tertiary education
- Health - % of children dying before 5 yrs of age
- Wealth - expressed in terms of livestock holdings, income levels, or ownership of key items (radio, bicycle, television, freeze, non-thatched roof, watch, factory made furniture, etc.)
- Employment - % of households with at least one person employed more than 6 months per year
- Remittances - % of households with wage/pensions

USE

- Domestic use - average liter of water used per household per day and no of persons in household (or average household size for village)
- Industrial use - get quantitative info from local water authority water records, or identify any local industry which need water (e.g. poultry, fish processing, textiles, etc), and national figures for proportion (%) of water used by industry

- Agricultural use - volume of water used for irrigation from water company records or from people's estimates of how much water they use for irrigation – if any
- Livestock - get total number and type of each in village, calculate necessary water consumption

ENVIRONMENT

- Erosion - get % of fields per household which have some erosion – from key informants in village, e.g. village leader, extension officer, teacher, sample of farmers
- Wildlife - % of households which report using wildlife (and or fish) for their own use and their opinion if the availability of these has decreased over the last 10 years
- Vegetation - % of households reporting a reduction in general vegetation cover over last 10 years, % households reporting a decrease in proximity to home of trees for fuel wood
- Rainfall - % of household reporting perceived changes in rainfall (% stating increase and % stating decrease)

C.2 Data Requirement at National Level

CEH (2007) has carried out a national level assessment on WPI to demonstrate the capability of WPI framework to be applied at a range of different scales. Components cores for 147 countries have been identified, using currently available data from published sources, and a calculation of national level WPI scores are made. The data used for component variables are:

Resource

- internal freshwater flows
- external inflows
- population

Access

- access to clean water, as a percentage of population
- access to sanitation, as a percentage of population
- access to irrigation coverage adjusted by per capita water resources

Capacity

- per capita GDP (at purchasing power parity rates)
- under five mortality rate
- educational enrolment rates
- Gini coefficients of income distribution
  (variables from the Human Development Index)

Use

- domestic water use in liters per day
- share of water use by industry and agriculture adjusted by the sector's share of GDP

Environment

- water quality
- water stress (same comments as above)
- environmental regulation and management
- informational capacity
- biodiversity based on threatened species

(variables from the Environmental Sustainability Index)

APPENDIX D
Lookup Table for Applying Weights to the WPI Structure

Local Condition Descriptors			**Variable weights**				
Hydrological condition	Economic condition	National Priorities	R_1	A_1	C_1	U_1	E_1
Very Good	Unsatisfied	Agricultural, Industrial and Social	1	2	2	3	1
Average	Average	Soc	1	2	2	1	1
Very Good	Good	Env & Soc	1	2	2	1	2
Unsatisfied	Unsatisfied	Ind & Ag	1	2	2	2	1

APPENDIX E
Example Calculations for Sub-component Scores

The following sections show examples for calculation of different component and sub-component scores.

E.1 Resource:

In Kharabadh village of Narayankhali FCD subproject, sub-components selected to calculate the resource component score are: availability of rainfall, surface water and groundwater. A score 100 is assigned to the maximum monthly rainfall of 344 mm. Then the scores for other months are calculated proportionately. For example, rainfall amount 207.8 mm in May has a score

$$= \frac{207.8 \times 100}{344} = 60.4$$

E.2 Access:

In Kharabadh, domestic water of 34 households among 51 Households is collected by women. Their percentage is calculated by,

$$\text{\% of households in which water is not collected by women} = \frac{(51-34) \times 100}{51} = 33.3\%$$

It is found that 45 households among 51 households have access to tubewell. Then the percentage of households having access to tubewell is calculated by,

$$\text{\% of households having access to tubewell} = \frac{45 \times 100}{51} = 88.2\%$$

It is found that among 51 households, 40 households have access to sanitation. Then the percentage of households having access to sanitation is calculated by,

$$\text{\% of households having access to sanitation} = \frac{40 \times 100}{51} = 78.4\%$$

For calculating the score of access to irrigation adjusted by climatic characteristics, it is found that one household in village Kharabadh has 1 acre of irrigated land while in that village the minimum irrigated land owned by a household is 0 acre and maximum is 7 acre. Then the score is calculated by (Eqn. 3.4),

$$\text{Sub-component Score} = \frac{X_i - X_{min}}{X_{max} - X_{min}} x100$$

$$= \frac{1-0}{7-0} x100$$

$$= 14.29$$

Where $X_i = 1$, $X_{min} = 0$, and $X_{max} = 7$.

