Project ID 473

Competitive Research Grant

Sub-Project Completion Report

on

Develop a hydrogeological framework and a sustainable crop establishment period for haor areas of Bangladesh

Project Duration

April 2017 to September 2018

Dept. of Irrigation and Water Management, Faculty of Agricultural Engineering and Technology, Sylhet Agricultural University, Sylhet-3100

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
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The execution of CRG sub-project has successfully been completed by [insert org/inst/uni] using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grand fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

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Acronyms

%	Percentage
/	Per, Or
^{0}C	Degree Celsius
^{0}N	Degree North
^{0}E	Degree East
km^2	Square Kilometer
m	Meter
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
STW	Shallow Tube Well
DTW	Deep Tube well
LU	Land Use
LC	Land Coverage

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Executive Summary (maximum one page)

The subproject entitled "Develop a hydrogeological framework and a sustainable crop establishment period for haor areas of Bangladesh" studied the effect of climatological parameters on productivity of land, agriculture, water availability, hydrogeological investigation, land use pattern and try to find out the suitable crop establishment period in hakaluki haor area. The baseline survey was conducted in the hard point of Hakaluki haor and its adjacent village of Fenchuganj Upazila, Moulvibazar district during the month of October, 2017. The structured interview schedule was prepared and respondents were selected randomly. Total 25 respondents from each village were interviewed regarding the information of rainfall, temperature, wind speed, flood level, idity etchum. The information regardingsocio economic status of the farmer, agricultural crop, water availability, and water utilization pattern were investigated through the structured interview schedule. The climatic data such as rainfall, temperature, relative humidity in Hakaluki haor varied seasonally. Hakaluki haor is a high rainfall area. More than 80% of annual rainfall occurs during May to October. The annual maximum and minimum temperature of Hakaluki haor ranges from 9.68 to 35.7 degree celsius. The average humidity in the haor is 80% during June through September. Farmers opined thatcropping season is one and they produce Boro rice in only one season.

and the performed on wasgatigeological investThe hydrobore log data were interpreted to determine the thickness and depth of the subsurface formations. The result revealed the presence of nine geo-structure layers comprising of Clay, Silty clay, Silt, Very Fine sand, Fine sand, Medium sand, Medium to coarse sand, Coarse sand and Very coarse sand. On the other hand, the stratigraphic data shows the different aquifer formation in the soil profile of the study area. From the analysis of bore log data the following soil formations were found: 1) Aquitard; 2) Poor aquifer; 3) Good aquifer; and 4) Very good aquifer. Analysis of lithological log suggests that the area contains medium to very good aquifer adjacent to Hakaluki haor which are capable of meeting the water demand of this area during the critical dry period. Adequacy of the monitoring system with installation of additional observation wells is also recommended for better understanding of aquifer system.

To assess land use pattern multi- temporal satellite imageries (LANDSAT 7 for the year of 2000 and (LANDSAT 8 for the year2019) were obtained. The haor was classified into five major LU/LC classes' viz. water bodies, dense vegetation, croplands, bare land and human settlement. Change detection analysis was done to compare the quantities of land cover class conversions between time intervals. The analysis revealed both increase and decrease of the different LU/LC classes from 2000 through to 2019. The results also showed a rapid growth in human settlement (91.61 km^2) between 2000 and 2019 while the same periods witnessed a reduction in water bodies (-28.69 km2), dense vegetation (-47.01 km^2), crop land (-12.96 km^2) and bare land (-2.95 km^2).

Short duration Boro rice (BRRI dhan 28) can be grown from end of December if November rain/depression does not damage the seedlings. Growing high yielding long duration varieties like BRRI dhan 29 is a risky venture as haor will be fully inundated by mid April. During the project period, April 2017 to September 2018 the experimental field was inundated during end of March. One year experimentation is not enough to make any conclusion or any suggestion on crop calendar or variety or season.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Develop a hydrogeological framework and a sustainable crop establishment period for haor areas of Bangladesh
2. **Implementing organization**: Sylhet Agricultural University

3. **Name and full address** with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator: Dr. Sanjida Parveen Ritu, Professor, Dept. of Irrigation and Water Management, Faculty of Agricultural Engineering and Technology, Sylhet Agricultural University, Sylhet-3100. Cell Phone: +8801711908431

Co-Principal Investigator: Dr. Muktarun Islam, Assistant Professor, Dept. of Irrigation and Water Management, Faculty of Agricultural Engineering and Technology, Sylhet Agricultural University, Sylhet-3100. Cell Phone: +8801917128945

4. **Sub-project budget (Tk):**
   - 4.1. Total: Tk.20,000,00.00 (Twenty Lakh)
   - 4.2. Revised (if any): N/A
5. **Duration of the sub-project**:
   - 5.1. Start date (based on LoA signed): 10 May 2017
   - 5.2. End date: :30 September 2018
6. **Justification of undertaking the sub-project:**

Wetland exerts a significant influence on the agriculture as it is influenced by altering flood flows, low flows and groundwater recharge. Land use changes encompass one of the greatest environmental concerns of human populations today, including climate change, the pollution of water, soils and air. There is limited information on wetland and its component, water use in dry season, land use pattern with changing climate. The current study is approaching an innovative research to the improvement of the quality of life addressing hydrology, hydrogeology, and climatological parameter for sustainable agricultural development, poverty alleviation and capacity building of local communities in haor area.

7. **Sub-project goal**: Land suitability and water productivity for major cropping pattern

8. **Sub-project objective (**s):
   i. To investigate the influence of climatic variability on haor water dynamics
   ii. to investigate the geo-structural and hydraulic characteristics of aquifer
   iii. to assess land suitability and cropping practice by application of GIS in haor area
   iv. to develop a crop establishment period and the water management package suitable for haor area

9. **Implementing location (s):**

Organization	Name of Haor	Upazillas	Districts
Sylhet Agricultural University	Hakaluki	Fenchuganj	Sylhet

10. Methodology in brief:

Review of Existing Database and Recommendation

A review of historical databases related to water level (both groundwater and surface water), agro-climatologic parameters such as rainfall, temperature, evaporation, relative humidity, wind speed etc. was done. This was carried out through a desk study after purchasing the information/data from the concerned organizations. Contacts were made and databases were maintained by the information of following national bodies such as Water Development Board (BWDB), Bangladesh Meteorological Department (BMD), Department of Public Health Engineering (DPHE), Bangladesh Agricultural Development Corporation (BADC) and Department of Agriculture Extension (DAE). Topographical, land use/vegetation coverage and geological maps and photographs were purchased from Space Research and Remote Sensing Organization (SPARSO), Centre for Environmental and Geographical Information System. (CEGIS), Institute of Water Modeling (IWM) etc. Secondary information sources such as reports and scientific publications were gathered and reviewed. Based on detailed interpretation of collected data, climatologic and water resources conditions in the regional context were evaluated and a guideline was formulated for up scaling tools.

Benchmark Survey and Farmer Selection

Benchmark survey was conducted using Participatory Rural Appraisal (PRA) tools to collect qualitative data and information regarding climate change vulnerabilities, resource identification, and land coverage, cropping practice in different season, land use, water management, and shortcomings of current irrigation practice, livelihood, and income level. Focus Group Discussions (FGDs), Key Informant Interview (KII) and in-depth interviews were conducted. The FGD participants included farmers and fishermen (both male and female). A number of 15-20 people participated in each FGD. The participants were selected based on certain level of knowledge on disaster, livelihood and relevant issues. The participants of FGD were selected by the researchers. Household survey was conducted to collect data and information on different issues and variables related to climate change impact on agriculture and livelihood. The checklist covered the areas of socio-economic status of the respondents, water use, cropping practice and knowledge on climate change and relevant damages on agriculture. A pilot testing of questionnaire was conducted prior to survey for validating the checklist or questionnaire to extract exact information from community level. All the social data were analyzed using SPSS. The entered data were checked through logical test, range and consistency check. A number of Consistency checks were done for checking internal consistency and quality of data. The processed data were analyzed using SPSS statistical data analysis pack.

Existing Data Collection and Compilation

The bore log data were collected from both primary and the secondary sources (DPHE-JICA, 2007, BWDB). Geological and hydrological data, historical data on groundwater level, river water level, and current land use practices over the study were collected and compiled.

Evaluation and Assessment of Water Use and Quality Status

The spatial and temporal trends of 20 years data on agro-climatological parameter such as rainfall, temperature, evaporation, relative humidity have been analyzed by MAKESENS trend model using the compiled data. Water table fluctuation was monitored and its long term trend analysis was done using MAKESENS trend model. The bore log data were analyzed by using the software Rockworks 15 (www.rockware.com) to evaluate stratification, configuration, and possible aquifer connectivity. Rockwork 15 is an integrated geological data management, analysis, and visualization packages. This software is specializing in visualization of subsurface data as logs, cross-section, fence diagrams, solid models etc. Topographical, land use/vegetation coverage and geological maps and photographs had been purchased from concerned organization. ARC/GIS version 9.2/10 was used in preparing the maps and the subsequent spatial analysis. The variation of river water level, interaction between groundwater levels on existing data were carried out. The collected data were processed graphically to make them error free and to fill out the missing data where possible. The processed data were analyzed both graphically and statistically. The dynamics of interaction between the groundwater and the river water for the rivers Kushiyara (Sheola), Sonai-Bardal (Jaldhup) and Continala (Juri) were evaluated by graphical analyses. The period of a year for which the flow occurred from the river to the aquifer or vice versa was estimated for the period of analysis. The results of all these evaluations for three rivers were compared. The correlation between the climatologic parameter and the river water level and groundwater level were also studied.

Consistency in data and uncertainties in interpretation were noted; and for improved interpretation, further analysis on the proposed monitoring network and its adequacy were carried out as elaborated in step 4 and step 5.

