EFFECT OF TEESTA BARRAGE PROJECT ON AMAN RICE PRODUCTION

By

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

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Dedicated to My Father
Who Lives in Heaven

ABSTRACT

Although the Teesta Barrage Project (TBP) went into operation in 1993, the full scale supplementary irrigation was provided from 2000. This study was initiated to assess the impact of supplementary irrigation on the expansion of HYV Aman area and yield. The study was based on secondary data on irrigation coverage, HYV Aman area and yield (for both 'within and outside the TBP command area' as well as 'before and after project period'), collected from BWDB and DAE. In order to assess the farmers' perception about supplementary irrigation, FGDs were carried out in 5 out of 12 Upazilas of the TBP.

Although the irrigated area of the TBP has been increasing steadily since 2000 and the maximum irrigated area of 76,000 ha was achieved in 2005, variability in the command area occurs from year to year mainly because of variability of monthly rainfall. The average 'before' project yield has increased marginally from 3.64 t/ha to 3.88 t/ha in the 'after' project condition. The average 'with' and 'without' project' yields are 3.89 t/ha and 3.66 t/ha, respectively. The small increase in yield in TBP implies that the project did not have a significant impact in increasing Aman production as irrigation is one of the many inputs in rice production.

Analyses of variability of yields of Aman show that the 'with project' variability is much less (standard deviations of 0.14 t/ha at Jaldhaka) compared to the 'without project' areas (0.28 and 0.27 t/ha in Diaper and Panchagarh, respectively). This signifies the TBP's impact in stabilizing the yield within the project area. Similarly, comparison of 'with' and 'without' project standard deviation of Aman area shows that the variability is much less in 'with project' areas compared to 'without project'. This implies that the TBP had contributed towards stabilizing the rain-fed Aman area with assured supplementary irrigation.

There is no change in the trend of the total seasonal rainfall. Nevertheless, there is variability in monthly rainfalls that indicate the importance of supplementary irrigation from the TBP in order to stabilize the Aman yield. Supplementary irrigation had a positive impact in increasing the recharge during the Aman season, although further analysis in more areas of the project is necessary in order to reach a conclusion.

In the project area, the farmers have switched from local to high yielding varieties of Aman rice. They reported yield increase and realized irrigation requirement during transplantation and reproductive stages. Nevertheless, they are reluctant to pay irrigation service charge (ISC) during the Aman season. In order to ascertain the study findings, an extensive study is necessary in each of the 12 Upazilas and Upazilas beyond the project area.

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Md. Enamur Rahman

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LIST OF ACRONYMS AND ABBREVIATIONS

A.C.E. Ltd.	Associated Consulting Engineers Limited
ADB	Asian Development Bank
BIDS	Bangladesh Institute of Development Studies
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
DAE	Department of Agriculture Extension
DSSTW	Deep Seated Shallow Tube Well
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
FSL	Full Supply Level
GPWM	Guidelines for Participatory Water Management
ha	Hectare
HYV	High Yielding Variety
IMED	Implementation Monitoring and Evaluation Division
ISC	Irrigation Service Charge
IWFM	Institute of Water and Flood Management
IWM	Institute of Water Modeling
LV	Local Variety
MPO	Master Plan Organization
MS Excel	Microsoft Excel
MT/H	Metric Ton per Hectare
NW	North West
READ	Research Evaluation Associates for Development Limited
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
SWR	Scheme Water Requirement
t/h	Metric Ton per Hectare
TBP	Teesta Barrage Project

Acronyms and Abbreviations continued

Tk.	Taka
UNDP	United Nations Development Programme
WARPO	Water Resources Planning Organization
WMA	Water Management Association
WMF	Water Management Federation
WMG	Water Management Group
WMO	Water Management Organization
WWF	World Water Forum

CHAPTER-1

INTRODUCTION

1.1 Background

Food production is always a crying need and it directly depends on irrigation systems, irrigated lands and other associated factors. However, surface water is the best option to produce more food which would enable the farmers to use cheaper irrigation water that would also be environment-friendly. Moreover, water is becoming an increasingly scarce commodity in Bangladesh because of the high population growth and decreasing arable land. In many cases, supply of irrigation water for their crops is a matter of life and death. However, water increases productivity in the agricultural sector and the cost-effectiveness of irrigation infrastructure are necessary to enhance the reliability of the water supply to the farmers. In fact, difficulties of having access to water frequently determine the position of the poor on the poverty scale (ADB, 2005; Islam and Akmam, 2007).

Irrigation is the artificial application of water to soil to help crop growth and production especially during stress period. Irrigation requirement of a crop refers to the amount of water needed to be applied as irrigation to supplement the water received through rainfall and soil profile contribution in meeting the water needs of the crop for optimum growth and yield. In a sub-tropical country like Bangladesh, where the natural rainfall occurs mainly during the monsoon season from June to September, irrigation is essential for the proper growth of plants due to erratic rainfall distribution. The crop damage from drought is many times higher than the damage from flood (MPO, 1987).

Supplementary irrigation can be defined as the addition of small amounts of water to essentially rainfed crops during times when rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields. Supplementary irrigation in areas with limited water resources is based on the three premises: 1) water is applied to a rainfed crop, which would normally produce some yield without irrigation, 2) since precipitation is the principal source of moisture for rainfed crops, supplementary irrigation is only applied when precipitation fails to provide essential moisture for improved and stabilized production, and 3) the amount and timing of supplementary irrigation are not scheduled to provide moisture-stress-free conditions throughout the growing season, but to ensure that the minimum amount of water required for optimal (not maximum) yield is available during the critical stages of crop growth. Supplementary irrigation is the opposite of full or conventional irrigation. In the latter, the principal source of moisture is fully controlled irrigation water, and highly variable limited precipitation is only supplementary.

Supplementary irrigation is dependent on the precipitation, which is the basic source of water for the crop. Water for supplementary irrigation comes mainly from surface sources, but shallow groundwater aquifers increasingly are being used. Among non-conventional water resources that have potential for the future, such as treated sewage water harvesting is also important.

A vast area of north-Bangladesh suffers from scarcity of water for irrigating its agricultural land, not only in the dry months but also in Kharif-2 season i.e. during the earlier and late monsoon season when prolonged spell of scarcity or no rainfall affects the crops' growth. In order to cope with this scarcity and considering suitable regional topography and landscape/geomorphology, the idea of gravity irrigation with water from the Teesta River was conceived since British period (1945). The preliminary feasibility report of the project was prepared in 1960 by M/s.Haigh Zinn and Associates in collaboration with A.C.E.Ltd. M/s.Binnie and Partners Ltd. prepared the revised feasibility report during 1968-70 (BWDB, 1985).

After independence of Bangladesh and under the changed circumstances of increased demand for food from ever decreasing arable land, the engineers of BWDB and BUET reviewed the previous reports and conducted fresh survey, investigation, planning and detailed engineering. The site of the Barrage was selected at Doani where the present Teesta Barrage proudly stands today (BWDB and BUET, 1989).

The Teesta Barrage Project (TBP) is bounded by the Teesta River on the North, the Atrai River on the West, Shantahar- Bogra Railway line on the South and Bogra-Kaunia Railway line on the East. The command area of the project is 750,000 ha and the irrigable area is 540,000 ha. Although the implementation of the project started in 1960, the actual construction of the Barrage was taken up in 1979 and that of the canal system in 1984-85. A location map of the project area is shown in Figure 1.1.

To derive the early benefits, the project has been phased out viz. Phase –I and Phase-II. The Phase –I has a command area of 154,250 ha with a net irrigable area of 111,406 ha. It is extended over twelve Upazilas namely Nilphamari, Dimla, Jaldhaka, Kishoregonj, Saidpur, Rangpur, Taraganj, Badarganj, Gangachara, Parbatipur, Chirir-bandar, and Khanshama. The project comprises of a barrage, flood embankment, flood by pass, silt trap, main canal and part of canal system with improvement of existing drainage canals.

After phasing out of project, the phase-I was declared completed in June 1980 covering a gross benefit area of 154,190 ha with net irrigable area of 111,363 ha. Yet, irrigation had been started from January, 1993 in the upper reach where canals were ready with cross drainage structure in place and 6,500 ha of land was irrigated during the Kharif I and Aman seasons in that year. The command area of the project has been progressively increased and in 2005 the maximum irrigated area was 76000 ha during the Aman season.

In the Teesta Barrage Project (TBP) area, seed to seed duration of Aman crop is from mid-June to mid- November. July to September is the period of water requirement of Aman crop when sufficient rainfall generally occurs. After the cessation of rainy season, i.e. in the month of September if drought hampers the Aman crop during booting stage, the yield decreases. Again, in the month of October flowering, pollination, and seed initiation (milk stage) occur. If there is drought in this month then yield decreases drastically. Besides, during seedbed and transplanting period sometimes no rainfall occurs, therefore, these activities are belated. Sometimes, even during the July- October period, droughts occur and affect the yield. All these problems could be solved by supplementary irrigation from the TBP.

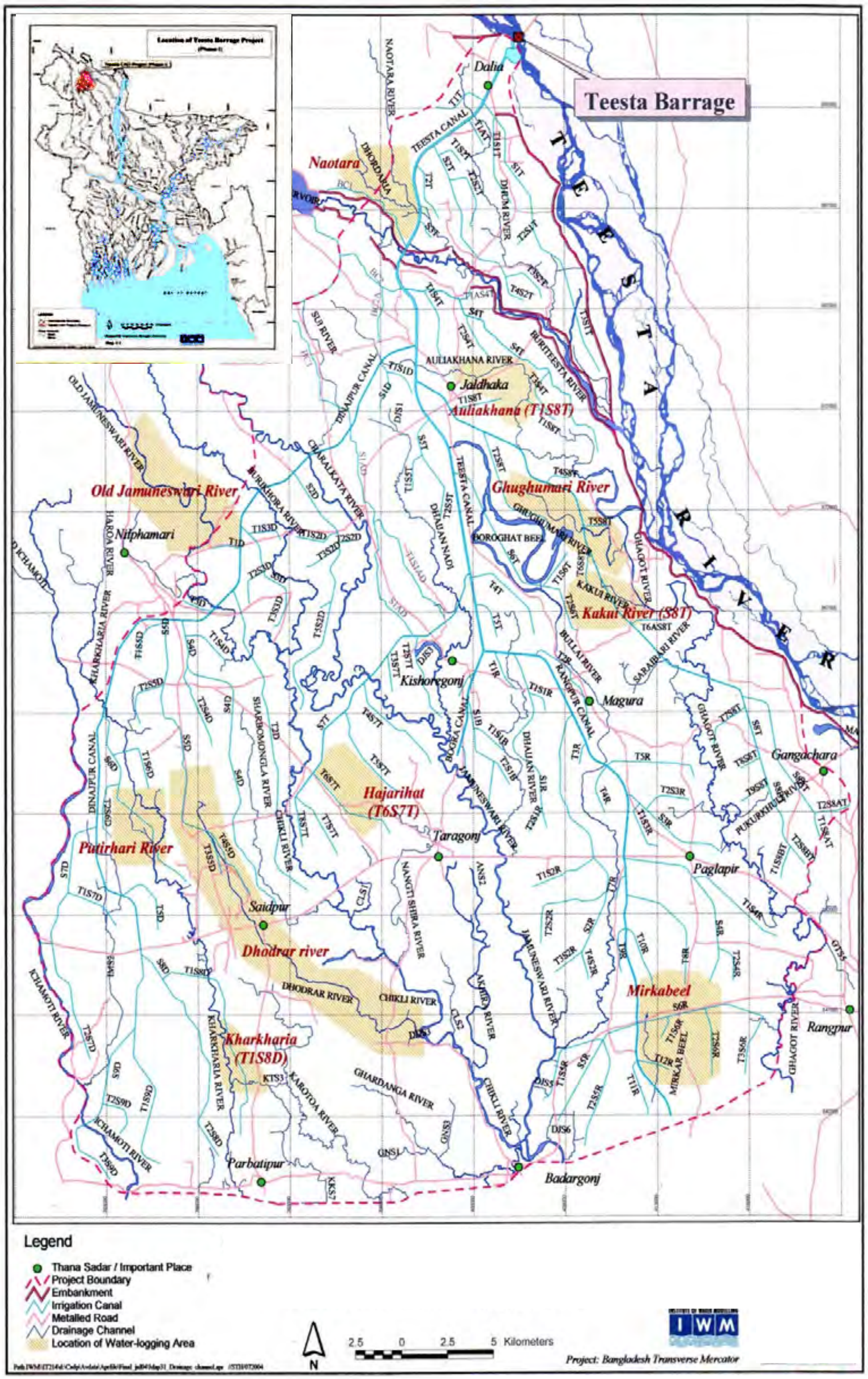

Figure 1.1: Location map of the project Area.

Now, with full effort, the TBP has been in operation for more than 10 years. It has become imperative to assess the performance of the project in terms of meeting its main objective of increasing the agricultural productivity.