It is found that among 51 households, 7 households have reported conflict in water use. Then the percentage of households not experiencing conflict in water use is calculated by,

$$\text{\% of households not experiencing conflict in water use} = \frac{(51 - 7) \times 100}{51} x100$$

$$= 86.3\%$$

E.3 Capacity

In village Kharabadh, for calculating the household education level, it is found that among 51 households, 11 households have at least one of their family members SSC passed. Then the percentage is calculated by,

$$\text{\% of households having an SSC-passed member} = \frac{11 \times 100}{51}$$

$$= 21.6\%$$

For assigning scores on the basis of wealth status based on items belonging to a household, the total price on the basis of present market price of items like TV, refrigerator, bi-cycle, CD set, cassette, sewing machine, radio, furniture, etc. belonging to the households are calculated. Then a score 100 is assigned to the total price of all items. On the basis of this score, the scores for individual households are assigned as follows:

$$\text{Score} = \frac{\text{Total price of the items belonging to a household x 100}}{\text{Total price of all items in one subproject site}}$$

For example, in Narayankhali subproject, the total price of all items in both project and control sites is 90,000 Taka. Assuming that the score for this price is 100, the score for a household whose total price of items is 8000,

$$\text{Score} = \frac{8000 \times 100}{90000}$$

$$= 9$$

Based on this calculation in village Kharabadh, the total score on wealth status is 578.5 and the total number of household is 51. Then the average wealth status of the households is calculated as:

$$\text{Average houschold wealth status} = \frac{\text{Total score on wealth status of household}}{\text{Total Household number}}$$

$$= \frac{578.5}{51}$$

$$= 11.34$$

Scores for other villages are calculated in the same way.

For calculating the percentage of households not reporting illness related to water, it is found that among 51 households 11 households reported conflict in water use. Therefore,

$$\text{\% of households not reporting illness} = \frac{(51 - 11) \times 100}{51}$$

$$= 78.4\%$$

For calculating household income status, only the number of households who are employed or earning wage or pension or income by farm selling products is calculated. Thus,

$$\text{\% of earning households} = \frac{\text{Total number of households earning from any source} \times 100}{\text{Total number of households}}$$

$$= \frac{24 \times 100}{51}$$

$$= 47.1\%$$

Percentage of households having membership in WMCA is calculated as,

$$\text{\% of households having membership in WMCA} = \frac{\text{Total number of households having membership in WMCA}}{\text{Total number of households}}$$

$$= \frac{23 \times 100}{51}$$

$$= 45\%$$

E.4 Use

In village Kharabadh, for calculating the households' water use for domestic purposes, first average water use per person at different distances is identified and then the number of household is multiplied to get the total use (Ahmed and Rahman, 2003). Thus,

Household's water use = Average water use per person at <50m distance x No. of total members

= 35 x 7 liter

= 245 liter

In Narayanklhali subproject the highest water use is 640 liter. Assuming the lowest water use to be 0 liter, the score of this household is calculated by using Eqn. 3.4,

$$\text{Score} = \frac{245 - 0}{640 - 0} \times 100$$

$$= 38.28$$

In village Kharabadh, based on this calculation the households' total score on water use is 1055.93 and the total number of household is 51. Then the average score on water use of the households is calculated as:

$$\text{Average household water use score for village Kharabadh} = \frac{\text{Total score on water use}}{\text{Total Household number}}$$

$$= \frac{1055.93}{51}$$

$$= 21$$

Scores for other villages are calculated in the same way.

The % of irrigated land in village Kharabadh is calculated as,

$$\text{\% of irrigated land} = \frac{\text{Total irrigated land} \times 100}{\text{Total cultivated land}}$$

$$= \frac{49 \times 100}{87.5}$$

$$= 56\%$$

In village Kharabadh, for calculating the households' livestock water use, first average number of different livestock owned by a household and its water consumption rate is multiplied to get the total livestock water use of a household. For example, in village Kharabadh the livestock water use of a household is calculated by,

Household livestock water use = Average water use per livestock x No. of livestock
= 20 x 1 liter (for Cow)
= 20 liter

Household livestock water use = Average water use per livestock x No. of livestock
= 5 x 3 liter (for Goat)
= 15 liter

Total livestock water use by the household = 20+15 liter = 35 liter.

In Narayanklhali subproject, the highest livestock water use is 160 and lowest is 0. So the score of this household is calculated by using Eqn. 3.4 as,

$$= \frac{35 - 0}{160 - 0} \times 100$$

$$= 21.88$$

Based on this calculation, households' total score on livestock water use is 831.25 and the total number of households is 51. Then the average score on water use of the households is calculated as:

$$\text{Score for livestock water use in Kharabadh} = \frac{\text{Total score on livestock water use}}{\text{Total household number}}$$

$$= \frac{831.25}{51}$$

$$= 16.3$$

E.5 Environment

In village Khrabadh, 16 households among 51 households reported that they depend on wildlife or fish for their own consumption. Therefore,

$$\text{\% of households using wildlife or fish} = \frac{\text{No of households depend on wildlife or fish x 100}}{\text{Total No. of households}}$$

$$= \frac{16 \times 100}{51}$$

$$= 31.37\%$$

Percentage of households reporting crop loss in last five years is calculated as:

$$\text{\% of households reporting crop loss} = \frac{\text{No of households report crop loss x 100}}{\text{Total No. of households}}$$

$$= \frac{6 \times 100}{51}$$

$$= 12\%$$

Percentage of households reporting erosion of their land is calculated as:

$$\text{\% of households reporting erosion} = \frac{\text{No of households report erosion x 100}}{\text{Total No. of households}}$$

$$= \frac{2 \times 100}{51}$$

$$= 4\%$$