Site Selection

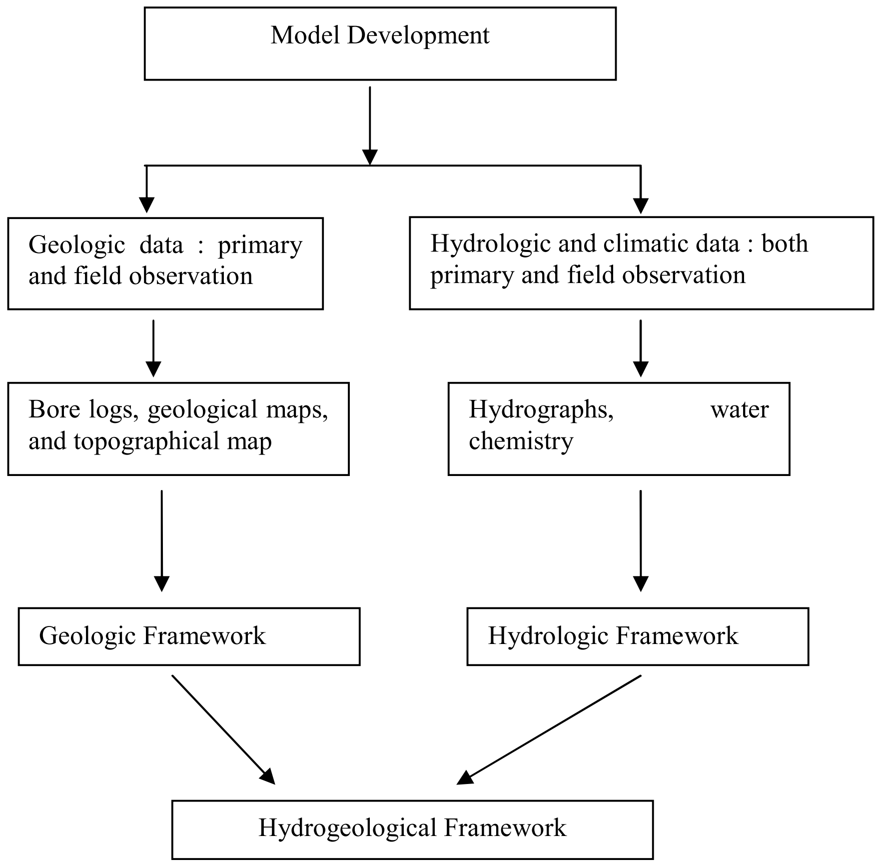
The site for monitoring river water level and groundwater level had been selected based on the field investigation, bore log information and. In the field investigation, the Key Informant Interview (Neogi and Babul, 2004) was done to evaluate the local indigenous and technical knowledge on aquifer condition, presence of chemical properties such as Fe, As, etc in the aquifer system. The Key Informant Interview (KII) involves the local leaders, well drillers, and the local officials of BWDB, DPHE, BADC and DAE.

Installation of staff gauge and observation well for water level and water quality monitoring

Staff gauges were installed at selected sites of the river and regular monitoring of river water levels and water quality were done during the whole project period. To validate water level/piezometric water level data with collected historical water level/piezometric water level data from secondary information 2 (Two) sets of observation wells at selected locations were installed. In addition at least 10 STWs and DTWs sites were used for water quality analysis. The water table/piezometric water levels at these observation wells would define variation of groundwater level.

Development of Hydrogeological Framework

The future state of the water resources (groundwater and surface water) was evaluated through scenario analysis considering the demand on groundwater and surface water interaction between river-aquifer system, sustainability of water extraction, the impact of climate variability as well as the interactions with development activities, land use, water use etc. Based on climatologic, hydrological and geological information, hydrogeological framework have been developed.



Improved Cropping System and Water Management

It was planned to conduct field experiments on rice and non-rice crops in Boro/Rabi season and Rice in aus season to get a suitable option of new cropping pattern in the selected site of Hakaluki haor. Prolonged flood occurred in Hakaluki haor area that kept the adjacent area up to October 2017. For this reason, the bench mark survey delayed despite of having no financial crisis. The social crisis was more. The rabi crop (Maize with mulch and non-mulch condition) establishment plan could not be executed as the water receded up to November 2017.

The planning of Boro season was to have two options (i) dry seeding of soaked seed in puddle soil just after removing the water from field and (ii) at the same date seeds were sown in seedbed for transplanted Boro with the hypothesis that direct seeded Boro would have shorter growth duration and thus could be able to avoid flash flood damage. The direct seeding was not possible due to huge standing water (about 15-20 cm height) in the main field. Boro season transplanted experiment had started but the seedling damaged due to heavy rainfall in first week of December. Thus the Boro and Rabi season experiment was a failure and no result could be achieved.

For this reason, the recommendation for haor area is not to go for Rabi crops and early awareness and discussion with the farmers to establish dry seeded and transplanted Boro.

Though during the project duration another Rabi and Boro season was not available but farmers of the project area were encouraged to establish dry seeded Boro rice and transplanted Boro rice under the super vision of students and teachers.

Another cropping pattern option was to grow aus rice followed by maize but it was highly ambitious as during aus season (from May-August; with a 110 days variety) the whole hoar inundate by river water forming a mini sea. Thus aus rice was thus established in the highland of haor that usually used for residence. In between the village house there is agricultural land. Transplanted aus was established in that land as a demonstration plot. Two aus varieties BRRI dhan48 (Farmers practice) and BRRI dhan65 (new BRRI variety having a growth duration of 100-110 days).

It was observed that the new variety of BRRI dhan 65 had a yield of 6 ton/ha and in farmer's usual practice, BRRI dhan48 had a yield of 4 ton/ha

Management practices

Seedbed for seedling raising

Seed rate of rice was 30 Kg/ha for aus season. Seedbed of transplanted rice aus was prepared in a separate place near the experimental field. Rice seed was soaked for 12 hours and incubated for 48-72 hours. Then the germinated seeds were sown in the seedbed. The width of seedbed was 1.0 m and length, 2/3m. Twenty one days old seedlings of rice were transplanted on the puddled land with a spacing of 20 cm x 20 cm in aus season.

Fertilizer application

For aus rice TSP, MOP, Gypsum, Zinc and Boric acid were applied at 60 kg P_2O_5, 40 kg K_2O, 60 kg $CaSO_4$ and 10 kg $ZnSO_4$ per ha as basal dose after final land preparation. Urea (100 kg N ha-1) was top dressed in 4 equal splits at basal, 15 days after transplanting (DAT), 5-7 days before PI (at 30-35 DAT) and at heading (at 55-60 DAT) (BRRI 2011).

Weeding, Insect pest and disease control

Weeding was done in rice plots manually synchronizing with urea topdressing to keep the crop field free from weed Attack. Insects and pests were closely monitored in all crops and insecticide and pesticide were applied when necessary.

Water and agro-climatic data measurement

Water management

Aus rice was mainly rainfed crop, as rainfall was sufficient to meet crop water requirement for rice but supplemental irrigation was provided in dry period from nearby pond by a low lift pump. Pond water was also used in land preparation for seedbed.

Rainfall and evaporation

A standard manual rain gauge and a USWB Class A evaporation pan was installed in the vicinity of the experimental field to determine rainfall and evaporation of the study site. These data were collected daily at 9:00 AM.

Yield

Rice grain yield of whole plot was harvested. The samples were threshed, cleaned and dried properly to calculate the yield per ha. Finally, the yield was converted to 14% moisture content. Yield components were not collected as it was demonstration.

Socio-economic impact study in the project area

The socio-economic changes in the study area due to the improved cropping pattern, effective use of the irrigation water in the study area (Fenchuganj) were obtained by comparing the benchmark study, initial framers information on income and livelihood with the research outputs.

11. Results and discussion:

11.1 Climatic Variability in the Study Area

11.1.1 Analysis of rainfall

The climatic factor of the region is subtropical monsoon in nature with four distinct seasons. These are: pre monsoon season which extends from April to May and is characterized by the increasing rainfall. The monsoon season spreads from June to September and is characterized by heavy rainfall occurring for a long duration. Post monsoon season extends from October to November and is characterized by decreasing rainfall. Dry season extends from November to March and is characterized by little or no rainfall. The average annual rainfall in the region is 4150 mm. Average annual rainfall over the last 20 years is shown in Fig. 1.

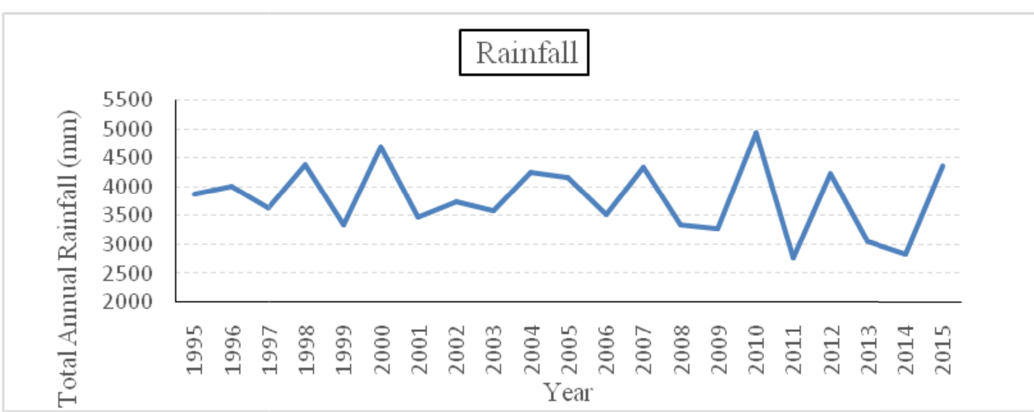
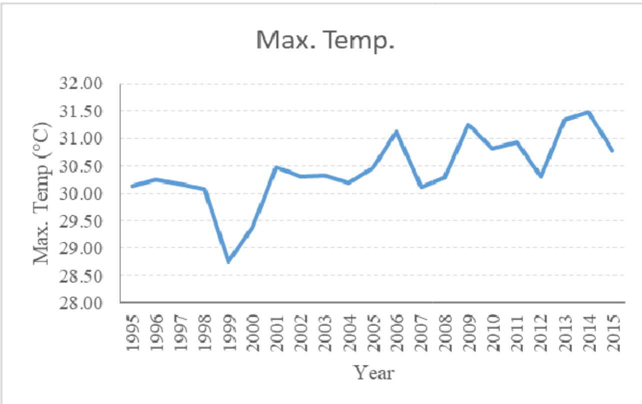


Figure 1: Average Annual Rainfall (mm) of the study area

11.1.2 Analysis of temperature

Temperature is an important meteorological parameter for maintaining ecological balance in Hakaluki haor. The sylhet area has been experiencing temperature range from 20°C to 31.5°C from December to January (Fig. 2). According to the historical monthly maximum and minimum temperature analysis (1995 to 2015), maximum temperature occurs in the month of March to April while minimum temperature occurs in December to January.