1.2 Study Objectives

The aim of this study is to evaluate the performance of the TBP in increasing the production of Aman rice. It should be emphasized here that due to time and budget constraints, a rigorous, holistic, and extensive performance analysis was beyond the scope of this study.

The specific objectives of this study are to:

(1) Assess the impact of the TBP on Aman rice production, and

(2) Assess the farmers' perception on supplementary irrigation.

The study is expected to reveal the impact of supplementary irrigation on Aman rice production in the Teesta Barrage Project area.

CHAPTER-2

REVIEW OF LITERATURE

In order to study the impacts of the Teesta Barrage Project (TBP) and also to make the observation realistic, reliable and logical, several literatures compatible with the present study of pre and post project research works were collected, reviewed and cited. A summary of the review is presented below.

The earliest feasibility study on construction of a barrage and irrigation command area development based on the Teesta River was carried out by Haig-Zinn and Associates in 1959. In 1968, Binnie and Partners carried out a comprehensive feasibility study on the Teesta Barrage Project. The consultant reported uncertainties in water availability and crop water requirement due to short period of time series data on river discharge, rainfall and traditional cropping pattern (BWDB, 1985).

The first extensive study on the planning and design of irrigation and drainage system of the TBP was carried out by BWDB and BUET (1989). It was observed that out of the net command area of 0.54 million ha (M ha), the area that could be irrigated with the available supply of the Teesta River amounted to only about 0.23 M ha. Increasing the water availability to bring the possible command area of the project under irrigation was a matter of great concern for BWDB. Options for augmenting the flow (by using the flow of the internal rivers, crop staggering etc.) were reviewed.

To increase the water availability in the TBP and to reduce the land acquisition requirement for canal construction, Saleh et. al. (1991) assessed the seepage loss in the project area and then recommended a feasible and cost effective lining for reducing the seepage loss. They found that the average seepage rate of the soils in the project area varied from 0.5m/day to 1.00 m/day. Considering the economic feasibility, Saleh et. al. (1991) concluded that cast in situ concrete lining is the most cost effective lining thus; they recommended it for applying in the Teesta Barrage Project.

Hoque et al. (2000) observed that many surface water irrigation projects do not receive irrigation water because of shortage of water, and as a result, areas of these projects remain fallow. These projects essentially demand for alternative sources of water during the Rabi season and sometimes also during the Kharif- II season. Their studies and evaluation indicate that there is an opportunity for the use of groundwater along with the surface water in all cropping seasons. They pointed out that there is a great potential for the development of groundwater resources within the Buri Teesta Irrigation Project. It is further believed that the experience in Buri Teesta in respect of conjunctive use of surface water and groundwater will benefit the Teesta project in particular and Bangladesh as a whole.

Wahid (2003) observed that groundwater development and utilization for dry season irrigation in the TBP area by farmers has led to near-unrestricted exploitation of the resource in the recent past, which necessitates a comprehensive effort to assess the available groundwater resource and its development potential. He noticed that groundwater-use potential varies considerably from Thana to Thana over the TBP area and the overall increase in groundwater-use potential in the TBP area is due to good prospects in a few Thanas only. He recommended zoning of the TBP area into different groundwater management classes based on use potential.

Islam et al. (2004) observed that expansion of cropped area and use of HYV rice in the TBP have contributed to labor demand which increased wage rate by 24.5% and also increased purchasing power of landless households. They investigated that Teesta River water reduced the irrigation cost by one-fifth. They calculated that increase in rice yield level together with the decrease in irrigation cost, has doubled the farm income. They further studied that the present flow in the Teesta River is inadequate to meet the present irrigation requirement, while the fluctuation in the flow rate affects directly the availability of water in the TBP area. They monitored that the irrigation water availability from the Teesta River has always been less than planned and the unilateral upstream withdrawal of the Teesta water by India limits irrigation water availability in the TBP area, which leads to suspension of irrigation programs during the dry season in a significant area.

Alam and Kabir (2004) pointed out that India's National Perspective Plan of 1980 proposes to develop projects for Inter-basin water transfer by linking rivers with a massive canal system. They concluded that when implemented, this plan would cut down the flow of the rivers that flow into Bangladesh. This will adversely affect agricultural production, fishery, ecology, navigation, and bio-diversity. They revealed that reduction of flow of the Teesta and other rivers in the NW region would adversely affect the agriculture, groundwater resource, navigation, industry, wetlands, and forestry in the NW region.

IWM (2004) made a detailed study on command area development of the Teesta Barrage Project, and articulated that due to scarcity of water in the Teesta River during dry period, farmers have to rely mostly on groundwater, which is costly and in some areas of the project, the groundwater level is nearly at mining state. In some areas, hand tubewell goes out of order due to lowering of groundwater level. IWM (2004) reiterated that the Teesta Barrage Project has been planned and implemented to provide primarily supplementary irrigation for transplanted Aman. The observation of the institute is that the cropping pattern and cropping intensity have changed remarkably in the irrigated area. Farmers have started to grow HYV Aman rice and at least two crops are grown in the irrigated area. After implementation of the TBP, the irrigation coverage has been increasing gradually.

Islam and Akmam (2007) studied the changes in socio-economic and environmental situations in the TBP during 2000-2007. In their study, they highlighted changes in socio-economic and environmental situations in the Dalia irrigation project (actually the TBP) area during 2000-2007. They carried out a socio-economic survey in 2000. In 2007, they carried out another follow-up survey in the same area. Based on a social survey, they pointed out that although the average yearly income in the project area increased by about 151%, dependency on agriculture decreased from 63% to 53% with no change in the cropping intensity. They found that some improvements have occurred among the inhabitants regarding education, housing, health, and sanitation.

An evaluation study of the TBP was carried out by IMED of the Ministry of Planning (IMED, 2008) and it was reported that in TBP, the single cropped area reduced by 100%, double-cropped area comprised of 84% and triple-cropped area comprised of 16% of the total cropped area. Cropping intensity increased to 233% in the year 2007. HYV Aman area increased in comparison to Local variety (LV) after intervention of TBP. HYV Aman area was increased by 45% whereas there has been a 54.8% decrease in local variety (LV) of Aman crop areas. Aman crop annual production significantly increased in all Upazilas under study area. It was clear that the reasons of increased crop production are due to introduction of HYV crop and TBP water as well as flood control. The mean monthly family income, before and after the project, has registered an increment of 73% and the benefit of increased income has been obtained by people belonging to poor and lower middle class. The study reported that there is scarcity of water during the dry season and only about 30% of the Kharif- II season irrigated area can come under irrigation during the Kharif-I (late Boro / early Aus) season.

Moshiur (2008) in his study on the impact of climate change on command area development of TBP found out that due to the climate change the crop water requirement for T. Aman in TBP would increase in the future projections (2025 to 2050) from that of the base line period (1990). From the analysis of rainfall data, he noticed that due to the climate change the amount of rainfall during the T. Aman season would decrease or increase depending upon the type of model used. During the critical period of crop growth (October), the monthly average rainfall may decrease. He moreover noticed that due to climate change the future flow of the Teesta River at Dalia would also decrease during the critical period of October compared to the observed baseline condition. Therefore, he predicted that during the entire critical period of October, the TBP might face problem to meet the future water requirement due to unavailability of sufficient flow in the Teesta River.

Ali et al. (2009) worked on the improvement of drainage condition for proper operation of irrigation and drainage system in the Teesta Barrage Project and found out that there is drainage congestion in several places inside the project area. They observed that the new road network and canal dykes interrupt the natural overland drainage pattern of the study area. They also noticed that no proper annual maintenance are being practiced to clean the siphon for functioning with full capacity, which results in blockage of the siphon to some extent and creates drainage congestions at the upstream of different structures.

Hossain (2010) discussed the benefits of using the modelling tools for optimum utilization of water resources in irrigation and drainage management of command area development projects.

In the Teesta Barrage Project (TBP), he observed that during Kharif-II season, the full supply levels (FSL) could not be achieved in a dynamic head for the required water flow in both the Teesta and the Rangpur main canals. He found, the reason behind this is that these canals were designed for larger flow to cover the areas of both phases (Phase-I & II). FSL was also not achieved during Rabi and Kharif-I as the water flow was not optimal in the Teesta. After modelling study he stated that to achieve FSL and required flow in the canal system, some interventions are required. TBP phase-I is now flood free and the annual return from paddy in that area is about Tk. 300.0 crore. He concluded that the effectiveness of the modelling tool has proven to be convenient as well as an asset for assessing quantitative measures.

Bari et al. (undated) worked on ‘Role of Remote Sensing Technology on Monitoring Large Irrigation Project in North Bangladesh’. They concluded that to monitor the gigantic Teesta Barrage Project, it is best to apply the remote sensing technology.

Higano et al. (undated) worked on rural poverty alleviation through large-scale irrigation planning and observed that due to the operation of the Gazoldoba Barrage (India), the water flow of the Teesta River decreased significantly, threatening the Teesta Irrigation Project. Exclusive control of Teesta’s water in the dry season and sudden release of excessive water through the barrage (India) in the rainy season lead to serious sufferings of the people in the Bangladesh area of the basin. Finally they propose some remedial measures to solve the problem of sharing of the Teesta water, especially during the dry season between India and Bangladesh (like establishment of basin-wise sharing criteria, storing of monsoon flow etc.) and also some other proposals regarding water management and control during rainy season (integrated water management).

Sarker et al. (2011) studied the change in microclimate in surrounding the TBP area due to irrigation. They observed that after implementation of the Teesta Irrigation Project, the percentage of mean annual rainfall is increased in Dalia, Kaunia, Nilphamari, Lalmonirhat, and Rangpur stations. They also observed that the humidity has increased all over the year, except in January and the amount of evaporation has increased, except in April, after implementation of the Teesta Irrigation Project.

CHAPTER-3

METHODOLOGY

3.1 Introduction

The Teesta Barrage Project (TBP) is extended over 12 Upazilas, namely, Nilphamari Sadar, Dimla, Jaldhaka, Kishoregonj, Saidpur, Rangpur Sadar, Taraganj, Badarganj, Gangachara, Parbatipur, Chirir-bandar and Khanshama under 4 BWDB divisions of Rangpur, Nilphamari, Saidpur and Dalia. According to administrative unit, these 4 BWDB divisions belong to 3 administrative districts. Rangpur BWDB division is in Rangpur district and covers Rangpur Sadar, Taraganj, Badarganj, and Gangachara Upazilas. Nilphamari, Saidpur and Dalia BWDB divisions are in Nilphamari district which covers Nilphamari Sadar, Dimla, Jaldhaka, Kishoregonj and Saidpur Upazilas. Parbatipur, Chirirbandar and Khanshama Upazilas of Dinajpur district cover a small area of TBP and are distributed among BWDB divisions of Saidpur, Nilphamari and Rangpur.

The evaluation of the impacts of TBP on Aman production was based on secondary data. On the other hand, the assessments of the farmers' perception about the project and on supplementary irrigation were carried out through focus group discussions. The details of the primary and secondary data collected and the analyses carried out are presented in the following sections.

3.2 Primary Data

The primary data have been collected from the study area through six focus group discussions (FGDs) at Dalia, Horichandrapat in Jaldhaka, Nilphamari Sadar, Kishoreganj, Saidpur, and at Mominpur in Rangpur Sadar. All the locations are within the TBP area. All the FGDs were held in the month of July 2011. In each of the FGDs, 10 to 12 members were selected from 3 to 4 water management groups (WMG). Water management group (WMG) is the organization of the local stakeholders at the lowest level for each smallest hydrological unit or social unit (para / village) and it is a primary tier of water management organization

(WMO). Water management organization (WMO) is the common name of organization of local stakeholders of the TBP like other water resource projects. From the group discussions, information was collected about the pre and post project varieties of Aman crop cultivation, their yields, yield variation, and causes of yield variation, availability, and adequacy of irrigation water.

Additionally, some selected issues were discussed in the meeting to assemble in-depth information on concepts and perceptions of the grouped people. The selected issues are about when and how many times to irrigate in the HYV Aman paddy field, what are the irrigation constraints, information on irrigation service charge, and the importance of the TBP. All the primary data are gathered and expressed in descriptive manner.

3.3 Secondary Data

Indispensable secondary data were collected from published reports, journals, booklets etc. as well as from the office records of Bangladesh Water Development Board (BWDB), Institute of Water Modeling (IWM), and Department of Agriculture Extension (DAE). The secondary data collected from these offices were before and after project as well as with and without project irrigated area, HYV Aman area, HYV Aman production, yields, monthly rainfall, and ground water level.

3.4 Data Analysis

Both with and without project, and before and after project scenarios were assessed on the effects of the TBP on Aman production. In with and without project condition, the comparisons were made on the benefits of the project. For assessing the without project condition, districts and upazilas surrounding the project area were selected. For this study, Dinajpur and Panchagarh districts were selected as without the project condition. In the Rangpur district, four Upazilas are within the project area and they are Rangpur Sadar, Gangachara, Badarganj, and Taraganj. On the other hand, Kaunia, Pirgacha, Mithapukur, and Pirganj upazillas of Rangpur district are without the project area and these four Upazilas were selected for assessing the without project condition.

