

SURFACE WATER POTENTIALITY FOR MINOR IRRIGATION EXPANSION IN HAOR AREAS OF BANGLADESH

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ABSTRACT

Haor is local name of saucer shaped naturally depressed areas in north-eastern region of Bangladesh. Most of these areas go under deep water during monsoon and pre-monsoon seasons due to overflow of flashy rivers and heavy rainfall. These areas are traditionally well-known for single-cropped area during agricultural seasons in dry period. Boro rice is the main dry season crop in the Haor areas requiring irrigation for cultivation. This paper focuses on the assessment of potentiality of surface water resources for irrigation in the Haor area. The study has been carried out based on limited primary data from survey and secondary data collected from different sources. One dimensional hydrodynamic model using MIKE 11 modelling software of DHI has been developed to fulfill the study objective. Besides, irrigation water requirement corresponding to the critical month has been computed using CROPWAT software of FAO. It was revealed from the model that the monthly minimum flow in the Kushiyara is around 89 cumec and more than 30 cumec in the Baulai rivers. As resources are available, the adjacent areas of the rivers would be benefited using surface water resources. However, there is some potential for surface water development from the river Surma with dry period flow which is about 5 cumec. In addition to existing irrigation equipments of 24 upazilas, i.e. sub-district, in the study area, an area of 225,552 ha cultivable land can be brought under irrigation using low lift pumps of cusec capacity.

KEYWORDS: Boro Rice, Haor Area, Irrigation Expansion, Irrigation Water Requirement, Mathematical Model

INTRODUCTION

Haor is local name of saucer shaped naturally depressed areas of northeastern region of Bangladesh. It constitutes 17% (approx) of the country's land area and the total number of Haors is around 414. The Haor areas are distributed in the districts (administrative unit) of Sylhet, Sunamganj, Moulavibazar, Habiganj, Mymensingh, Netrokona, Kishoreganj and Brahmanbaria (Figure 1). The mean annual rainfall of the region exceeds 5500 mm/yr in its north-eastern tip and decreases to about 2500 mm/yr in the southern and western part. Rainfall runoff from the hills within and outside Bangladesh, flows overland as well as through rivers to the Haors. This results in flash floods characterized by a rapid increase in flood levels during the pre-monsoon season and deep flooding in the monsoon season. According to the hydrologic regime, farmers adjusted their cropping practices. These areas are traditionally well-known for single-cropped area during agricultural seasons in dry periods.

Boro rice, of which high yielding variety's (HYV) share is about 60%, is the main dry season crop grown in the Haor areas requiring irrigation for cultivation. Only 32% of cultivable areas are brought under irrigation there. Boro alone contributes 8% of total rice production in Bangladesh (BBS, 2011). Saleh and Mondal (2007) found that both HYV Boro coverage area and production have increased with average annual growth rates of 10.7% and 14.9% respectively. The adoption rate of HYV Boro from local variety at farmers' level has been increased which requires of more water for irrigation.

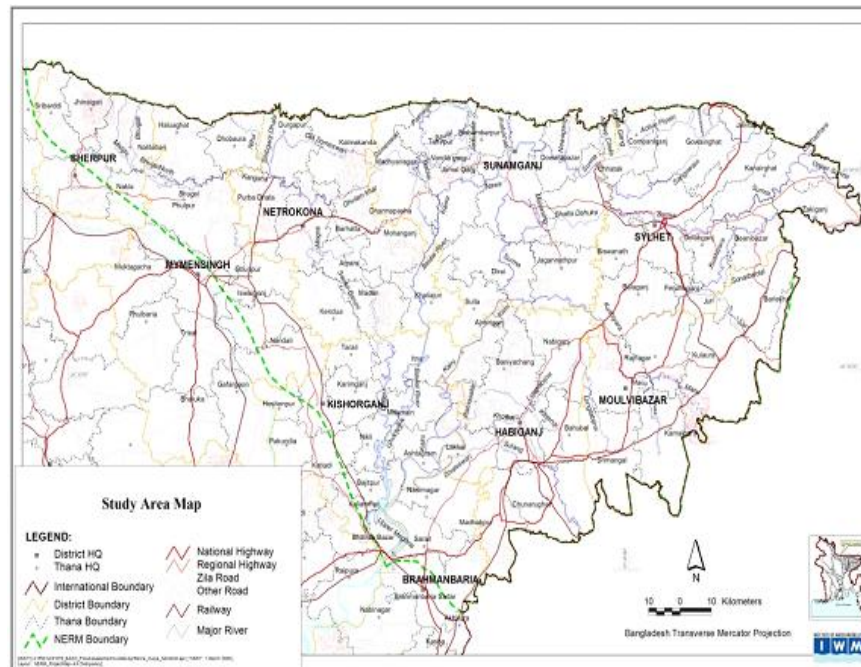


Figure 1: Map of the Study Area

Irrigation in Haor areas mainly depends on surface water. It is recommended to increase agricultural production by bringing potential area under irrigation with the highest priority for surface water development (NWPo, 1999). NWMP (2001) indicated that there are large amount of static surface water resources in the northeastern region whereas there is limited scope for groundwater development. In order to make utilization of surface water in irrigation and expansion of irrigation in Haor areas during Boro season, the present study has been carried out.