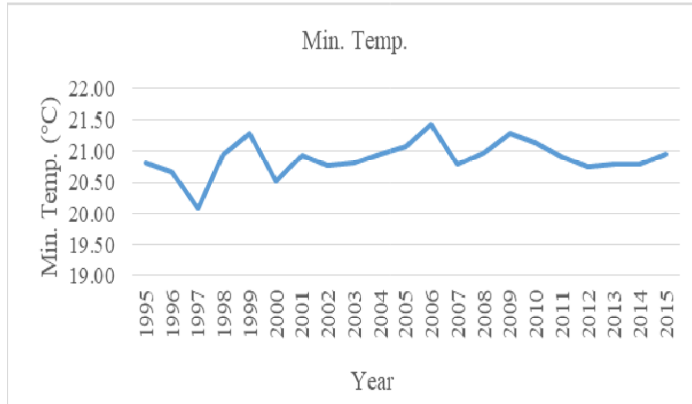


Figure 2: Annual Maximum and Minimum Temperature

11.1.3 Analysis of humidity

Humidity is the important meteorological parameter in Hakaluki haor. Figure 3 represents the annual relative humidity in Hakaluki haor from 1995 to 2015. On an average, August is the most humid and March/April is the least humid month. The relative humidity is over 80% during June through September.

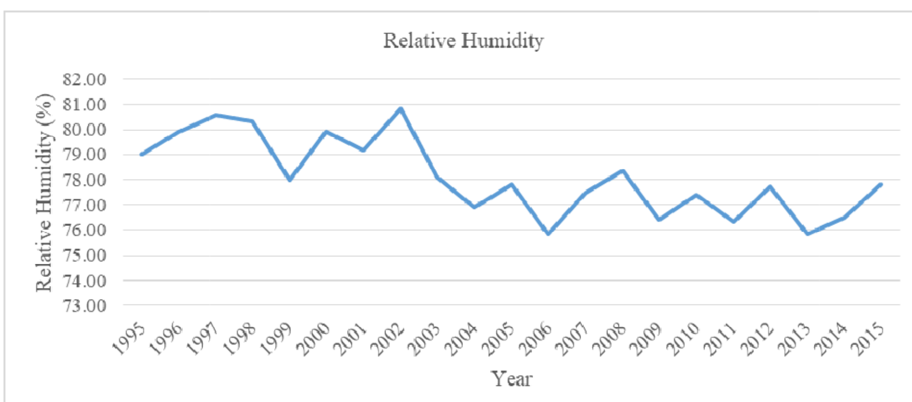


Figure 3: Relative Humidity (%)

Table 1 shows the mean value of Temperature, Rainfall, and Relative Humidity from 1995 to 2015 for the study area. The maximum mean temperature from 1995 to 2015 was 30 to 31 degree celcious. Maximum mean temperature occurs in the month of March to April. It may vary from 29 to 31 degree celsius. In 2015 the maximum mean temperature was 30.78 degree celsius. The minimum mean temperature varies from 20 to 21. The minimum mean temperature occurs in the month of December to January. In 2015 the minimum mean temperature was 20.95. Mean rainfall from 1995 to 2015 is shown in table 1. The average annual rainfall in this region is 4150 mm. Humidity is the important meteorological parameter in Hakaluki haor. Average relative humidity from 1995 to 2015 is shown in table 1. On an average, August is the most humid and March/April is the least humid month. The average relative humidity in this region is 80%.

Table 1 showed 20 years mean value of Temperature, Rainfall, and Relative Humidity for the study area

Year	Maximum Mean Temperature	Minimum Mean Temperature	Rainfall (mm)	Relative Humidity (%)
1995	30.13	20.81	6.51	79.00
1996	30.25	20.67	33.34	79.92
1997	30.18	20.09	128.03	80.58
1998	30.07	20.97	371.63	80.33
1999	28.76	21.28	577.57	78.00
2000	29.38	20.53	762.06	79.92
2001	30.48	20.94	755.97	79.17
2002	30.30	20.76	626.66	80.83
2003	30.31	20.82	547.43	78.08
2004	30.20	20.96	191.03	76.92
2005	30.46	21.07	26.57	77.83
2006	31.12	21.43	11.49	75.83
2007	30.11	20.80	261.00	77.50
2008	30.28	20.98	181.05	78.33
2009	31.25	21.29	127.10	76.42
2010	30.82	21.14	42.33	77.42
2011	30.92	20.91	20.93	76.33
2012	30.31	20.76	177.25	77.75
2013	31.35	20.80	235.81	75.83
2014	31.48	20.80	681.91	76.50
2015	30.78	20.95	237.74	77.83

11.2 Variation of river water level

The river system of north eastern corner of Bangladesh has played a very significant role in shaping the physical characteristics of Hakaluki haor. The Kushiyara river flows by the northern boundary of the study sites. The two main rivers, namely the Sonai and Bardal river enters the wetland haor from the east and the Juri river from the southeast. The water levels inside Hakaluki haor are governed by the water levels in the Kushiyara river at the outfall of the Juri river. The maximum water level occurred between April to July in each year. The highest water level was found in the month of July and the lowest water level in the month of December. During the wet seasons, water levels within the haor area gradually rise as water flows from the rivers into the haor. In dry season, water level recedes in the haor as the reversal of flow takes place with the falling stages in the rivers as well as evaporation exceeds rainfall.

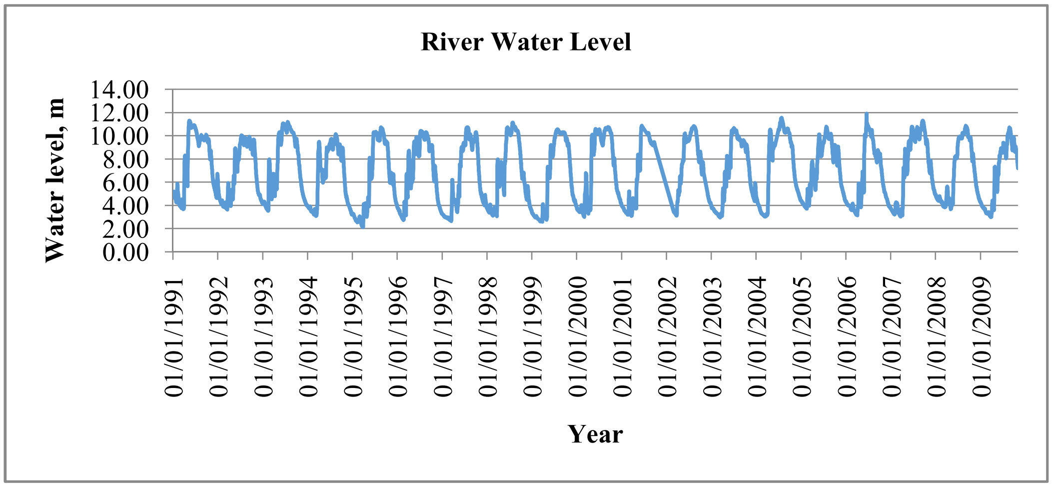


Figure 4: Variation of water level in Kushiyara River

Staff gauges were prepared and set at 3 points in Hakaluki haor at a distance of 150 m from each other. When water level in Hakaluki haor was rising, staff gauges were shifted and data were recorded. The measurement of water level was taken from 19 July 2017 and ends at 15 December 2017. The variation of water level is depicted in Fig. 5

Photograph 1: Staff gauge and measurement of water level

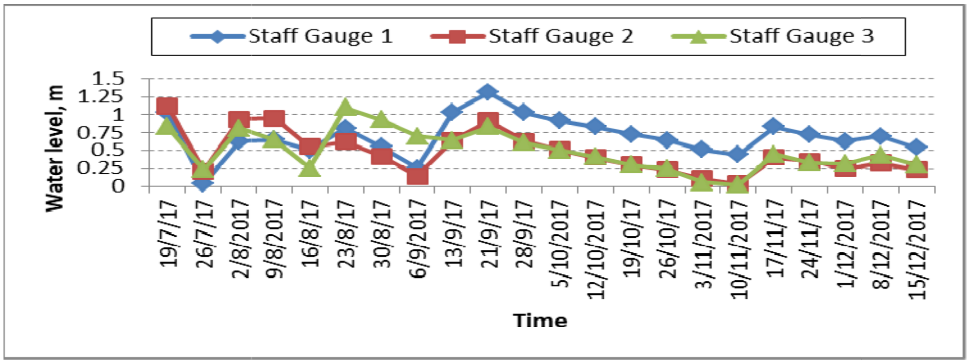


Figure 5: Variation of water level at different points in Hakaluki haor

11.3 Hydrogeological Investigation

11.3.1 Geologic setting

Bangladesh is bounded on two sides by the Himalayas to the north and the Indo-Burma ranges to the east. Between Bangladesh and the main Himalayan range, the Brahmaputra valley and the Shillong Massif are situated. The 'Hinge Zone' marks the edge of the Indian continental plate. Southeast of the Hinge Line, sediments of the Bengal Basin up to 12 km thick, overlie ocean crust. The Shillong Massif is a southern extension of the main Himalayan thrust zone, formed by Asia over-riding the Indian plate. The Indo-Burman ranges extend southward into the Andaman Arc (Curray and Moore, 1974). The two ranges meet to the north-east of Sylhet, producing rapid subsidence in the Sylhet Trough shown in Fig. 6 (Rahman and Ravenscroft, 2003).