Trend analysis on different development criteria were evaluated in before and after project condition. Although, officially the supplementary irrigation was started in the TBP area from 1993, however, the actual supplementary irrigation was provided from 2000. Therefore, data from 2000 and onward were considered as the after project condition, and data before 2000 and earlier period were taken into account as the before project condition.

The data were then tabulated, processed, and analyzed using standard spreadsheet software (MS Excel). The analyzed data were shown in figures, and in tables, as and wherever required. The mean value, standard deviation, linear trend line, correlation coefficient and the level of significance were also determined for better interpretation of the results. The level of significance was determined using standard tables (Gomez and Gomez, 1984).

3.5 Limitations of the Study

The study findings (especially the yields) are based on secondary data collected from BWDB and DAE and primary data collected through FGDs from only 5 Upazilas out of 12 Upazilas. As such, in order to ascertain the study findings, an extensive study in each of the 12 Upazilas and Upazilas outside project area is needed.

CHAPTER-4

RESULTS AND DISCUSSION

The impact of supplementary irrigation from the Teesta Barrage Project (TBP) on the development of the TBP irrigated area, HYV Aman area, and yields are presented in the following sections. The secondary impacts of the TBP on the groundwater level and the farmers' perception on the impacts of the project are also discussed.

4.1 Impact on Irrigated Area

Before the implementation of the TBP in 2000, very little of the project area was irrigated. A plot of irrigated area before and after the project is shown in Figure 4.1.

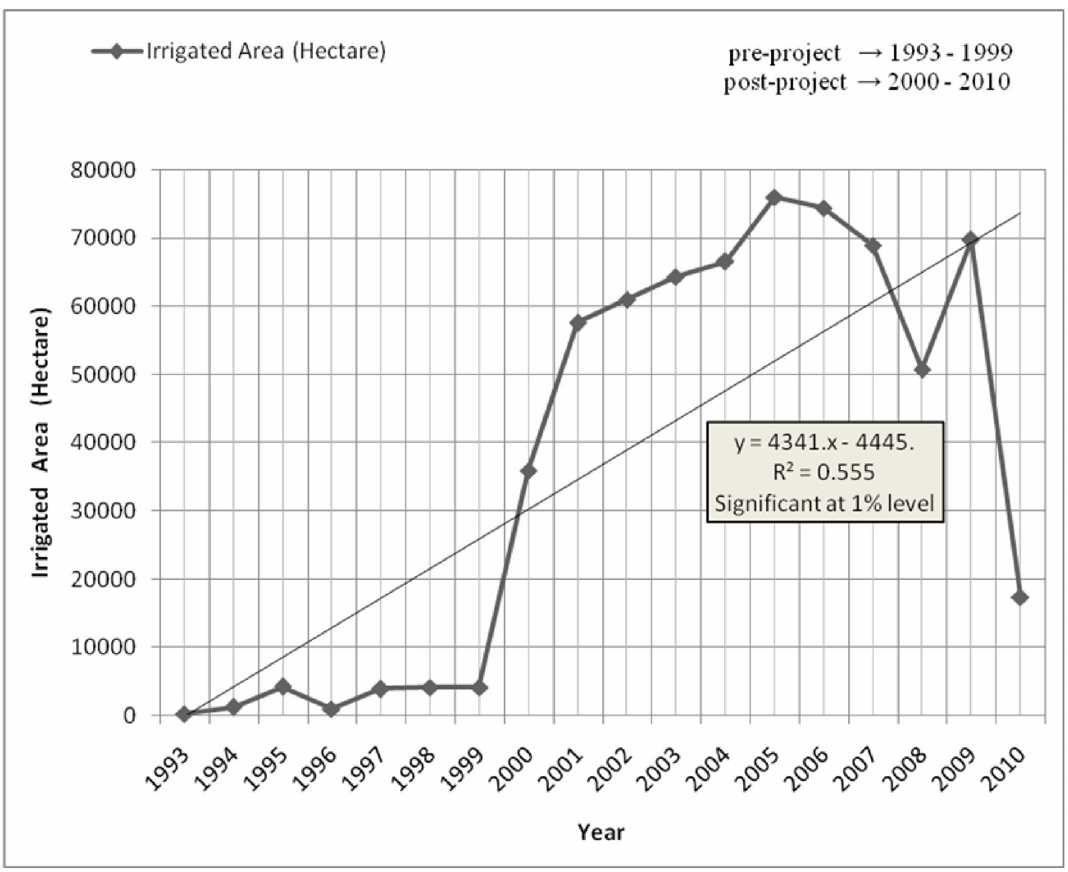

Figure 4.1. Teesta Barrage Project Irrigated Area from 1993 to 2010.

From the above figure it can be seen that irrigation started from 1993 in the upper reaches of the Teesta main canal (Dalia division), where canals were ready for conveying irrigation water in the Aman (Kharif-II) season. But the actual irrigation to the whole the TBP was started from 2000. From 2000 onward, there has been a steady rise in the irrigated area, although variations may be observed from year to year. The main reason for the variation in area is due to variability in rainfall. When there was timely and sufficient rainfall, the command area did not increase and sometimes even decreased to some extent (as in 2008 and 2010) from the previous year. Field officers of the TBP informed that during the Aman season of 2010 the rainfall was timely and sufficient in amount. Consequently, less irrigation was required and the TBP irrigated area was reduced.

Figure 4.2 reveals the development of irrigation among the four BWDB divisions; Saidpur, Nilphamari, Dalia and Rangpur. The figure shows that among the four divisions, Saidpur has the highest irrigated area, followed by Nilphamari. As Rangpur division is comparatively far away than other divisions, the irrigated area increased gradually in the division with the development of the canal system. The maximum irrigated area was

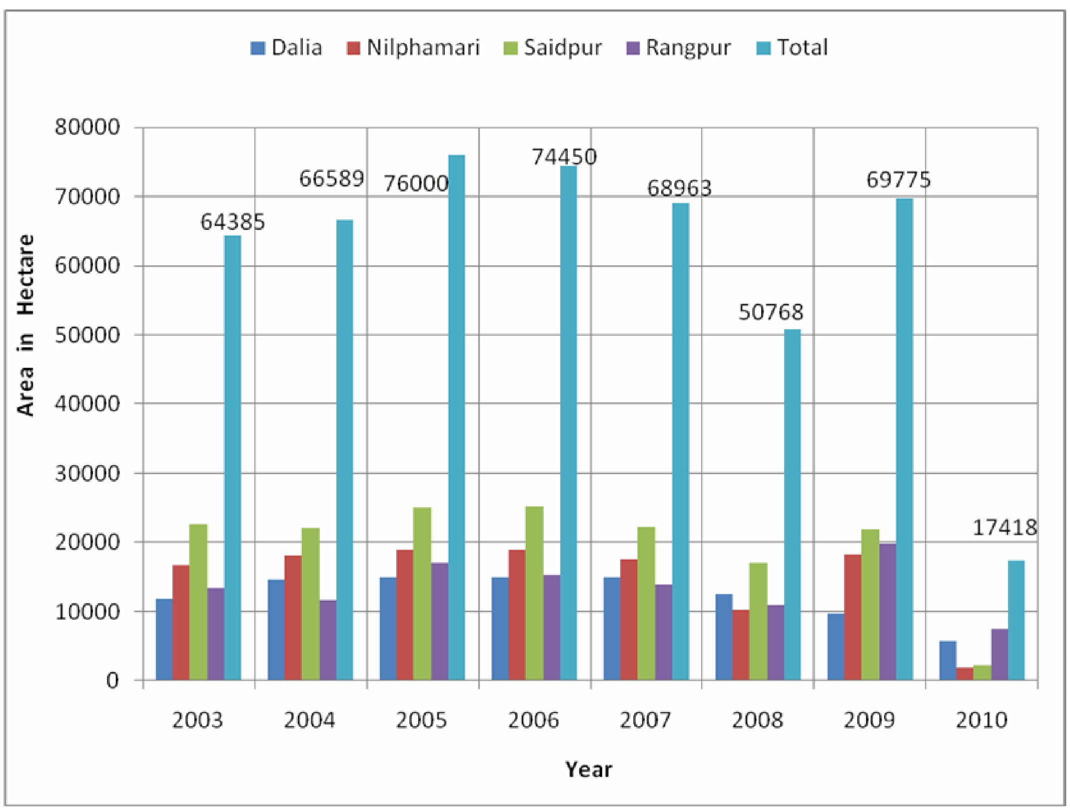

Figure 4.2. Division-wise Teesta Barrage Project irrigated area from 2003 to 2010.

76,000 ha in 2005. But, this is far short of the designed target of about 111,000 ha, as per the feasibility report (BWDB and BUET, 1989). Lack of supply canal, inability to acquire land for canal system, less demand of water for supplementary irrigation and inadequate supply of water during October is some of the important reasons for not achieving the designed target.

4.2 Impact on Yield

The impact of TBP on the Aman yield was assessed for both 'before' and 'after' project and 'with' and without' project conditions.

4.2.1 'Before' and 'After' Project Yields

It has been mentioned earlier that from 1993 to 1999, only Teesta main canal got irrigation water. Other main canals i.e. Dinajpur and Rangpur canals got indiscernible irrigation water.

The effect of irrigation from TBP on yield is shown in Figure 4.3. It can be seen from the figure that HYV Aman yield is higher at Jaldhaka (on Teesta main canal) than at Nilphamari (on Dinajpur canal) from the early nineties till 2005. The yield at Nilphamari picked up from 2000, with the gradual increase of irrigated area (as shown in Figure 4.1). From 2005 onward, the yields are almost the same at Jaldhaka and at Nilphamari.

Figure 4.4 indicates that during the 'before' project condition (i.e. from 1991 to 1999) HYV Aman yield had a slight decreasing trend in Nilphamari district while it had an increasing trend in Jaldhaka Upazila. The main reason for the higher yield at Jaldhaka during the 'before' project condition is that the TBP irrigation started from 1993 in a low scale and in full swing it started from 2000. From 1993 to 1999, Jaldhaka area was facilitated with irrigation, which resulted in comparatively higher yield than Nilphamari.

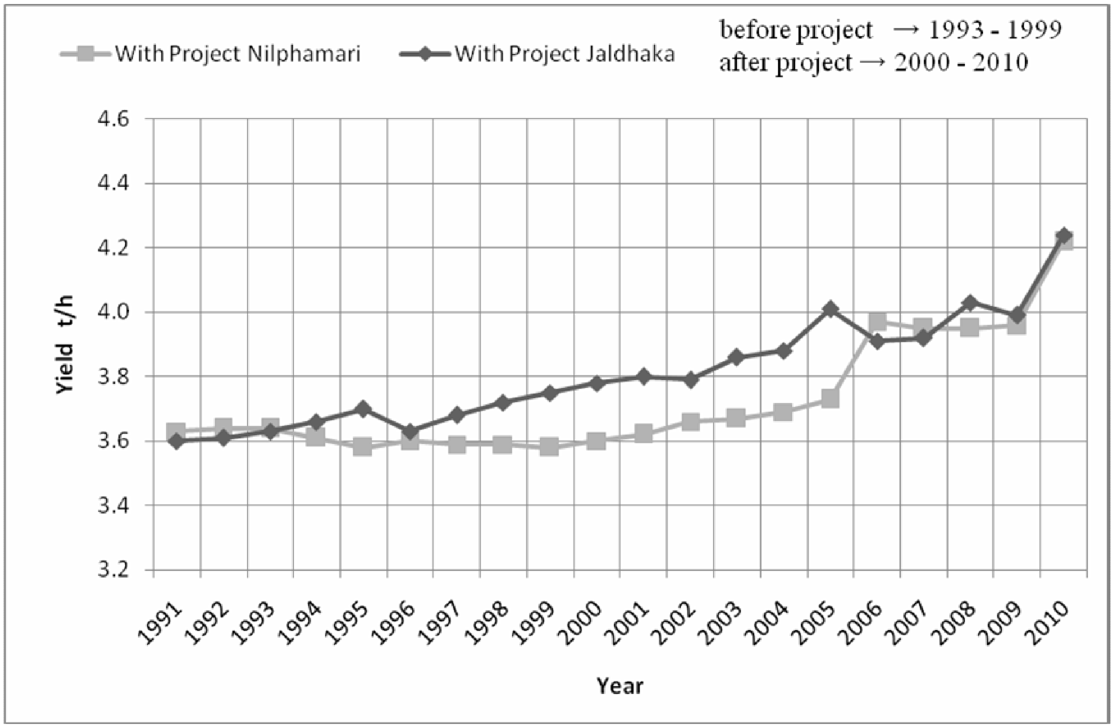

Figure 4.3. Before and after project HYV Aman yield at Nilphamari and Jaldhaka.