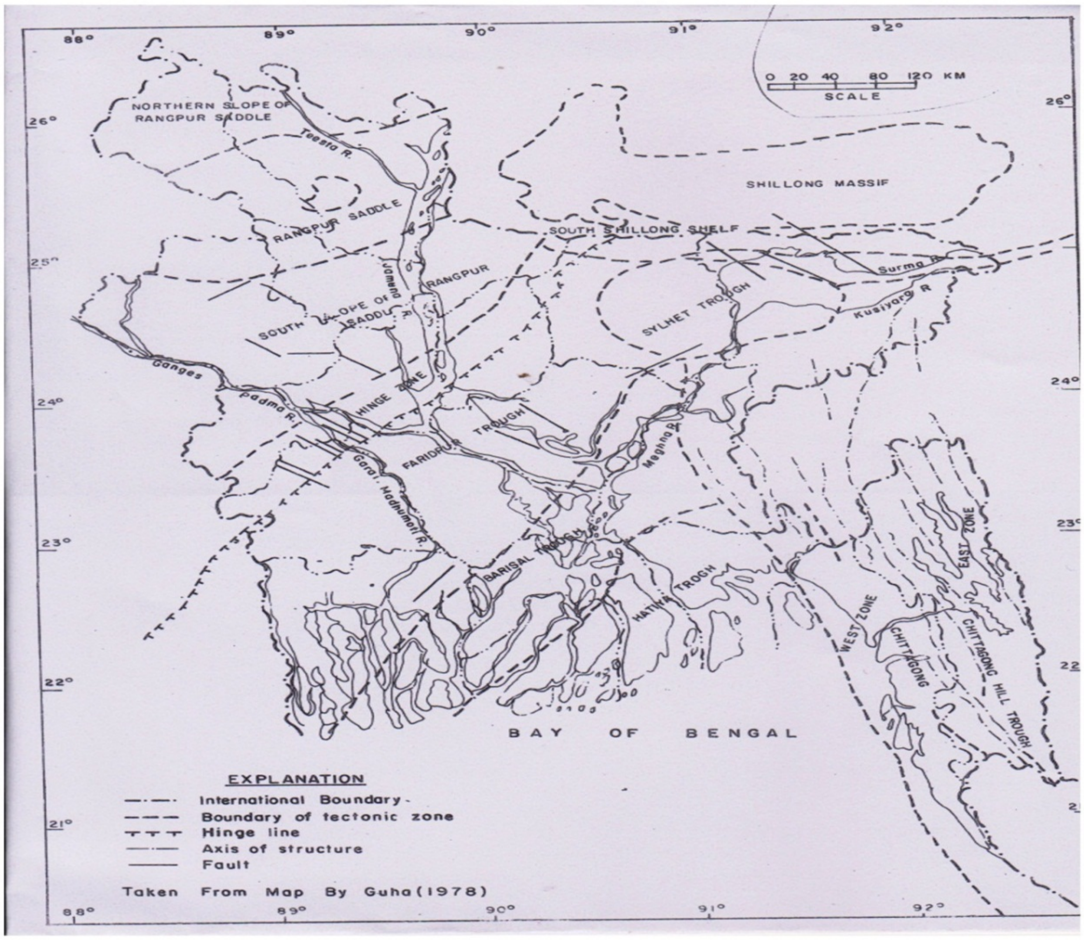


Figure 6: Tectonic Map of Bangladesh (Rahman and Ravenscroft, 2003)

In Cretaceous to Eocene times, the area that is now Bangladesh occupied a shelf sea on the eastern edge of the Indian Plate. The Sylhet Limestone was deposited in a shallow shelf sea and Kopili Shale was deposited in deeper water to the south-east (Fig. 7A). During the Oligocene major changes in the tectonic regime took place. The Indian plate had begun to collide with Asia and begun the first phase in the uplift of the Himalayas (Brunschweiler, 1974). The continuous marine border of the Indian plate was converted into an embayment (now the Bay of Bengal) (Fig. 7B). During the Miocene (Fig 7C), uplift of the Himalayas and Indo-Burma ranges became more intense, while subsidence and sediment accumulation in the Bengal basin increased significantly. The drainage pattern of the proto-Brahmaputra would have been increasingly confined by the rising mountain ranges to the south-east and north. This river flowed through the present area of Bangladesh in the Sylhet region. The Bengal basin took on its present form in the Pliocene (figure 7D). Uplift of the Himalayas and Indo-Burma ranges continued on a spasmodic basis. The sedimentary environment changed from delta front to braided river with deposition of the Tipam and DupiTila sandstones (Rahman and Ravenscroft, 2003).

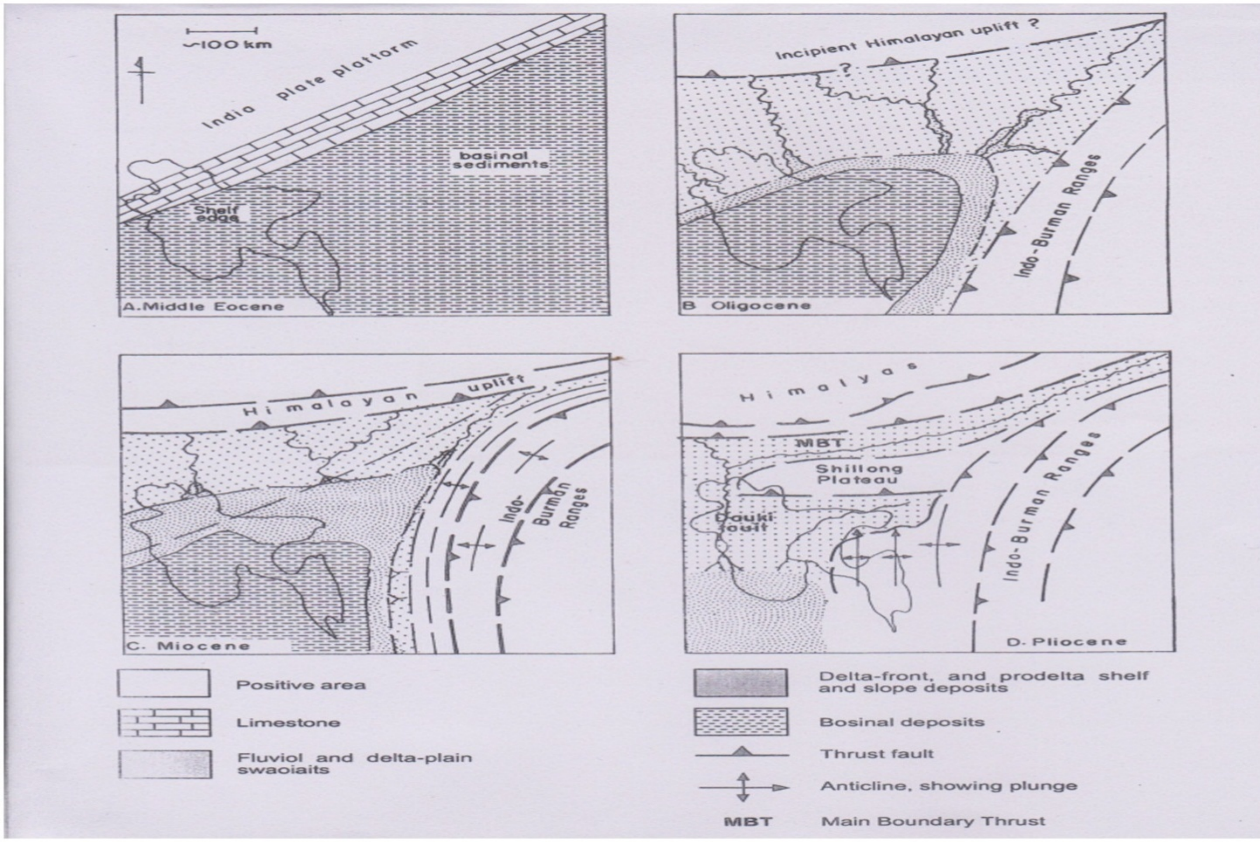


Figure 7: Tectonic Evolution of the Sylhet Trough (Rahman and Ravenscroft, 2003)

The Stratigraphical column of the Sylhet region is shown in the table 2. The undifferentiated quaternery sediments are consisting of siliciclastics, organics and freshwater carbonates stored. The siliciclastics are light grey, brown to black, unconsolidated to poorly consolidated silty and sandy clays (Scott et al. 2001). Dihing Formation has scatteredly occurred in the Bengal Basin. The formation has a patchy distribution within Bangladesh. The formation consists of yellow and grey, medium-grained, occasionally clayey sandstone. The rocks are in most part poorly consolidated. Tipamsereis is a Mio-Pliocene lithostratigraphic unit in the Bengal Basin comprising several formations. It is visible in Upper Assam and the Surma valley and extends to the Arakan coast. This formation is subdivided into two formations: the Tipam Sandstone Formation and the Girujan Clay Formation. The Tipam Sandstone formation is coarse-grained sandstone. In the case of absence of the Girujan Clay Formation, the Tipam Sandstone formation is unconformably overlain by the DupiTila Formation. The Tipam Sandstone Formation typically consists of grey-brown, coarse-grained sandstone. The Girujan Clay formation develops from the underlying Tipam Sandstone. The Girujan Clay Formation represents lacustrine floodplain and over bank deposits (Banglapedia). The DupiTila Formation is composed of yellow to light brown medium to very fine moderately hard to loose sandstone, siltstone (Roy et al. 2012). In Sylhet, the DupiTila formation consists of two distinct units. The lower part is composed chiefly of massive sandstone. The sandstone is yellow to yellowish brown, medium to coarse. The upper part consists of claystone and siltstone (BADC, 1992).

Table 2: Stratigraphical Column for Greater Sylhet (BADC, 1992)

Age	Formation	Lithology	Thickness
Quaternary	Undifferentiated	Stream, over-bank and piedmont deposits	
Pliocene	Dihing Series	Sands with gravel beds	0-5000 ft
Mio-Pliocene	Tipam Series		
	Upper DupiTilla	Sandstones, sandy clays	Approximately 6000 ft
	Lower DupiTilla	Sands, fining to the south and west,	Approximately 6000 ft
	Girujan Clay	Clay, sandy clay and clayey sand	0-5000 ft

In the Sylhet Trough, the thickness of the Tipam and DupiTila are reduced over the anticlines (which now form the prominent linear hills of southern Sylhet) indicating that folding had commenced. Deprived of sediment input from the regional rivers, beds of medium to coarse sands became rarer and more localised and as subsidence continued the Sylhet Trough was increasingly filled in by fine sediments which cause poor aquifer conditions in Sylhet which also supported by the results of Rahman and Ravenscroft, 2003 studied geological background to the hydrogeology of Bangladesh. BADC 1992, concluded that the DupiTilla formation offered the only good aquifer formation among all the strata.

11.3.2 Lithological and stratigraphic analysis

The secondary Bore log data of Fenchuganj Upazilaadjacent to Hakaluki haor was collected from Bangladesh Water Development Board (BWDB). To get the profile of aquifer characteristics the lithologic profile of Gowainghat, South Surma, Golapganj also studied (Table 3).From the extraction of these lithologic data, the lithologic and stratigraphic condition of those areas was carried out. The aquifer top, aquifer thickness and aquitard thickness was also determined from the stratigraphic condition.

Table 3: Location and number of bore log

Location	Number of Bore log
Fenchuganj Upazila	4
Golapganj Upazila	5
Gowainghat Upazila	2
Jaintiapur Upazila	1
South Surma Upazila	3

The lithological data describes the formation of different layers in the soil in those locations. The stratigraphical data help to identify the aquifer formation in different layers. Stratigraphical data also support to find the best aquifer formation from which water can be extract at the desired rate and in sufficient quantity. The lithology of the samples were classified as Clay, Silty clay, Very Fine sand, Fine sand, Medium sand, Medium to coarse sand, Coarse sand, Coarse sand with Gravel, Gravel. From that classification of bore log data, the samples were also stratigraphically classified as Aquitard, Poor Aquifer, Good Aquifer and Very Good Aquifer.

The location 1 of Fenchuganj Upazila is situated between 24.68^0 N and 91.94^0 E. This borehole is drilled to the depth of 274 m and is divided into 20 layers. The depth from the ground surface to 68 m has 6 layers in which 3 layers are made up of aquifer material whereas other 3 layers are aquitard. From the depth of 68 m to the depth of 140 m it is composed of different poor geologic formation to yield water. Then a 16 m thick Medium sand layer is found in this borehole that can bear water. Rest of the depth about 118 m is composed of different non-water bearing strata that make the location poor according to the aspect of water accessibility.

The borehole 2 of Fenchuganj Upazila is situated between 24.67^0 N and 91.95^0 E with the total depth of 142 m. The depth up to 90 m is made up of clay, Silty clay and Very Fine sand. From 90 m to 105 m a very good aquifer formation which is composed of Coarse sand with gravel is found that can store and transmit significant quantities of water. Then a 9 m thick Sandy clay layer is found. After that, a 28 m thick continuous good aquifer layer is found that can yield sufficient water.

The borehole at location 3 is situated between 24.73^0 N and 91.92^0 E. This borehole is drilled to the depth of 155 m and is divided into 24 layers. The layers of this borehole are very thin and the formations of soil in these layers are changed very rapidly. The first layer is only 10 m thick composed of clay. The second layer is 12 m thick and composed of Silty clay. Most of the layers are composed of either non-water bearing or low water bearing strata to the depth of 155 m. Only 15 m thick aquifer formation is found at 3 discrete layers. The first aquifer layer is found at the depth of 38 m which is only 2 m thick, second layer is found at 42 m of 8 m thickness and the last aquifer layer is found at 148 m to 153 m.

The fourth borehole of Fenchuganj Upazila is located between 24.65^0 N and 92^0 E with the total depth of 128 m. The lithological and stratigraphic formation of this location is very poor on the aspect of water storage and transmits capacity. There is no well-developed water bearing strata.

In the Fenchuganj Upazila, very good aquifer formation is not found except second borehole which is moderately capable to produce water which has aquifer thickness of 88 m. Other boreholes are unsuitable for production of sufficient water as the aquifer thickness has been found very thin (4-5 m). In high land areas, STW is mainly used for irrigation but in dry seasons water level goes downward and water can not be pumped through the STW. This is the common scenario in high lands of haor area. Therefore, it is recommended that irrigation should be supplied by installing DTW with proper operation and maintenance for the sustainable crop production in high lands of haor area.

Table 4: Lithology and Stratigraphy of Fenchuganj Upazila

Location	Layer	Thickness (m)	Depth (m)	Lithology	Stratigraphy
1	1	30	30	Clay	Aquitard
	2	4	34	Medium sand	Thin aquifer
	3	11	45	Silty clay	Aquitard
	4	5	50	Medium sand	Thin aquifer
	5	8	58	Silty clay	Aquitard
	6	10	68	Medium sand	Good aquifer
	7	14	82	Clay	Aquitard
	8	3	85	Silty clay	Aquitard
	9	15	100	Clay	Aquitard
	10	14	114	Silty clay	Aquitard
	11	14	128	Clay	Aquitard
	12	12	140	Silty clay	Aquitard
	13	16	156	Medium sand	Good aquifer
	14	30	186	Clay	Aquitard
	15	10	196	Silty clay	Aquitard
	16	4	200	Medium sand	Good aquifer
	17	8	208	Silty clay	Aquitard
	18	14	222	Clay	Aquitard
	19	16	238	Silty clay	Aquitard
	20	36	274	Clay	Aquitard
2	1	15	15	Clay	Aquitard
	2	25	40	Very Fine sand	Poor Aquifer
	3	14	54	Silty clay	Aquitard
	4	10	64	Clay	Aquitard
	5	6	70	Silty clay	Aquitard
	6	20	90	Very Fine sand	Poor Aquifer
	7	15	105	Coarse sand with Gravel	Very Good Aquifer
	8	9	114	Sandy Clay	Aquitard
	9	10	124	Coarse sand	Very Good Aquifer
	10	18	142	Medium to Coarse sand	Good aquifer
3	1	10	10	Clay	Aquitard
	2	12	22	Silty clay	Aquitard
	3	4	26	Sandy Clay	Aquitard

3	4	6	32	Silty clay	Aquitard
	5	6	38	Fine sand	Poor Aquifer
	6	2	40	Coarse sand	Very Good Aquifer
	7	2	42	Fine sand	Poor Aquifer
	8	8	50	Medium sand	Good aquifer
	9	6	56	Fine to Medium sand	Poor Aquifer
	10	2	58	Clay	Aquitard
	11	12	70	Silty clay	Aquitard
	12	10	80	Clay	Aquitard
	13	2	82	Silty clay	Aquitard
	14	10	92	Clay	Aquitard
	15	5	97	Silty clay	Aquitard
	16	5	102	Sandy Clay	Aquitard
	17	22	124	Very Fine sand	Poor Aquifer
	18	4	128	Silty clay	Aquitard
	19	2	130	Clay	Aquitard
	20	10	140	Very Fine sand	Poor Aquifer
	21	6	146	Fine to Medium sand	Poor Aquifer
	22	2	148	Clay	Aquitard
	23	5	153	Coarse sand	Very Good Aquifer
	24	2	155	Silty clay	Aquitard
4	1	8	8	Silt	Aquitard
	2	52	60	Silty clay	Aquitard
	3	24	84	Silt	Aquitard
	4	16	100	Very Fine sand	Poor Aquifer
	5	10	110	Clay	Aquitard
	6	6	116	Silt	Aquitard
	7	12	128	Fine sand	Poor Aquifer

11.4 Aquifer characterististics

11.4.1 Aquitard thickness

The Figure 8 covers the areas of Gowainghat, South Surma, Golapganj and Fenchuganj Upazilas from North to South. The maximum thicknes of aquitard 235 m is found in Fenchuganj-1 and the minimum thickness of 54 m is found in Fenchuganj-2. The average aquitard thickness of Gowainghat, South Surma and Golapganj is found between 111 m - 210 m whereas the average aquitard thickness of Fenchuganj upazila is found below 100 m except in Fenchuganj-1. It is found that, the aquifer formation is better in Fenchuganj than other location, since the non-water bearing strata is thinner in this upazila.

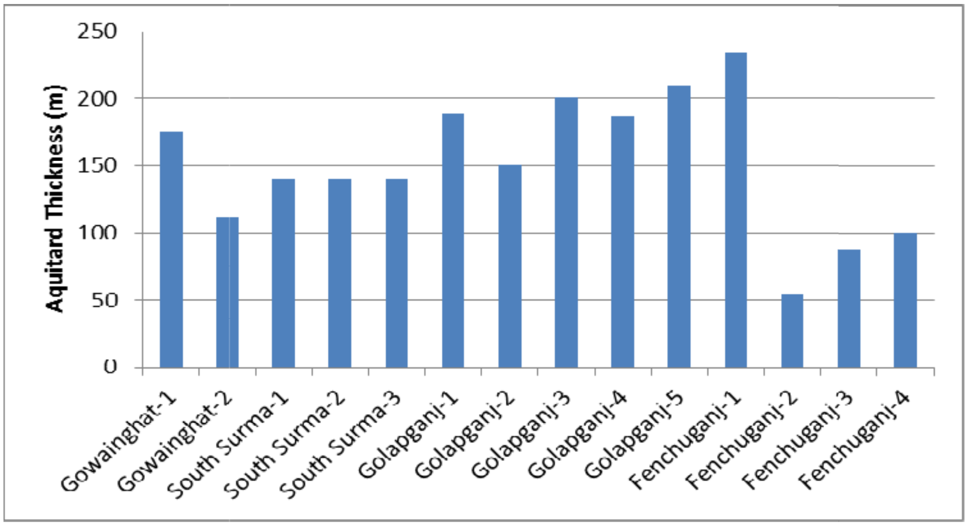


Figure 8: Spatial Variation of Aquitard Thickness

11.4.2 Aquifer top

Figure 9 covers the areas of Gowainghat, South Surma, Golapganj and Fenchuganj Upazila from North to South. The maximum depth of aquifer top, 140 m, is found in South Surma-1, 2 and the minimum depth of aquifer top, 6 m, is found in Golapganj-4. In Gowainghat, South Surma and Golapganj, the aquifer top is found between 32 m - 108 m whereas the average depth of aquifer top in Fenchuganjupazila is found between 15 m - 32 m except in Fenchuganj-4. It is found that, the aquifer formation is found to haveshallower depth in Fenchuganj than other location.

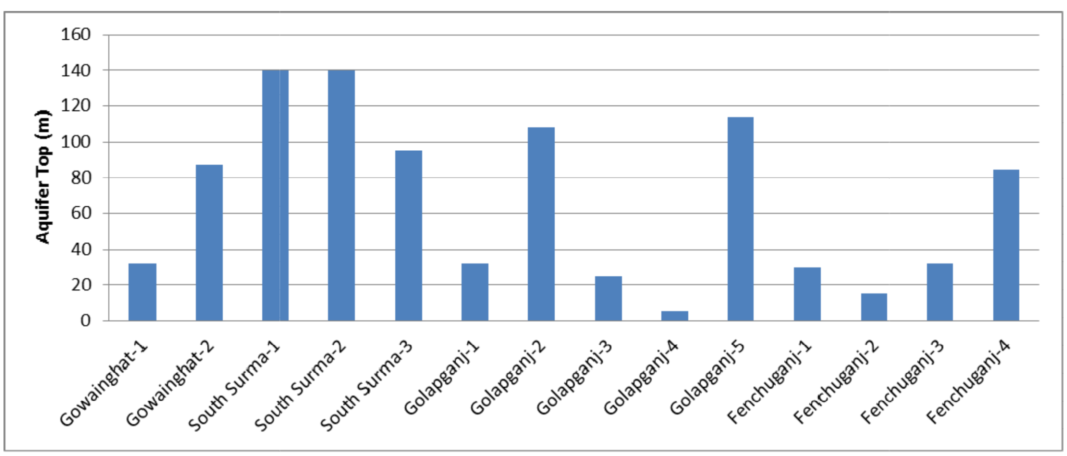


Figure 9 : Spatial Variation of Aquifer Top

11.4.3 Thickness of aquifer

Figure 10 covers the areas of Gowainghat, South Surma, Golapganj and Fenchuganj Upazila from North to South maximum thicknes of aquifer, 88 m, is found in Fenchuganj-2 and the minimum thickness of aquifer, 12 m, is found in South Surma-1 and 2. The average aquifer thickness of Gowainghat, South Surma and Golapganj is found below 40 m, whereas, the average aquifer thickness of Fenchuganjupazila is found over 40 m. From both the aquitard and aquifer thickness, it is found that, the aquifer formation is better in Fenchuganj than other location since the non-water bearing strata is thinner and aquifer layer is thicker in this upazila.