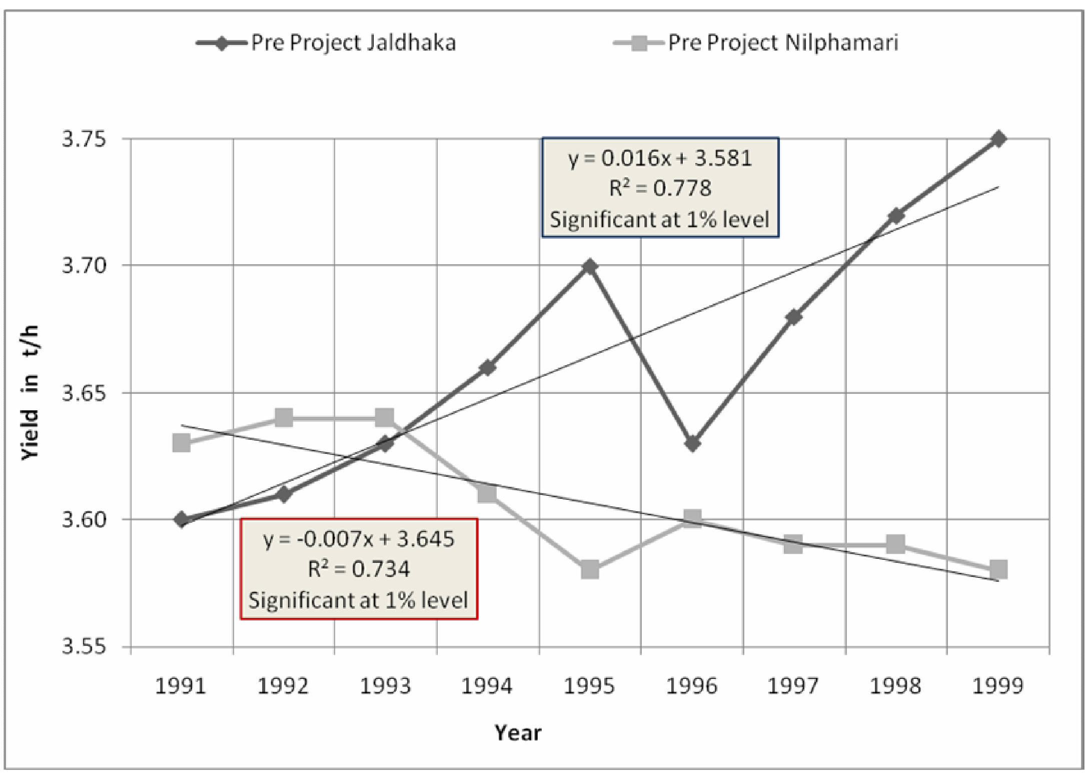

Figure 4.4. Comparison of 'before' project yield between Jaldhaka and Nilphamari.

Figure 4.5 indicates that with the availability of irrigation water in the ‘after’ project condition (i.e. from 2000 to 2010), the yield at Nilphamari district had an increasing trend. From 2006 onward, the yields at Nilphamari and Jaldhaka were similar.

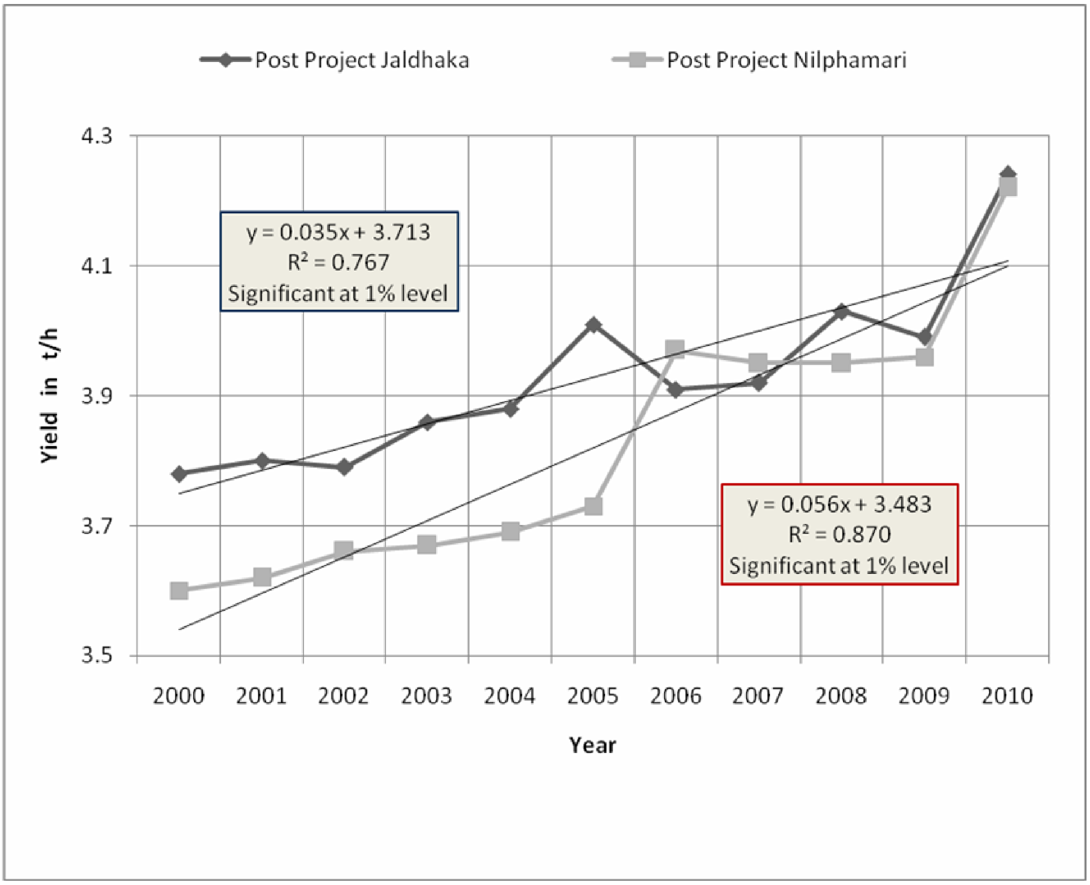

Figure 4.5. Comparison of ‘after’ project yield between Jaldhaka and Nilphamari.

The average ‘before’ (1991-99) and ‘after’ (2000-10) project yields at Jaldhaka and Nilphamari are shown in Table 4.1. It can be seen from the table that the average increase in the ‘before’ and ‘after’ project yield is 0.24 t/ha (an increase of 6.6%). As irrigation is one of the many inputs contributing towards increase in yield, it can be concluded that the TBP did not have a significant impact in increasing the yield of Aman rice in the project area. In the project appraisal report (BWDB, 1989), it was estimated that the post project yield would increase to 3.87 t/ha from the pre-project yield of 2.13 t/ha. On the basis of the appraisal report it can be considered that the TBP had a huge impact in increasing HYV Aman yield. But, as mentioned earlier, the increase in yield is not only due to irrigation but also may be due to other inputs (variety, fertilizer, technology etc.).

Table- 4.1. Comparison of average HYV Aman yield (t/ha) between 'before' and 'after' TBP.

Location	'Before' Project Yield (t/ha)	'After' Project Yield (t/ha)
Jaldhaka	3.66	3.93
Nilphamari	3.61	3.82
Average	3.64	3.88

4.2.2 'With' and 'Without' Project Yield

To show the impact of TBP on increasing the Aman yield, a comparison of yields of Aman within the TBP area (Jaldhaka) and without the project (Dinajpur and Panchagrah) are shown in Figures 4.6 and 4.7. It has already been mentioned that Jaldhaka Upazila is situated at the head end of the main canal and is facilitated with full irrigation coverage of the TBP. On the other hand, both Dinajpur and Panchagarh districts are totally outside the coverage of the TBP and Aman is cultivated under rainfed condition.

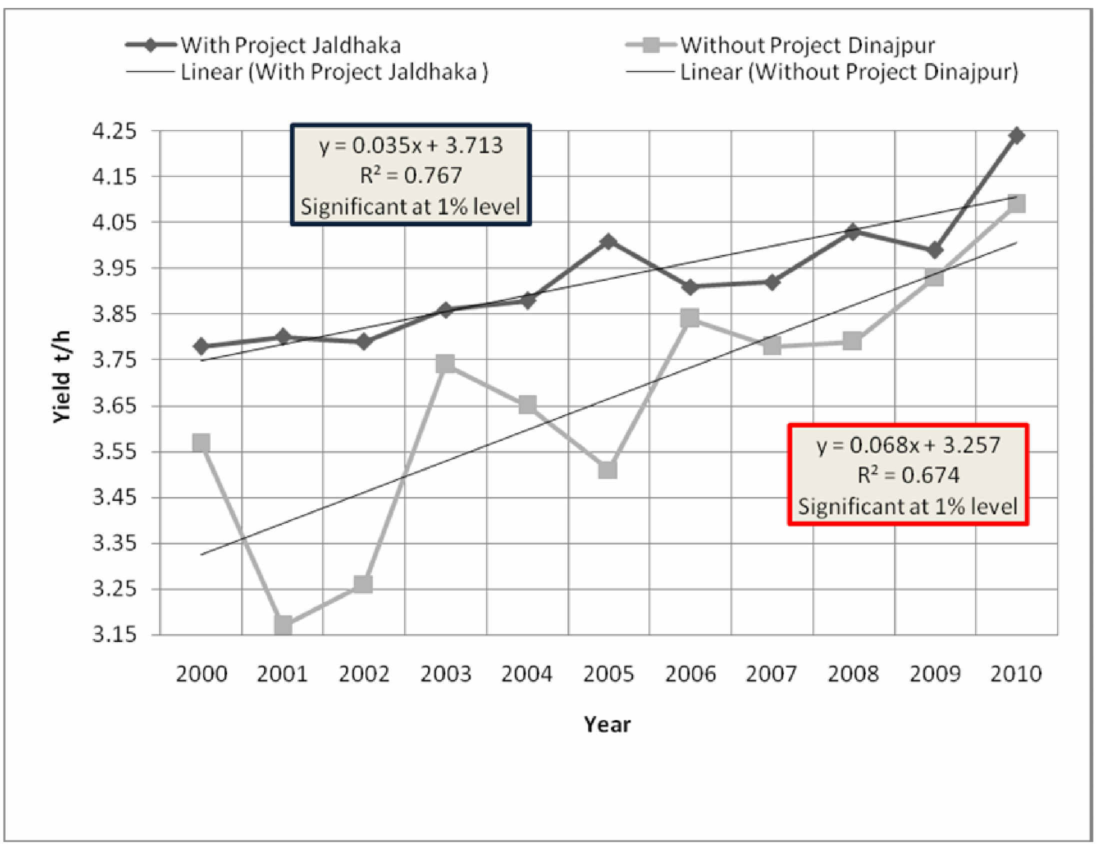

Figure 4.6. Comparison of 'with' and 'without' project yield between Jaldhaka and Dinajpur.

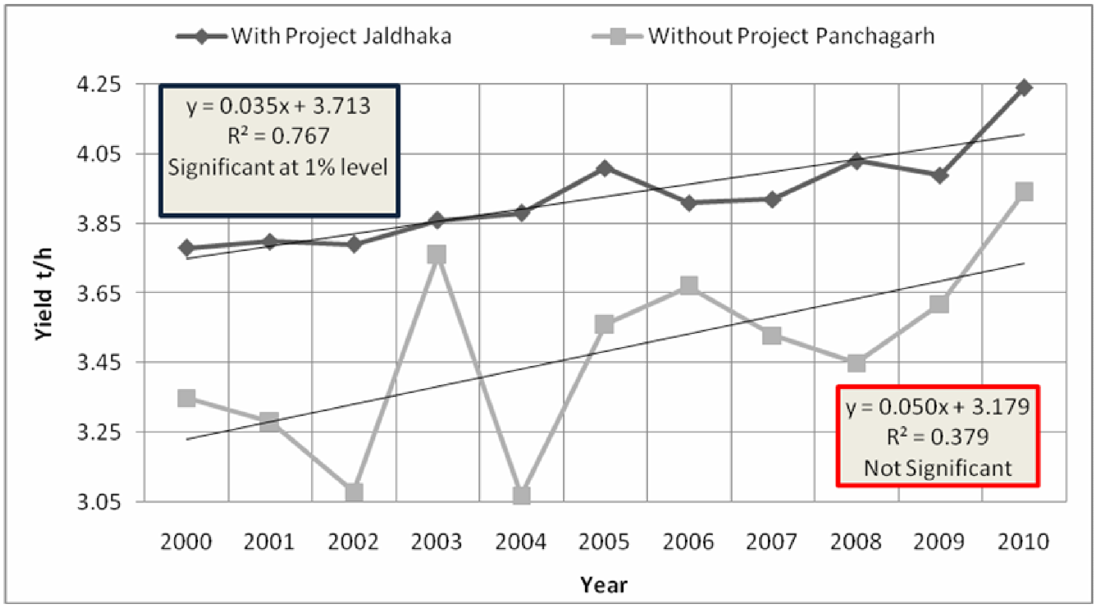

Figure 4.7. Comparison of 'with' and 'without' project yield between Jaldhaka and Panchagarh.