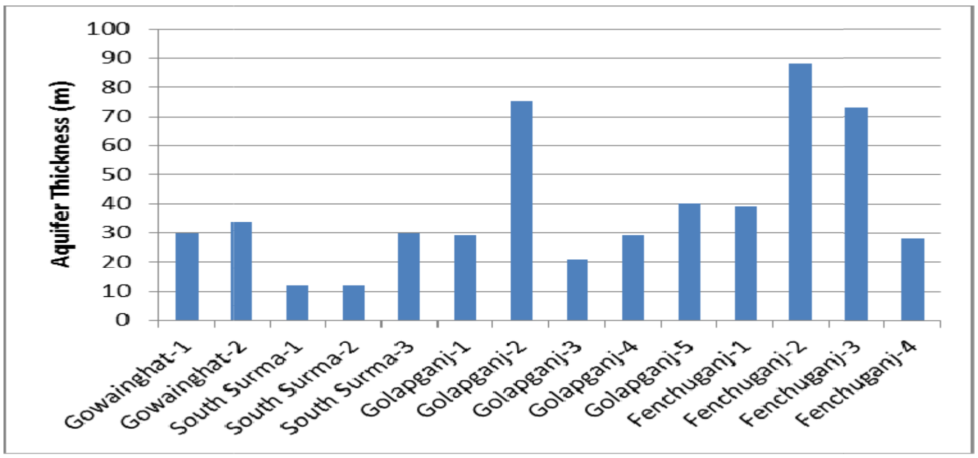


Figure 10: Spatial Variation of Aquifer Thickness

11.5 Land Use/Land Cover Pattern in Hakaluki Haor

11.5.1 Satellite data collection

For the study, two types of data were used. Satellite data that comprised of five years multi- temporal satellite imageries (LANDSAT 7 image 2000 and LANDSAT 8 image of 2019) for the month of February at path (136) and row (43) were acquired from the USGS GLOVIS website (Table 1). Ancillary data included the ground truth data for the LU/LC classes. The ground truth data was in the form of reference points collected using Geographical Positioning System (GPS) and used for image classification and overall accuracy assessment of the classification results.

Table 5: Data Source

S/N	Data type	Date of Acquisition	Spatial Resolution	Source
1	LANDSAT 7 image	12-02-200	30m x 30m	USGS GLOVIS
2	LANDSAT 7 image	02-02-2005	30m x 30m	USGS GLOVIS
3	LANDSAT 7 image	16-02-2010	30m x 30m	USGS GLOVIS
4	LANDSAT 8 image	10-02-2015	30m x 30m	USGS GLOVIS
5	LANDSAT 8 image	02-02-2019	30m x 30m	USGS GLOVIS

Based on the priori knowledge of the study area and a brief reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area. The developed classification scheme gives a rather broad classification where the land use land cover was identified by a single digit.

Table 6: Land Use/Land Cover Classification Scheme

Land Use/Land Cover Categories		Description
1	Water Bodies	This class of land cover describes the areas covered with water either along the river bed, in the beels or in ponds
2	Dense Vegetation	This describes the areas with evergreen trees mainly growing naturally in the land, along the river
3	Crop Land	The land which is mainly used for growing food crops
4	Bare Land	This describes the land left without vegetation cover. This result from abandoned crop land, eroded land due to land degradation.
5	Human Settlement	This class describes the land covered with buildup area

11.5.2 Landsat image analysis

The maximum likelihood supervised classification has been adopted successfully to classify land use/land cover (LU/LC) in Hakaluki Haor. Landsat images used in this study were taken from USGS GLOVIS website. Five LU/LC categories were identified in Hakaluki haor as water bodies, dense vegetation, crop land, bare land and human settlement.

11.5.3 Land use/Land cover classification scheme for the Year 2000

The entire study area of 420.23 Km^2 has been classified into five major LU/LC scheme. The LU/LC classification result is summarized for the year 2000 in Table 7. The corresponding classification also presented as map using different colors to represent each LU/LC scheme which is illustrated in Fig. 11. In 2000, water bodies occupied 47 km^2 which was 11.18 % of the total area. In Fig. 11 Ultra Blue color is representing all water bodies which were third highest LULC category in 2000. About 58.79 km^2 area was covered with dense vegetation and Quetzel Green color of the Fig 11 signifying it. Crop land occupied large portion of total area and that was 268.44 km^2. Fir Green color is representing spatial expansion of crop land over the entire area (Fig. 11). On the other hand, at the very same year human settlement occupied least amount of area (19.48 km^2). The area covered with Citron Yellow color is indicating human settlement. From Fig. 11 it can be seen that Nuback Tan color specifying bare land which shielded about 26.52 km^2 of the total area.

Table 7: Land Use/Land Cover Classes of 2000

SL. No	LU/LC category	Area in sq.km	Area in %
1	Water Bodies	47.00	11.18
2	Dense Vegetation	58.79	13.99
3	Crop Land	268.44	63.88
4	Bare Land	26.52	6.31
5	Human Settlement	19.48	4.64
	Total	420.23	100

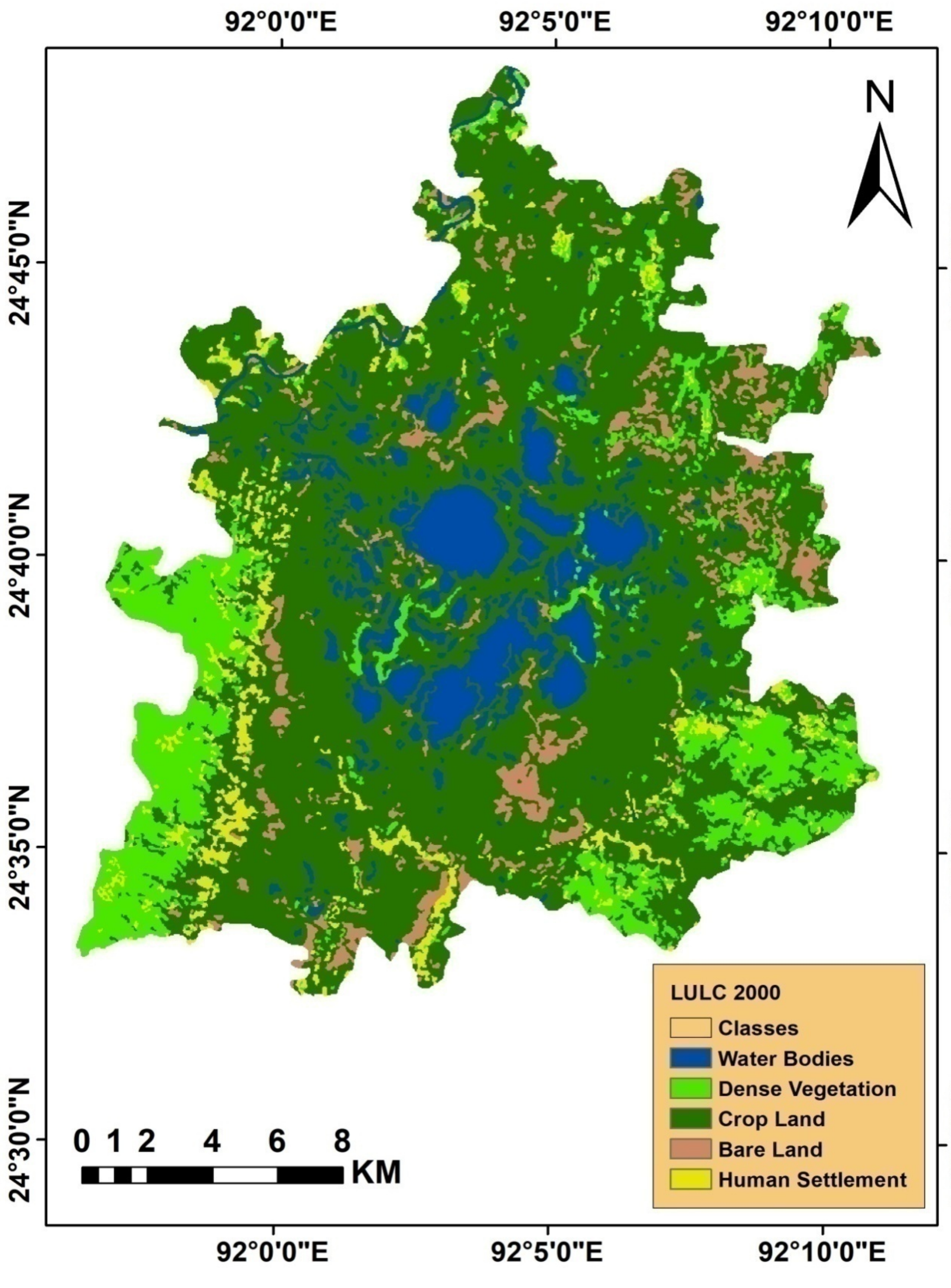


Figure 11: The Classification Image of Land Use/Land Cover in Hakaluki Haor (2000)

11.5.4 Land use/Land cover classification scheme for the Year 2019

Table 8 illustrates the LU/LC classification result for the year 2019. The area occupied by water bodies has been reduced to 18.31 km^2 which were 28.54 km^2 in 2015. From Fig. 12 it can be observed clearly that how fast the water bodies in Hakaluki Haor is shrinking over the time period.

Table 8: Land Use/Land Cover Classes of 2019

SL. No	Class	Area in sq.km	Area in %
1	Water Bodies	18.31	4.36
2	Dense Vegetation	11.78	2.80
3	Crop Land	255.48	60.79
4	Bare Land	23.57	5.61
5	Human Settlement	111.09	26.44
	Total	420.23	100.00

The occurrence of sedimentation in Hakaluki haor over a time periods introduces new soil boundaries along with high yielding rice crops which increases the shrinkage of the water body. The sedimentation process is speeded with the flow of upstream water from the surrounding hilly areas. As a result high yielding Boro rice cultivation is gaining popularity with ultimately shrinking the bio-resources of this wetland (Rana et al., 2010). For this reason, also in 2019, crop land occupied larger portion of area and that was 255.48 km^2. Spatial expansion of crop land over the entire area is significantly visible in Fig.12. It was also found that, the area shielded with bare land was decreased in 2015. However, in 2019, area of bare land in Haor increased to 23.57 km^2 by 2.83 %. By comparing Fig. 12 with Fig. 11 it can be seen that area covered with bare land is increased. Dense vegetation coverage decreased by 79.96 % from 58.79 km^2 to 11.78 km^2. By the next five years human settlement increased from 23.19 % to 26.44 %.

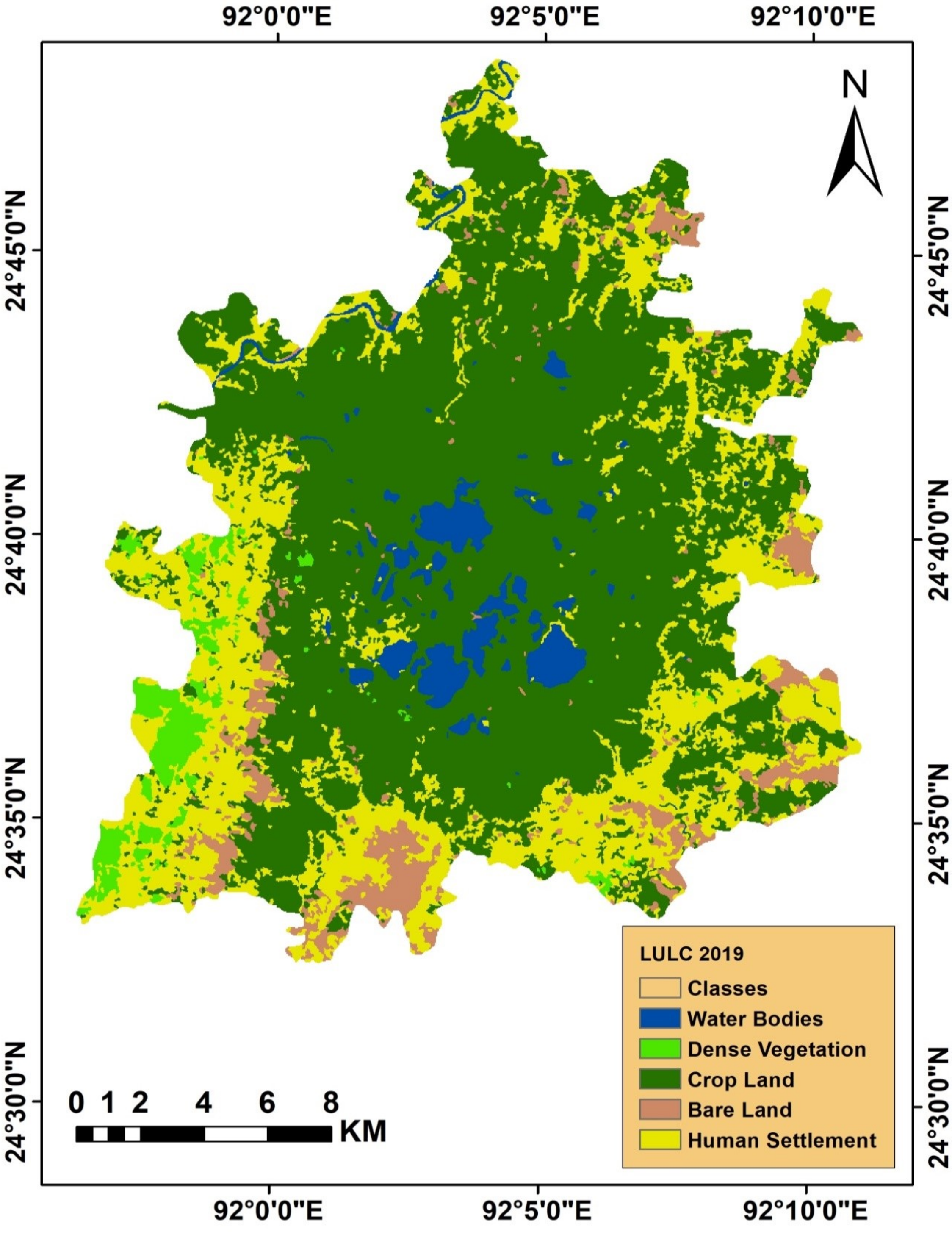


Figure 12: The Classification Image of Land Use/Land Cover in Hakaluki Haor (2019)

11.5.5 Change of area analysis between 2000 and 2019

Change of areas of different LU/LC categories between 2000 and 2019 are summarized in Table 9 and depicted in Figure 13. From 2000 to 2019, human settlement increased significantly by 21.80 % from 19.48 km^2 to 111.09 km^2. The results of this study showed that, water bodies, dense vegetation, crop land and bare land decreased by 28.69 km^2, 47.01 km^2, 12.96 km^2 and 2.95 km^2 respectively. LU/LC changes are complex and at the same time interrelated such that the expansion of one LU/LC type occurs at the expense of other LU/LC classes.

Table 9: Change of Area Analysis between 2000 and 2019

LU/LC Type	2000		2019		Relative Change	
	Area (km^2)	% Area	Area (km^2)	% Area	Area (km^2)	% Area
Water Bodies	47	11.18	18.31	4.36	-28.69	- 6.82
Dense Vegetation	58.79	13.99	11.78	2.8	-47.01	-11.19
Crop Land	268.44	63.88	255.48	60.79	-12.96	-3.09
Bare Land	26.52	6.31	23.57	5.61	-2.95	- 0.7
Human Settlement	19.48	4.64	111.09	26.44	91.61	21.8

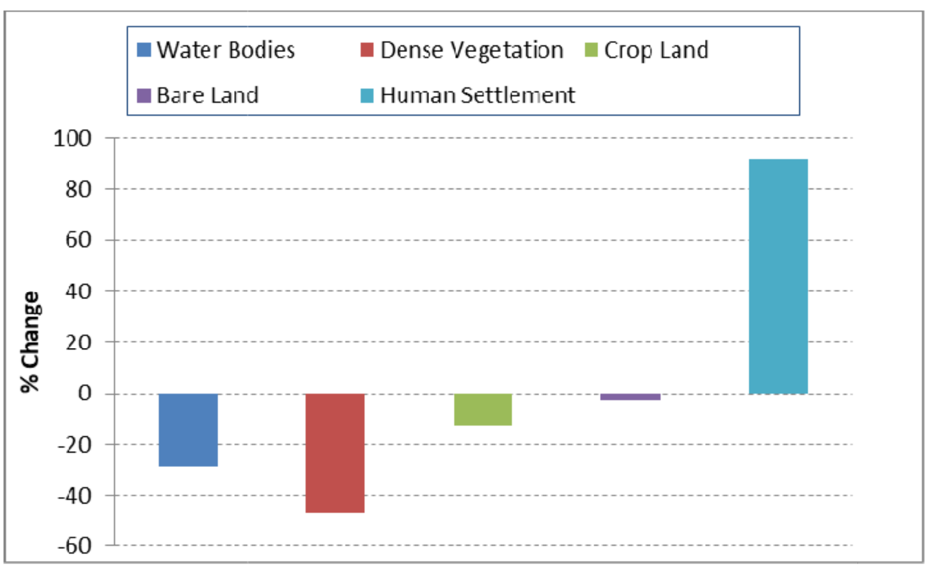


Figure 13h: Observed land use changes during the period of 2000-2019

11.6 Existing Cropping Practice and Challenges

Boro is the main economic crop in a mono-cropping agricultural system in haor. But early flash floods often wash away standing crops and people lose their harvest. Flood, especially at the brim of harvest make the farmers frustrated. They face a huge loss before few hours to three or four days to harvest of the crops which is irredeemable.

Badedeuli and Judhisthipur village, the adjacent villages of Hakaluki haor, are generally single cropped area. Hakaluki haor is the largest haor in Sylhet district having boundaries named Deotara in North, Nadbil in South, Chiraiakandi in East and Kechoruli in West. Gilacholra bazar is the entry point towards the haor that resides in the South-East corner of Haor. Villagers cultivate local Boro rice mostly BRRI dhan28 because of its shorter duration to escape flash flood damage. Few farmers also cultivate BRRI dhan29. This boro crop supplies food for six months. Most landowners are absentee farmers, living abroad. Thus active farmers are tenant and most of the farmers are poor. Farmers get about 15 Mond paddy per kayar (kayar means bigha) (about 44.64 ton / ha). According to the farmers opinion, the yield level is less compared to other location of Bangladesh due to no intercultural operation and less protective measures against pest and diseases. Farmers who take lease get half of the production. Cost of production to grow rice per bigha is approximately Tk 4000.00 (about 32921.81 TK/ha), excluding the seed and fertilizer provided by land owner. The selling price of one Mond paddy is about Tk 800.00 (about 20 TK/Kg). So farmers get Tk 12000.00 per bigha of 15 Maunds paddy (about 164.61 TK/ha/Kg). But subtracting production cost of this amount, their profit is only Tk 8000.00 per bigha (about 54.87 TK/ha/Kg). But most of their un-matured crops go under water because of early or sudden flood due to excessive rainfall and upstream water pressure. Even sometimes they don’t get their expected rate of return. This is due to flash flood impairs crops partially and sometimes fully.

Despite of all ignorance and laziness, farmers are now trying to protect their crop from flash flood damage by keeping some fallow land in the haor that are used as threshing floor. They usually rent combined harvester to harvest, thresh and pack paddy in bags and just carry those bags to home and then dry them in direct sunlight.

Sometimes monsoon flood increases adversity in the life of villagers. Their agricultural equipments like plough, yoke etc. are taken away by flood. Sometimes these equipments are found but mostly these are lost. Their agricultural lands are submerged fully or partially by water. Their crops are damaged. They don’t conserve their crops properly. In the study areas, due to frequent occurrence of flash flood the farmers have to store their products immediately, but they do not have enough storage facility. Again, farmers don’t have enough platforms for boat to transport their produced crops for the purpose of storage or marketing, so they cannot take their products to the market timely for sell. As a result, large quantities of products get damaged and they don’t get actual prices of their crops. So they have to bear losses. Homestead gardening is also hampered. So, villagers cannot cultivate vegetables in their courtyards or its quantity is decreasing.