The above figures show that 'with' project yields at Jaldhaka are higher than the 'without' project yields at both Dinajpur and Panchagrah. Moreover, the yield of Jaldhaka has less yearly variability (standard deviation of 0.14 t/ha) compared to variability of yields of both Dinajpur and Panchagarh (standard deviations of (0.28 t/ha and 0.27 t/ha, respectively), which could be due to uncertainty of rainfed cultural practice.

A comparison of the yields of Jaldhaka and Rangpur (with project) is shown in Figure 4.8. It has already been mentioned that Rangpur has 4 Upazilas within the TBP area and are facilitated with irrigation. Another 4 Upazilas are beyond the TBP area and are devoid of TBP irrigation. The figure indicates that the yield fluctuates in Rangpur (with project) while at Jaldhaka, the yield is consistent. The reason for the inconsistency in Rangpur yield (with project) is because of the irregular supply of irrigation water in Rangpur (tail end of main canal with gradual development of irrigation) compared to Jaldhaka (head end). The figure also shows that with regular supply in the recent years (2008-10), the yields at Rangpur were slightly higher than those of Jaldhaka.

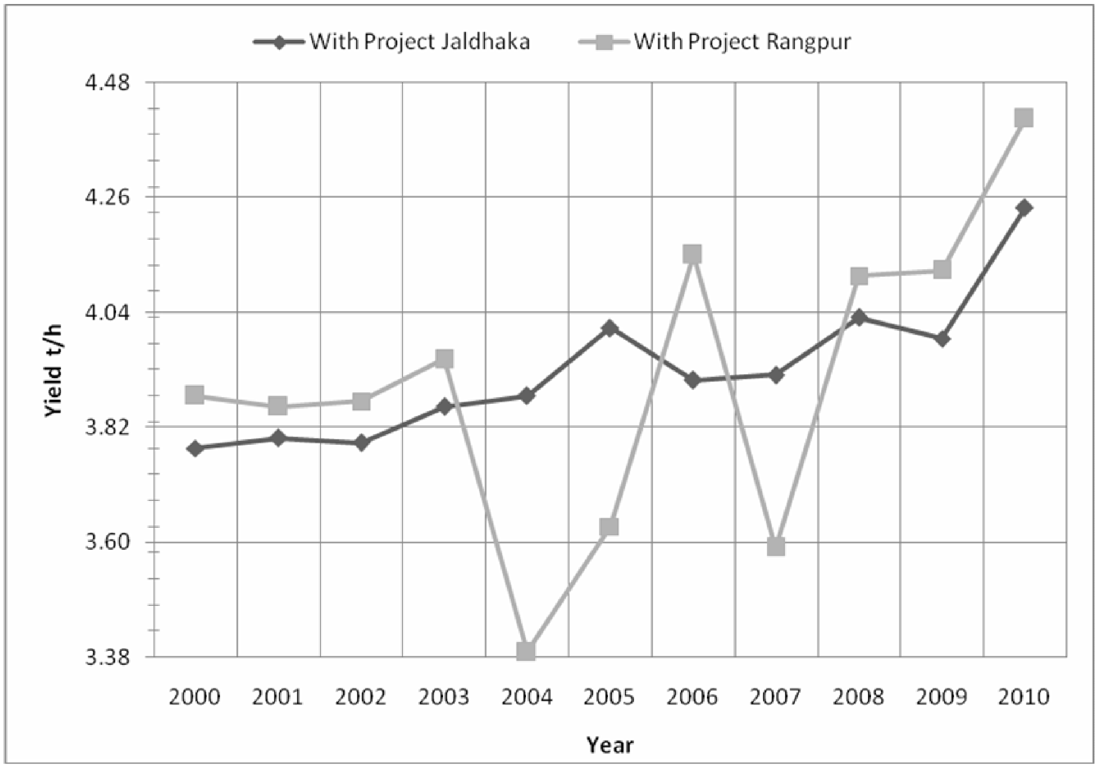

Figure 4.8. Comparison of 'with' project yields between Jaldhaka and Rangpur.

Figure 4.9 indicates the variation of yield of HYV Aman between 'with' project and 'without' project area of Rangpur. Due to irrigation in 'with' project condition, the yield is comparatively higher than the 'without' project area, especially after 2005 (when the irrigation water supply became adequate and fully developed).

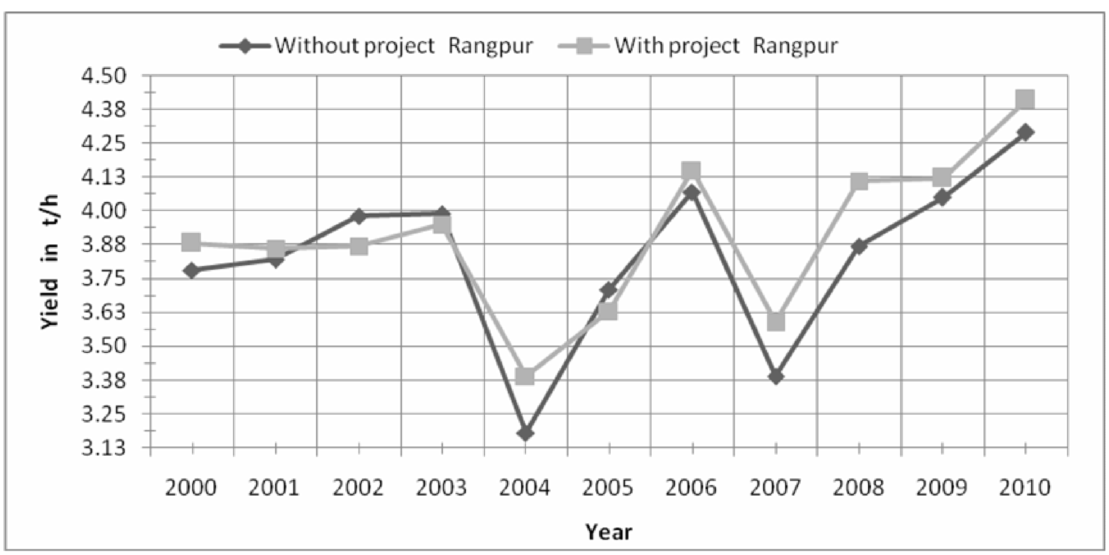

Figure 4.9. Comparison of yields between' with' project and 'without' project areas of Rangpur.

The average ‘with’ and ‘without’ project yields at different locations of TBP and outside TBP during the 2000-10 period are shown in Table 4.2. From the table it can be seen that the average ‘with’ project yield is 0.23 t/ha higher (about 6%) than the average ‘without’ project yield. As expected, the highest yield of 3.93 t/ha was obtained at Jaldhaka which is in within TBP and has full access to irrigation. The table also shows that the average highest ‘without’ project yield of 3.83 t/ha was obtained at Rangpur and the difference between the ‘with’ and ‘without’ project yields at Rangpur is only about 0.08 t/ha. Thus, it can be concluded that the TBP did not have a significant effect on improving the yield of Aman in the project area, as irrigation is one of the many inputs that affect the yield.

The table also shows the variability of yields of ‘with’ and ‘without’ projects. Except for Rangur, the variability of ‘with’ project is much less than ‘without’ project condition. For Rangpur, the variability is comparable with ‘without’ project condition because of late irrigation coverage from the TBP.

Table 4.2. Comparison of mean and standard deviation HYV Aman yield (t/ha) between ‘with’ and ‘without’ TBP.

Location	‘With’ Project HYV Aman	STDEV	‘Without’ Project HYV Aman	STDEV
Jaldhaka	3.93	0.14	-	
Nilphamari	3.82	0.20	-	
Rangpur	3.91	0.29	3.83	0.32
Dinajpur	-		3.67	0.28
Panchagarh	-		3.48	0.27
Mean	3.89		3.66	

4.3 Impact on HYV Aman area

A prime objective of the TBP was that after the implementation of the project, the local rice varieties would be replaced by HYV. Figure 4.10 indicates the increase in HYV area at Jaldhaka Upazila after the implementation of the project. It can be seen from the figure that there is a sharp increase in HYV Aman cultivation in Jaldhaka Upazila with little yearly variation.

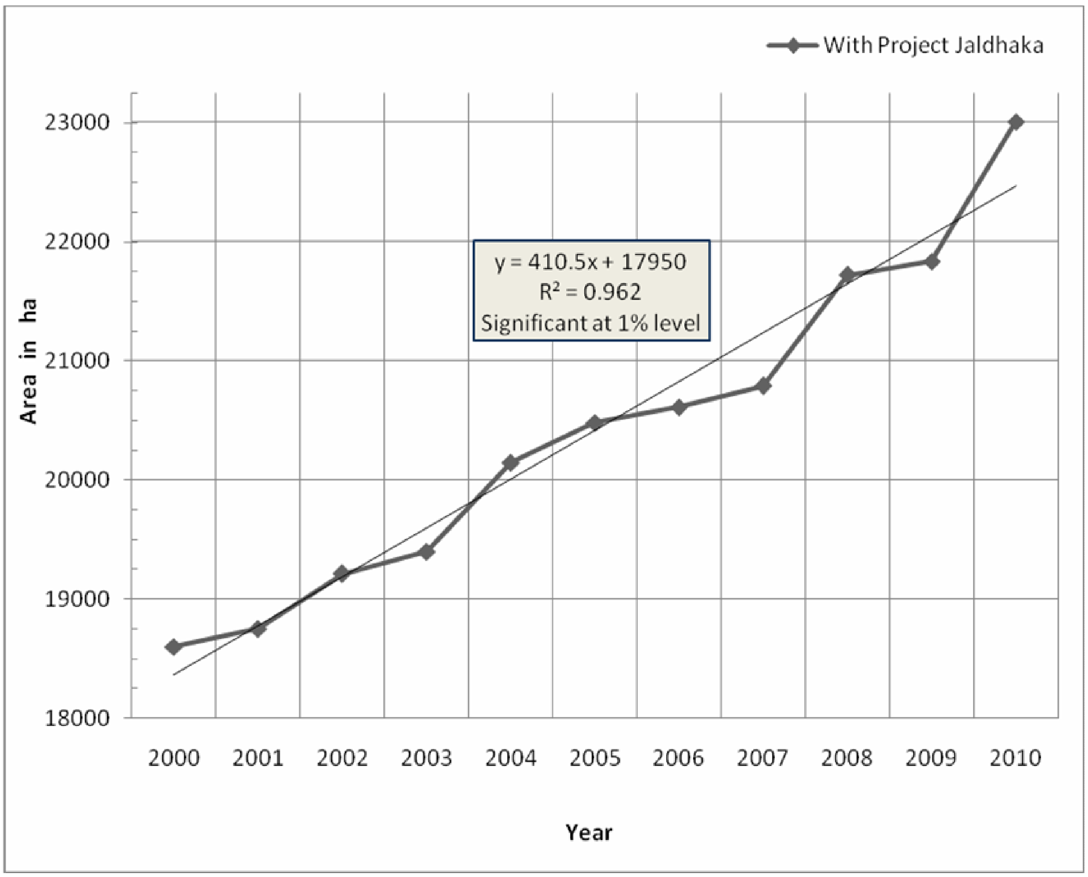

Figure 4.10. Yearly increase in HYV Aman Area at Jaldhaka Upazila in the post project period.

The yearly increase in HYV Aman area of Panchagarh district which is beyond the TBP area is shown in Figure 4.11. As the district is outside the TBP area, uncertainty of timely and adequate rainfall prevail, which causes yearly fluctuation of HYV Aman area (although there is an increasing trend). Similar fluctuations have also been observed in other 'without' project area.

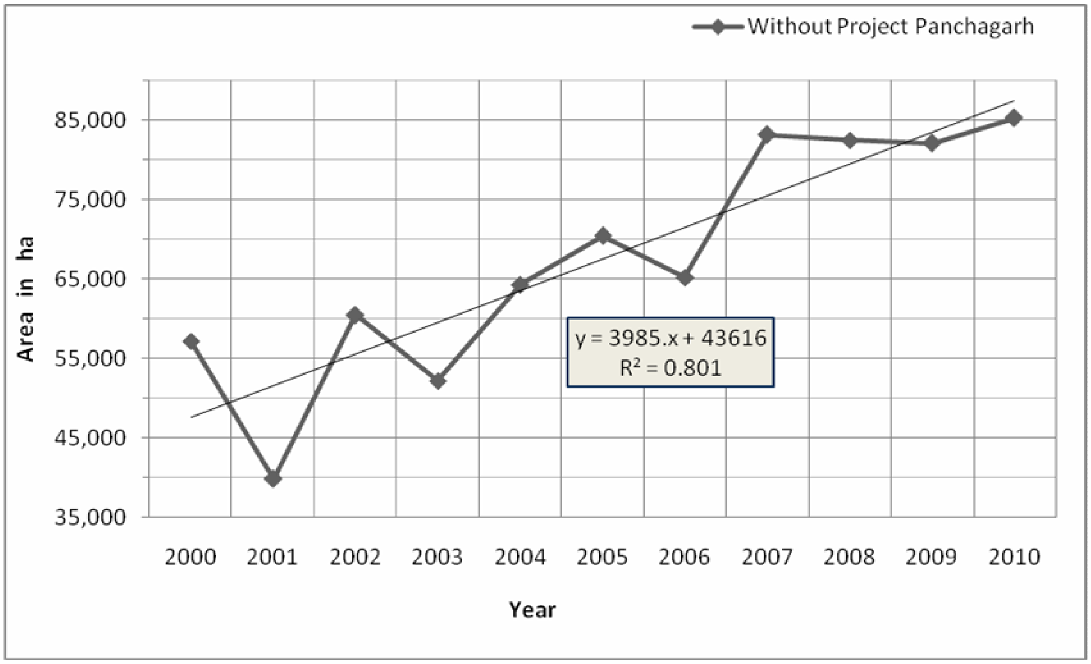

Figure 4.11. Yearly increase in HYV Aman area at Panchagarh District (without project).

Table 4.3 shows the standard deviations of HYV Aman areas of 'with' and 'without' project conditions. It is evident from the figure that the variability is higher in Panchagarh and Dinajpur (without project) compared to Nilphamari and Jaldhaka (with project).

Table 4.3. Comparison of 'with' and 'without' project standard deviations of HYV Aman area (ha).

Year	With Project Nilphamari	With Project Jaldhaka	Without Project Rangpur	Without Project Dinajpur	Without Project Panchagarh
2000-10	1775	1388	8564	18450	14763

4.4 Effect of Rainfall on Supplementary Irrigation

The variation of rainfall during the Aman season was studied in order to see whether there is any trend in seasonal rainfall. Figure 4.12 shows the seasonal rainfall during the Aman season (July to November) for the 1993-2010 periods at Dalia. The figure shows that during that period there is no change in the trend of the total seasonal rainfall.

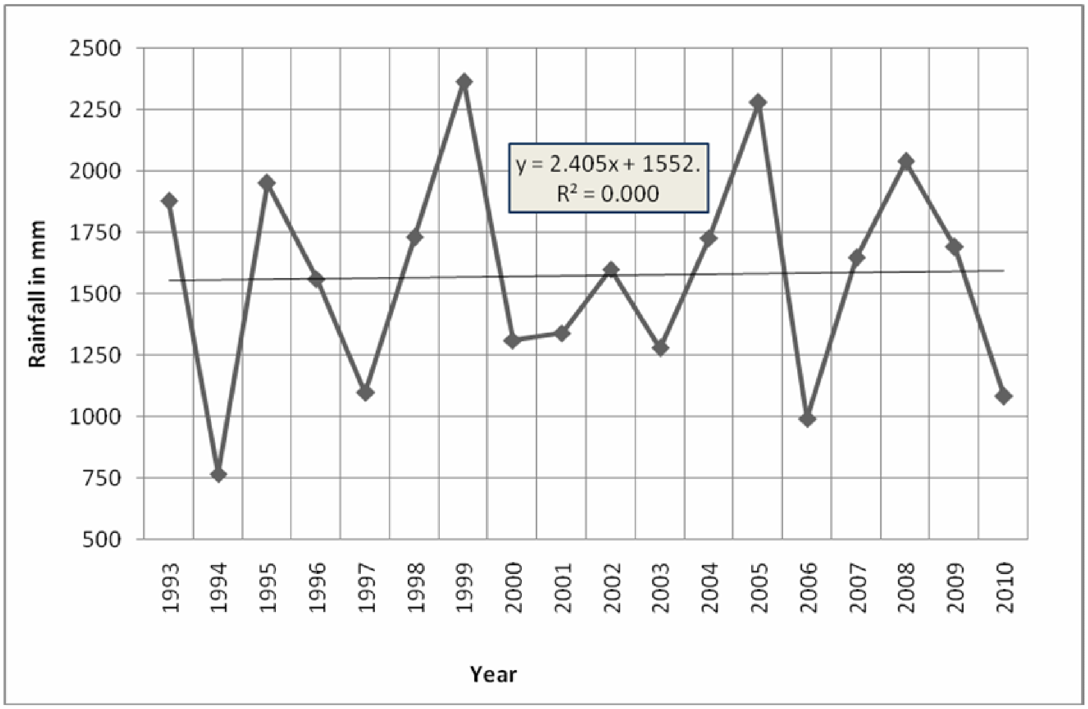

Figure 4.12. Seasonal (July-November) rainfall at Dalia of Nilphamari District.

The trends of monthly rainfall for each of the months of July to November are shown in Fig. 13-17. The figures show that the month of July has a decreasing trend and except for November, the other months have an increasing trend (although the trends are insignificant).

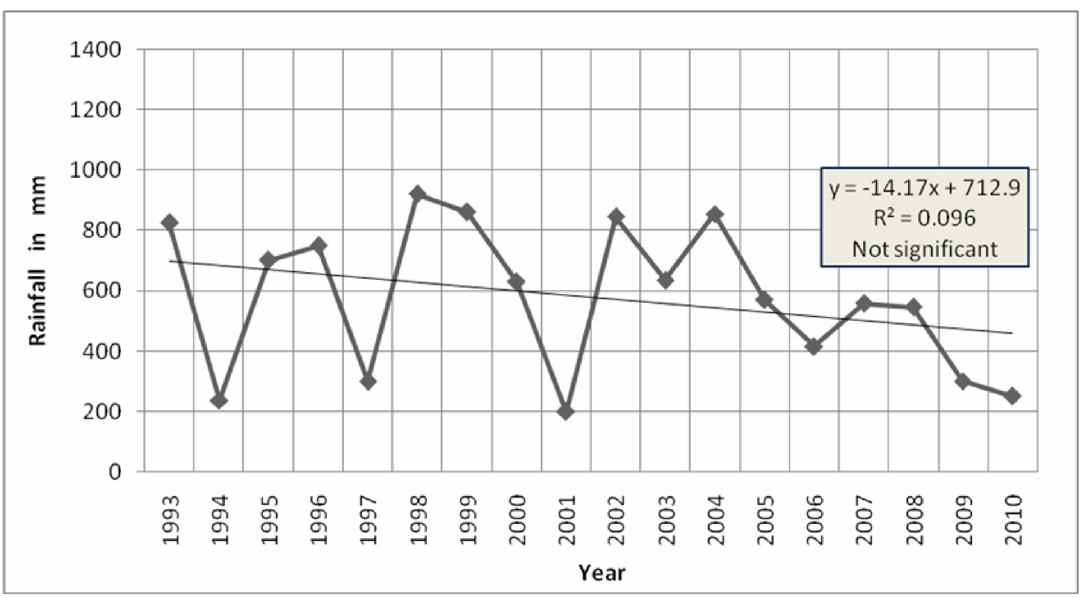

Figure 4.13. Rainfall data of July at Dalia of Nilphamari District.

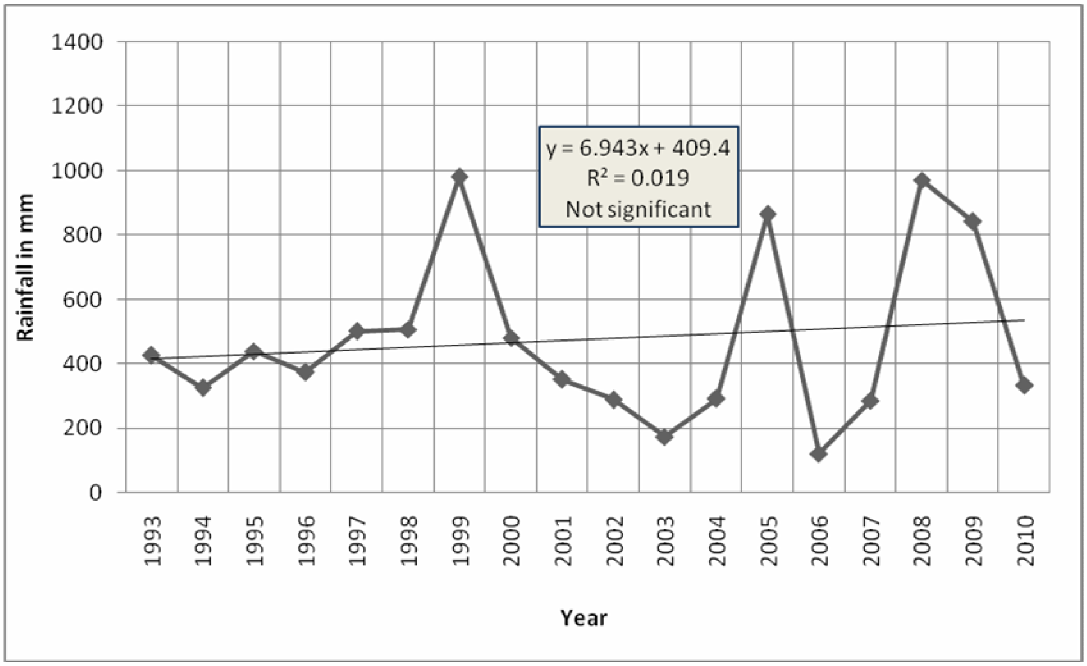

Figure 4.14. Rainfall data of August at Dalia of Nilphamari District.

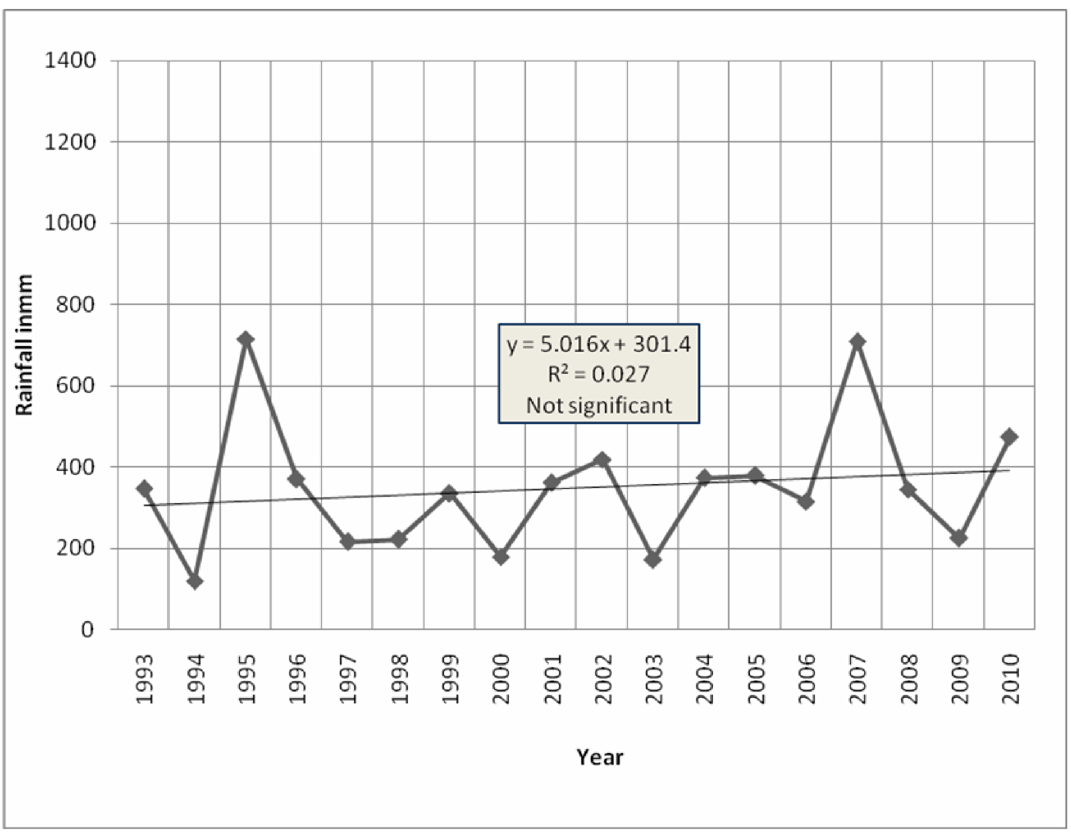

Figure 4.15. Rainfall data of September at Dalia of Nilphamari District.