Besides, farmers are losing their interest to cultivate rice. Because crop diversity is decreasing day by day in those villages, sufficient labors are hardly found in time, lower market price, less production, lack of institutional support etc. So many villagers migrate into other villages or cities in search of new employment. As a result, during harvesting period only a limited number of labors are available and they charge more money. The farmers are compelled to pay higher price of their requirement. To fulfill farmer's demand for increasing crop yield, steps can be taken like: i) short duration high yielding variety, ii) develop submergence tolerant boro variety to sustain flash flood for at least two weeks, iii) training on modern cultivation package and use of machinery for early establishment and quick harvest. They also opined for dredging the silted river, construction of dam in the upstream of river to prevent sudden flow of water and permanent cannel network for irrigation and reduce water loss.

Most of the farmers don't cultivate in their farmland which are mortgaged. There are many types of early varieties of rice in Bangladesh like as BINA-10; if farmers cultivate the early varieties their loss in a short will be reduced. Because these varieties are become matured before 10 to 15 days of flash flood starting. But the farmers don't have any interest to cultivate crops with these varieties because:

I. If farmers cultivate early varieties, about 5 to 7 maund rice will be reduced per kayar (about 2304.53 Kg/ha); whereas they get normally 15 to 20 maund of rice (about 5596.71 Kg/ha). They are not conscious or aware that the loss of 5 maund is better than whole or partial loss of crops.

II. Rice is damaged due to strong wind blowing.

Crops are also damaged because of water logging. From the discussions with the local people, it is known that hail-storm causes large damage to the Boro crops. Last year (2016) their whole Boro crops were damaged by hail-storm.

11.7 Performance of High Yielding Aus Rice Compared with Farmers Practiced Varieties

Field demonstration was conducted in Gilachara union to validate the farmer's option to grow aus rice followed by maize. As the aus growing season (from May-August; with a 110 days variety) the whole irrigated area under haor was inundated thus it was established in the highland of haor that usually used for residence. Transplanted aus was established in that land as a demonstration plot. Two aus varieties such as BRRI dhan 48 (Farmer's practice) and BRRI dhan65 (new BRRI variety having a growth duration of 100-110 days) were used for demonstration.

Yield of aus rice : Rainfed transplanted aus

Growth duration of BRRI dhan65 and BRRI dhan48 was 115 days and 135 days, respectively

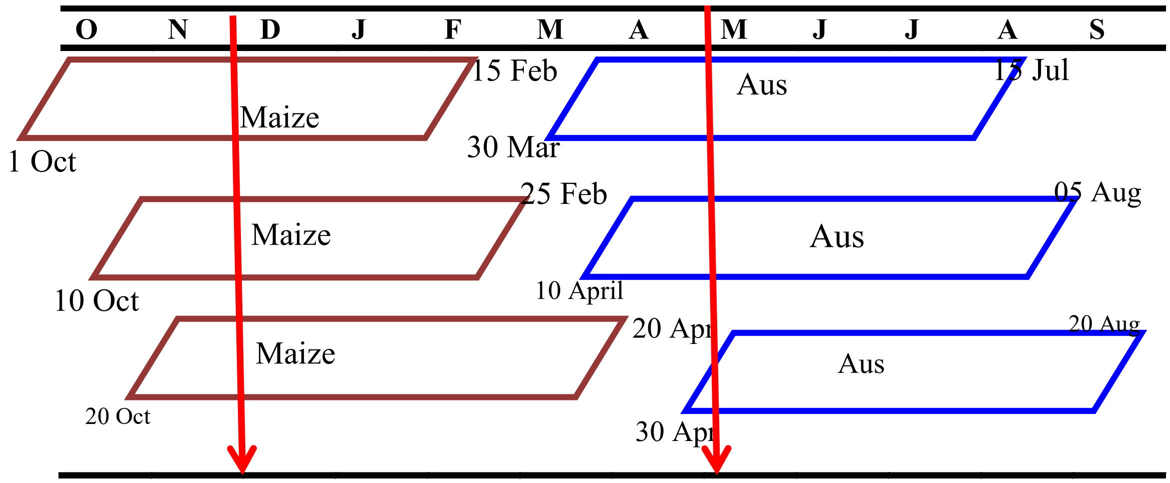
- Yield of BRRI dhan65 and BRRI dhan48 were 9 maunds/ bigha and 6 maunds/bigha, respectively
- BRRI dhan48 was affected by leaf blight.

BRRI dhan48

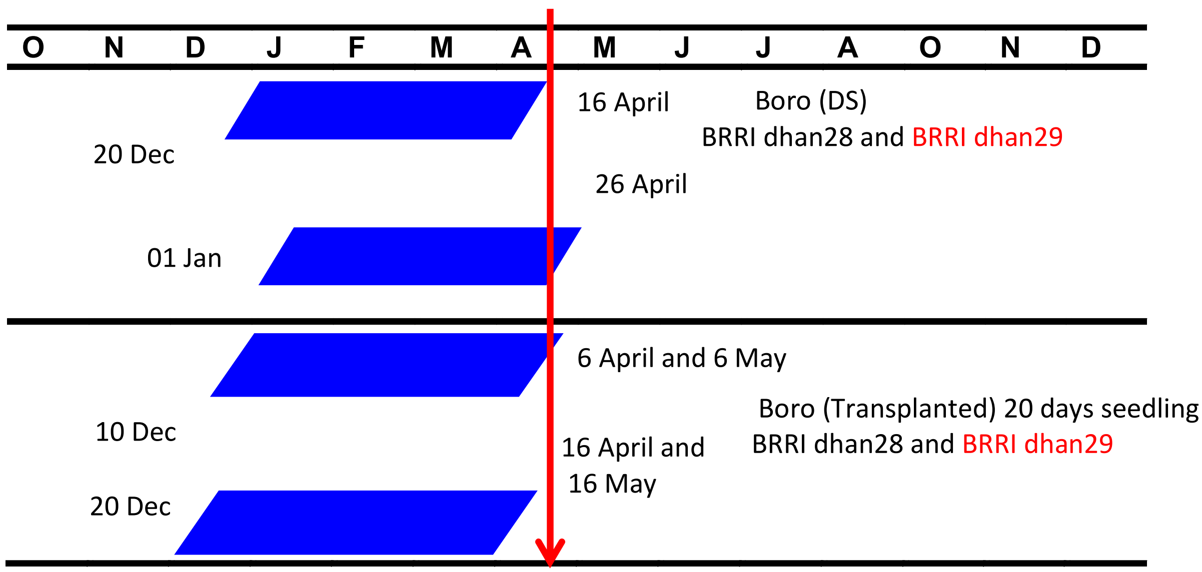
BRRI dhan65

11.8 Proposed crop Calender :

Pattern 1: This is not feasible as both crops are in danger due to high water level in haor. Maize will not be possible to establish because water will not receed from haor to an optimum soil moisture level untill mid December which will not allow to establish any other crop. Field duration of aus rice ends in August when haor will be under about 10 m standing water level. Only one crop of this pattern can be done. But from one year experimental failure it is very difficult to make any comment.



Pattern 2: Short duration Boro rice (BRRI dhan 28) can be grown from end of December if November rain/depression does not damage the seedlings. Growing high yield long duration varieties like BRRI dhan 29 is a risky venture as haor will be fully inundated by mid April. In the project year it inundated during end of March. Similar to pattern 1, one year experimentation is not enough to make any comment on crop calendar or variety or season.



**Beyond red line cropping is not possible in haor

12. **Research highlight/findings (Bullet point – max 10 nos.):**

- In the study area complex hydrogeological condition is found. Aquifer is semi-confined to confined in nature. In highland area groundwater irrigation is possible if the command area can be brought under an irrigation scheme.
- Land use pattern is changing day by day. In hakaluki haor water body is shrinking and settlement is increasing. This is due to population pressure and increasing the human demand day by day. Anthropogenic activities like cutting down trees, overgazing hamper the haor ecosystem. This creates the tendency of breakage of existing intervention and wash out crops.
- Short duration Boro rice (BRRI dhan 28) can be grown from the end of December if November rain/depression does not damage the seedlings
- Long duration Boro rice cultivation is a risky venture as haor will be fully inundated by mid April
- Non rice crop cultivation like maize can be grown alone without keeping any option for other rice crop
- Aus rice cannot be grown in haor under any circumstances as it is harvested in August, but crop field nearby farmers housing is a good option for short duration (115 days) high yielding BRRI dhan 65 yielding 5 t/ ha compared to farmer's variety BRRI dhan 48 (3 t/ ha)

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	3	72000	3	72000	Desktop scanner and printer purchased
(b) Lab &field equipment	11	169000	11	169000	Equipment purchased
(c) Other capital items	4	30000	4	30000	File cabinet computer table chair purchased

2. Establishment/renovation facilities: Not Applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not Applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					Not in pp
(b) Workshop					Not done

C. Financial and physical progress

Fig. in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	3,93,000	3,93,000	393000	0	100	
B. Field research/lab expenses and supplies	6,21,000	621000	513488	107512	83	
C. Operating expenses	1,30,000	115574	115044	530	99	
D. Vehicle hire and fuel, oil & maintenance	1,30,000	130000	130000	0	100	
E. Training/workshop/seminar etc.	80,000	0	0	0	0	
F. Publications and printing	95,000	95000	15,000	80000	16	
G. Miscellaneous	35,000	35000	33,780	1220	97	
H. Capital expenses	5,16,000	5,16,000	516000	0	100	
Total	**20,00000**	**1905574**		**1,89,262**		

D. Achievement of Sub-project by objectives (Tangible form) :

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**

E. Materials development/Publication made under the sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	√		
Journal publication	√		
Information development	√		
Other publications, if any		**Thesis of MS Student**	

F. Technology/Knowledge generation/Policy support (as applied):

i. **Generation of technology (Commodity & Non-commodity)**

ii. **Generation of new knowledge that help in developing more technology in future**

2 staff gauges and 2 observation wells were installed in the Hakaluki haor area.

iii. **Technology transferred that help increased agricultural productivity and farmers' income**

G. Information regarding desk and field monitoring

i) **Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):**

ii) **Field Monitoring (time& No. of visit, Team visit and output):**

I. Lesson learned/Challenges (if any)

i) Haor has a complex eco-system, at least five years works should be done to get a clear picture
ii) For crop related experiment one year study is not enough to conclude as technology

J. Challenges (if any)

Signature of the Principal Investigator
Date ………………………….
Seal

Counter signature of the Head of the organization/authorized representative
Date …………………………..
Seal