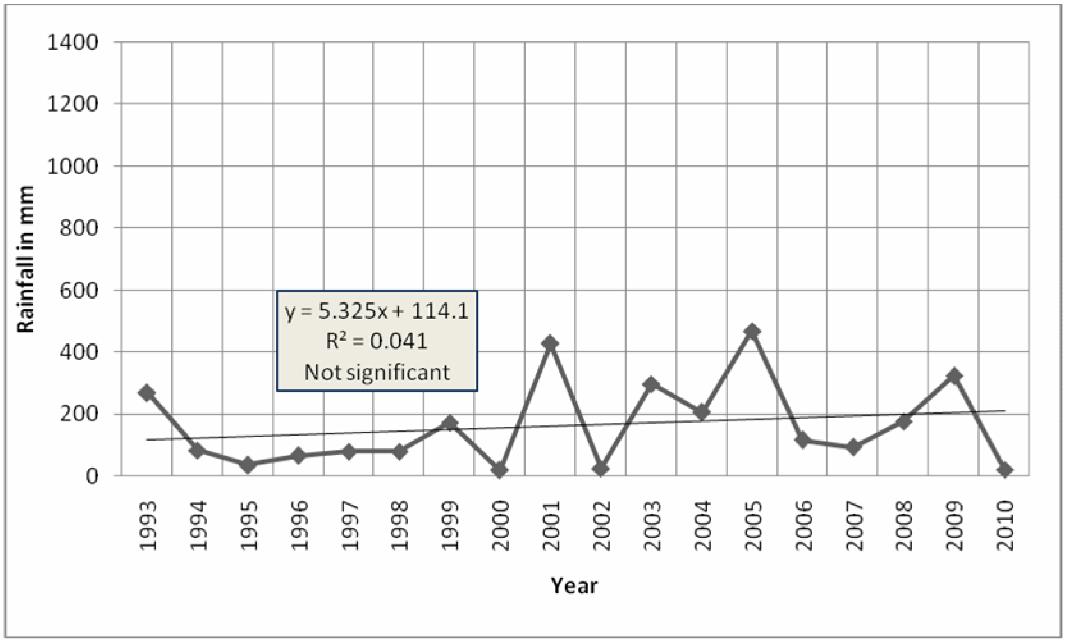

Figure 4.16. Rainfall data of October at Dalia of Nilphamari District.

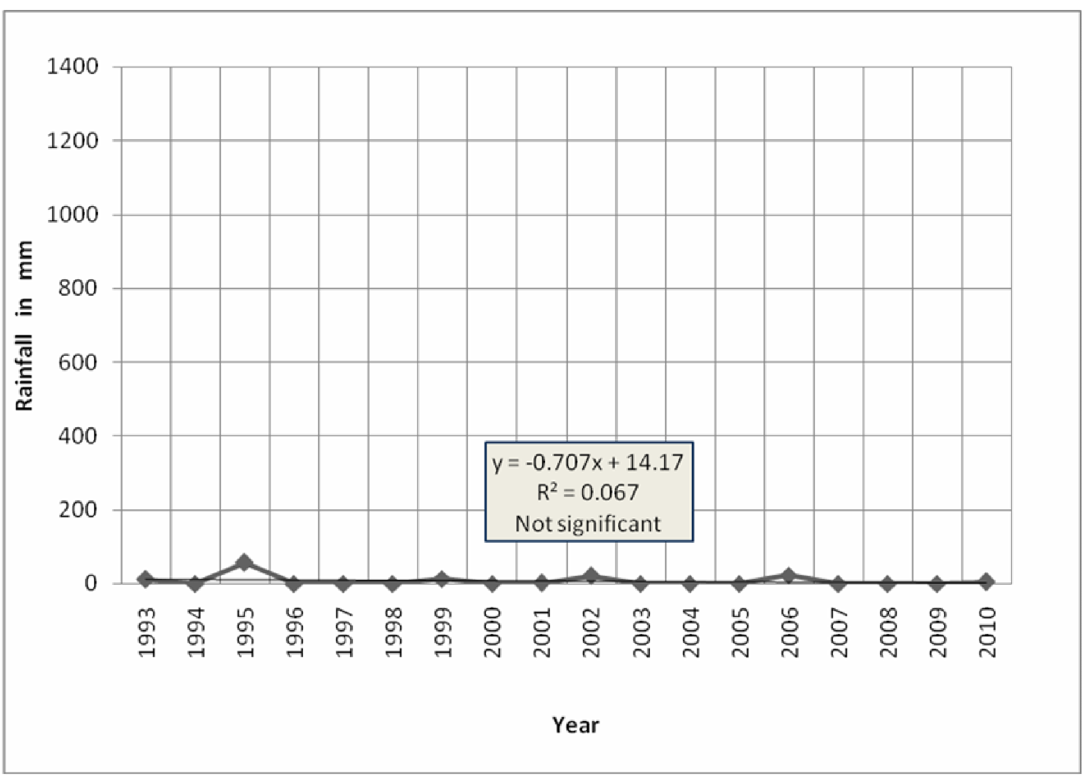

Figure 4.17. Rainfall data of November at Dalia of Nilphamari District.

The mean and the standard deviation of the monthly rainfall at Dalia are shown in Table 4.4. It is evident from the table that the monthly rainfalls are highly variable, especially in the months of October, emphasizing the need for supplementary irrigation from the TBP in order to stabilize the Aman yield.

Table 4.4. Monthly mean and standard deviation of rainfall (in mm) at Dalia.

	July	August	September	October	November
Mean	578.27	475.36	349.14	164.73	7.44
STDEV	243.40	263.65	162.43	139.84	14.57

4.5 Effect of Supplementary Irrigation on Ground Water Table

In order to assess the impact of supplementary irrigation from TBP on the groundwater status of the project area, long term groundwater data (1986-2010) were analyzed.

The yearly maximum and minimum water groundwater levels at Nilphamari and Rangpur were assessed and are shown in Figures 4.18 and 4.19 respectively. Rangpur and Nilphamari are facilitated with TBP irrigation. It can be seen from the figures that TBP has a good impact on the groundwater table of both of these areas. Considering that there is no trend of seasonal rainfall in the TBP area (as shown in Figure 4.12) the only source of the additional water for replenishing the aquifer could come from the supplementary irrigation of the TBP.

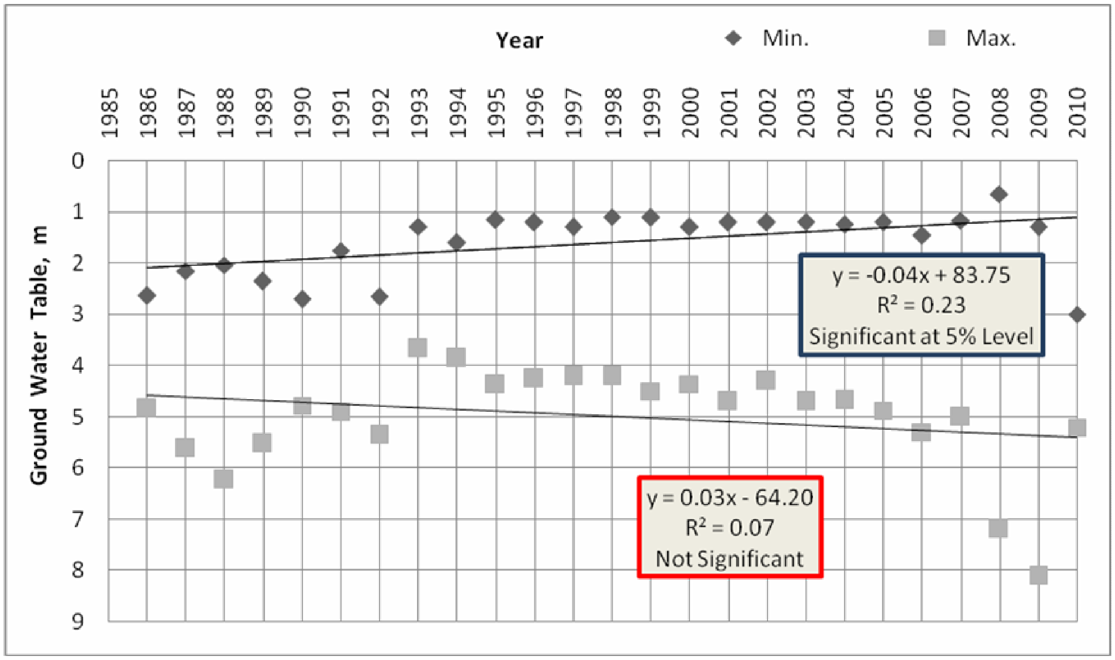

Figure 4.18. Yearly maximum and minimum groundwater level of Nilphamari Sadar.

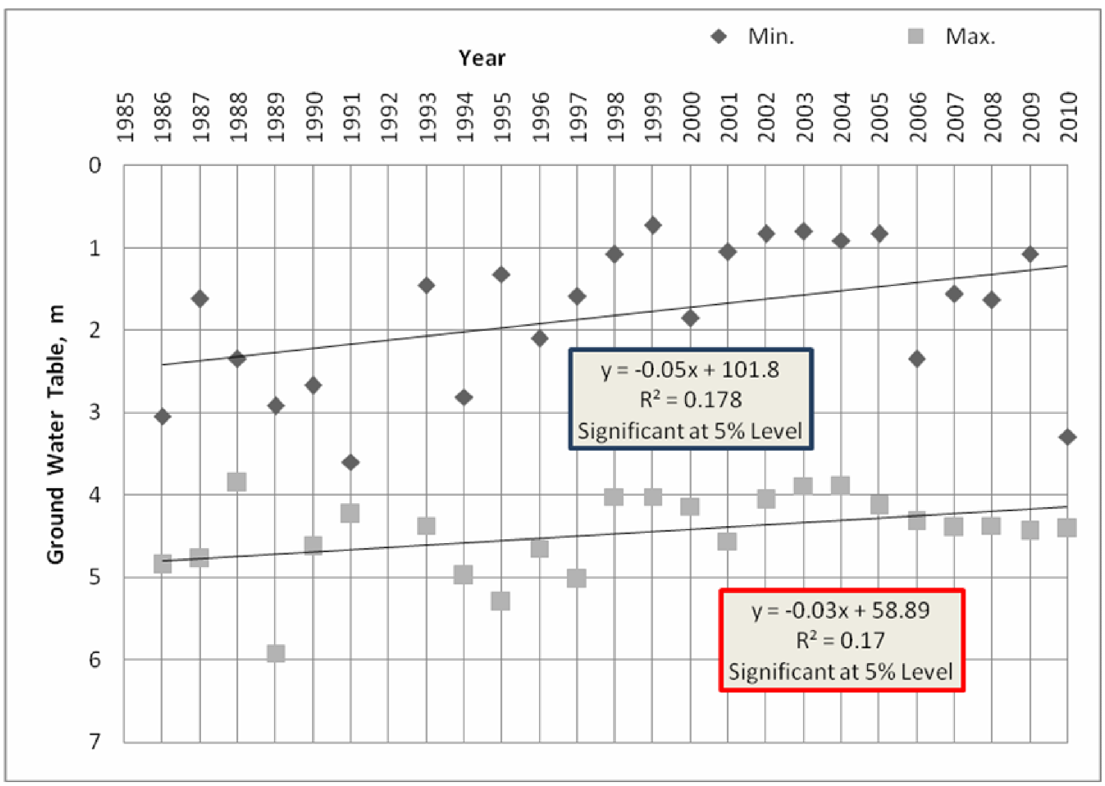

Figure 4.19. Yearly maximum and minimum groundwater level of Rangpur Sadar.

The analysis of maximum and minimum groundwater levels of areas outside the TBP (Atwari and Panchagarh) shows the decreasing trend of groundwater level both during the dry and the wet seasons (Figures 4.20 and 4.21). The explanation for the decreasing trend could be because of the increasing use of groundwater during the dry season for Boro cultivation and the inability of the monsoon rainfall (which has remained the same in the long run as shown in Figure 4.15) to replenish the increasing deficit. Unlike the TBP area, there is no supplementary irrigation to replenish the aquifer.

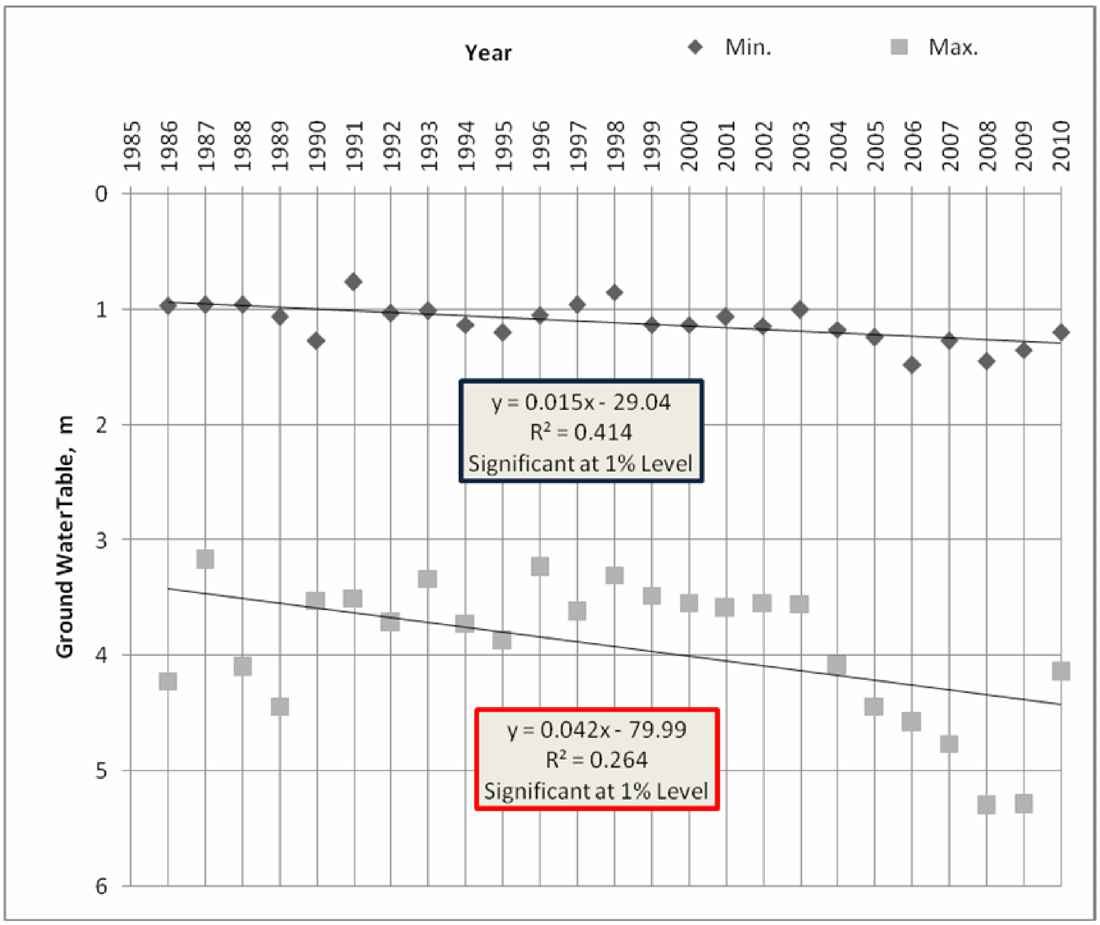

Fig. 4.20. Yearly maximum and minimum groundwater level at Atwari.

Thus, it can be observed that the supplementary irrigation from the TBP had a positive impact in increasing the recharge during the wet season. It should be emphasized here that analysis of groundwater recharge and replenishment of the aquifer is a complex process and requires a rigorous analysis and a definite conclusion on increasing trend of groundwater cannot be made only from the groundwater level profiles.

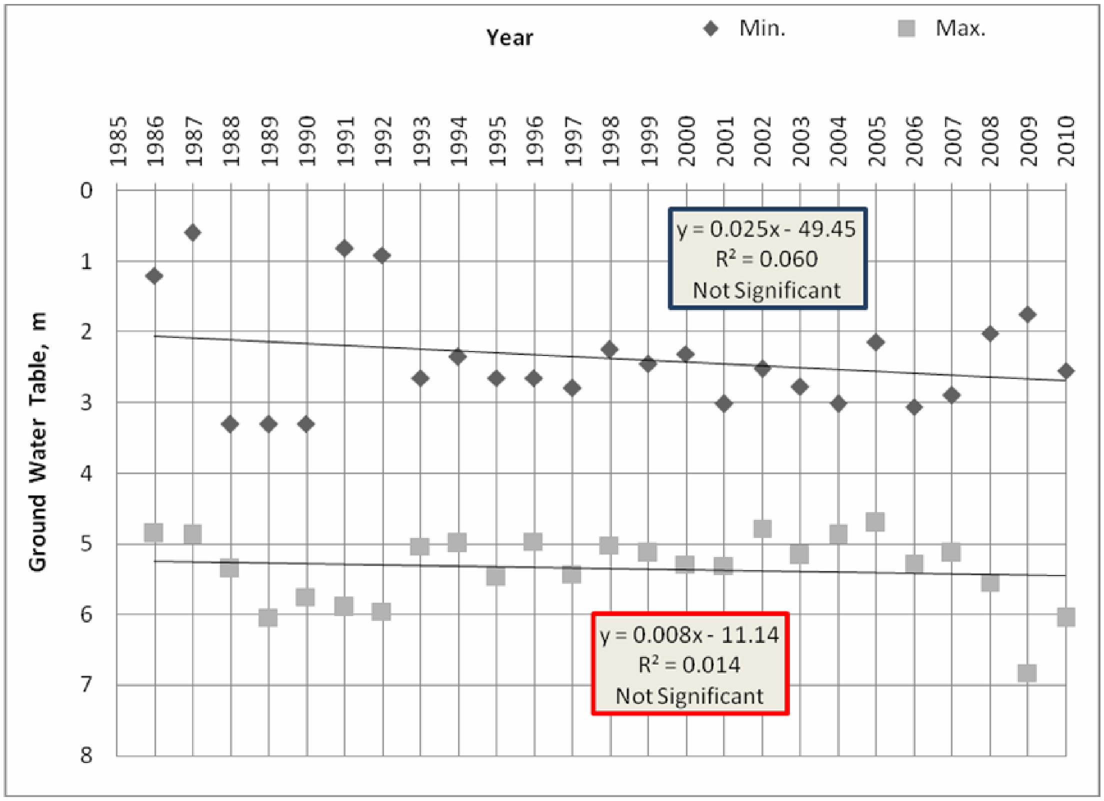

Figure 4.21. Yearly maximum and minimum groundwater level at Panchagarh.

4.6 Farmers' perception on supplementary irrigation

In order to assess farmers' perceptions about the impact of supplementary irrigation, focus group discussions (FGDs) were carried out in six locations of the Teesta Barrage Project area. The places are Dalia, Horichandrapat in Jaldhaka, Nilphamari Sadar, Kishoreganj, Saidpur, and Mominpur in Rangpur Sadar. The participants of the FGDs were farmers and belonged to the irrigation water management groups (WMGs). WMG is the lowest level of Water Management Organization (WMO). WMO consists of three tiers of institutions; Water Management Group (WMG), Water Management Association (WMA) and Water Management Federation (WMF).

From the focus group discussion it is learned that during the pre project condition, local as well as HYV Aman rice were cultivated in the project area. In the early nineteen eighties HYV Aman crop cultivation was initiated. In the beginning, the yields of HYV varieties were remarkable. In the nineties, widely cultivated BR-11 had lost its quality, thus its yield decreased. Due to recurrent cultivation of BR-11 year after year, fertility status of the soil decreased and vulnerability to diseases increased. Furthermore, the farmers used seeds from their own stock, which was not cultivated, collected, and stored properly; therefore, less quality seeds were cultivated. Farmers did not change BR-11 variety, as it is tall, strong, does not lodge due to flooding with irrigation water or wind, and could be cultivated in the low land.

However, from beginning of the first decade of this century, other HYV and hybrid varieties are being cultivated. These HYV varieties as well as hybrid varieties have higher yields. BR-11 variety is also cultivated in small areas. The local and high yielding varieties cultivated during ‘before’ and ‘after’ project conditions are given in Table 4.5.

From the FGDs, it was revealed that availability of timely and adequate irrigation from the TBP and higher yield were the main reasons for shifting the varieties during the ‘after’ project condition.

Table 4.5: Rice varieties cultivated during ‘before’ and ‘after’ project condition.

‘Before’ project	‘After’ project
Local Variety	Local Variety
Nil Komor, Shil Domor, Sapahar, Nayaraj, Malshira, Joshoha, Hodi, Depa, Bosi Dhan, Pani Shail, Badhai Dhan, Kocho dala, Lohadang, Agoor Dhan.	None
Improved Local Variety	Improved Local Variety
Paijam	Paijam
High Yielding Variety	High Yielding Variety
BR-3, BR-11	BR-3, BR-4, BR-11, BRRI dhan-33, BRRI dhan -41, BRRI dhan -49 and BINA-7.
	Hybrid Variety
	Gooti Sharna, Bonjit Sharna, Nepali Sharna, Mamoon Sharna, Hori Dhan, Hybrid Hira-2

The yields obtained by the farmers during 'before' and 'after' the TBP are shown in Table 4.6. It can be seen from the table that the farmers have reported slight increase in yield of the local improved variety. As explained earlier, the increase in yield of the high yielding varieties is not due to irrigation from the TBP but also due to change of variety.

Table 4.6. 'Before' and 'after' project Aman rice yields obtained from FGDs.

Variety	Yield 'before' project (t/ha)	Yield 'after' project (t/ha)
Local Variety	1.8-3.0	-
Local Improved	2.2-3.1	3.0-3.1
High Yielding Variety	Initially, 4.6-5.5 after a decade, 2.5-3.7	3.5-5.6
Hybrid Variety	-	4.3-8.5

When asked about the timing of the use of the irrigation water from the TBP, the farmers informed that rainfall in general is neither timely nor sufficient in accordance with crop water requirement of Aman. Generally, irrigation is required during two stages of crop growth. The farmers informed that there is generally drought from 15 July to 15 August, i.e. when the Aman paddy is in transplanting and in tillering stage and irrigation is required for the timely transplantation of the crop. They also informed that another critical period is 15 September to 15 October, which is the time of flowering and pollination stage of the Aman. If timely and optimum rainfall does not occur at this stage, then irrigation is needed for optimum yield. The rainfall in other growth stages of the crop is generally sufficient to meet the crop water requirement. When irrigation is required, the number of irrigations in a season varies between 2 to 4.

From FGDs it is revealed that the irrigation service charges (ISC) is fixed on the basis of area served irrespective of the volume of water supplied (area based water pricing). At present, the ISC imposed by BWDB is Tk. 445/ha. The WMO receives the supply of irrigation water and manages the internal distribution and collection of ISC from its members. In some years BWDB authority also leases out the canal to the local influential persons and they collect the ISC ignoring WMO. Such a system of ISC collection has resulted in inactivating the role of WMO. From the discussions with the farmers it was clear that the farmers give more priority to take irrigation in the Boro /early Aus season, when there is little or no rainfall to meet the crop's water requirement. They are more interested to pay ISC in the Boro season than in the Aman season. This is because irrigation is not required every year in the Aman season and also when required; the requirement is much less compared to Boro irrigation.

During the FGDs the farmers informed about the secondary use of irrigation water in terms of increasing the soil fertility. The canal water brings sediments of silt as well as clay, which results in textural development of the soil and increases the soil's water-holding capacity. The canal water also brings phytoplankton and zooplankton, which improves the organic matter content of the soil and increases the soil fertility.

All the farmers agreed that the TBP played a great role in the agricultural as well as socio-economic development of the region (especially in stabilizing the yield). They assured that if irrigation water is ensured at the time of need they will cooperate in the O&M of the project and also contribute by timely and regular payment of the ISC.

CHAPTER-5

CONCLUSIONS

5.1 Conclusions

The evaluation of the impacts of the Teesta Barrage Project (TBP) on Aman production was based on secondary data. On the other hand, the assessments of the farmers' perception about the project and on supplementary irrigation were carried out through focus group discussions. The findings of the study are:

Although the irrigated area of the TBP has been increasing steadily since 2000 and the maximum irrigated area of 76,000 ha was achieved in 2005, this is still far short of the designed capacity of about 111,000 ha. Variability in the command area occurs from year to year mainly because of variability of monthly rainfall.

The average 'before' project yield has increased marginally from 3.64 t/ha to 3.88 t/ha in the 'after' project condition. As irrigation is one of the many inputs contributing towards increase in yield, it can be concluded that the TBP did not have a significant impact in increasing the yield of Aman rice in the project area.

The average 'with' and 'without' project' yields are 3.89 t/ha and 3.66 t/ha, respectively. A yield increase of 0.23 t/ha in the 'with' project condition does not suggest a significant increase in yield in the 'with' project condition.

The TBP had significant impact in stabilizing the yield and the HYV Aman area as the variability in yield and HYV Aman area have been reduced in the 'with' project condition compared to 'without' project condition.

There has been no trend in the seasonal rainfall during the Aman season. But, there is variability in monthly rainfall which signifies the importance of supplementary irrigation from the TBP in order to stabilize the Aman yield.

Supplementary irrigation had a positive impact in increasing the recharge to the groundwater during the Aman season, although further analysis in more areas of the project is necessary in order to reach a conclusion.

In the project area, the farmers have switched from local to high yielding varieties of rice. The farmers have also reported increase in yield in the project area. The farmers are aware of the impact of the TBP in stabilizing the yield, especially at the time of transplantation and during the reproductive stages. But, there is lack in interest in paying the irrigation service charge (ISC) due to non regular and less requirement of irrigation during the Aman season. The famers are more interested about irrigation during the Boro season from the TBP.

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