METHODOLOGY

The present study has been carried out based on extensive data collection and mathematical modelling technique. The data have been used for model development, updating and establishing baseline condition.

Data Collection

In order to develop the proposed mathematical model, data from primary source is very important since the scope for primary data collection under the present study is very limited. Thus the primary data collection has been carried out at important locations only during the dry period of 2009. It includes cross section survey of rivers at selected locations, water level and discharge measurements at some key locations of the significant rivers. Besides primary data, secondary time series data on water level, flows, rainfall and evaporation were collected by Bangladesh Water Development Board (BWDB). In order to assess crop water requirement climatological data namely maximum and minimum temperature, relative humidity, wind speed, daily sunshine hours, etc of two stations, Sylhet and Mymensingh, were collected from Bangladesh Meteorological Department.

Agricultural data including cropping pattern, crop calendar, irrigation equipment used, irrigated area, percolation rate, soil characteristics etc has been obtained from secondary sources such as Department of Agricultural Extension (DAE), discussions with the officials concerned of Bangladesh Agricultural Development Corporation (BADC) and interview with local farmers during field visits. In addition, IWM central database was also used as the principal secondary data source. Quality control of all surveyed and secondary data has been maintained through standard procedures as outlined in the Data Processing Manual of IWM (IWM, 2004).

Computation of Water Requirement

Computation of Irrigation Water Requirement (IWR) is essential to make an assessment of the amount of water that would be required for irrigation of the crops to attain its maximum yield and assess available water resources at upazila levels for future scope of expansion. It includes requires of crop evapotranspiration, percolation loss, water required for land preparation minus the available effective rainfall. Conveyance losses were not considered here as it is considered in estimating the diversion requirement of the project as a whole. The irrigation water requirement can be expressed as;

$$IWR = (K_c \cdot ET_0 + P - R_{eff}) \quad (1)$$

Where,

K_c - crop coefficient; ET_0 – reference crop evapotranspiration (mm/day);

P – percolation loss (mm/day); R_{eff} – effective rainfall (mm/day).

Crop evapotranspiration (ET_c) represents the evapotranspiration of a reference crop (ET_0) multiplied by the crop coefficient of that crop (K_c), i.e. $ET_c = ET_0 \times K_c$. ET_c is the requirement of a crop for its full development without any water stress. It depends on several key factors namely reference crop evapotranspiration, type of the crop, its plantation time and duration of the crop. Computing ET_c for Boro that would be irrigated in the area during dry period was conducted using meteorological data. Besides, standard values of crop coefficients (K_c) of HYV Boro rice for different growth stages and growth period have been used. Effective monthly rainfall in the study area was calculated as 80% of mean monthly rainfall. Percolation rates of various types of soils scattered all over the study area have been collected primarily from publications of different organizations. Values of percolation rate in the study area vary from 1.5 to 3.0 mm/day.

Irrigation Water Requirement (IWR) has been computed from CROPWAT (FAO, 1992) version 5.7. Water requirement for land preparation of 180 mm has been considered. The maximum unit scheme water requirement (SWR) corresponding to critical month is computed with a conveyance efficiency of 85% as the scheme area is small with silty clay type soil. Due to rainfall variation over the month, the computation of IWR has been carried out for each decade of the months during dry period (Jan-Apr). The maximum value of ISWR of Boro crop is 0.8 l/s/ha.

Development of the Model

One-dimensional hydrodynamic modelling technique has been applied to calculate water level and discharge at the ungauged locations of the important river system in the Haor area. MIKE 11 software developed by Danish Hydraulic Institute has been used for the study (DHI, 2007). The surface water model for the study area has been extracted from the northeast regional model available at IWM (2007). The model was updated by incorporating surveyed data conducted under the present study.

The significant rivers included in the model are Surma, Kushiyara, Sarigowain, Jadukata, Patniganj, Baulai, Kalni, Dhaleswari, Someswari, Dhanu, Ghorautra, Bhugai, Kangsha, Ratnasat, Khowai and Upper Meghna. All the major rivers come from India and boundaries of the river for the model development were extended to the Indo-Bangladesh border. The upstream boundaries of the model have been defined with discharge time series generated from rating curves. The model has been calibrated against dry period water level at key locations with observed water level data for the year, 2007-2008. Validation of the model has been done for 2005-2006. Bed resistance or channel roughness was the main calibration parameter of the model. However, a satisfactory match has been achieved between simulated and observed water levels. The sample comparison plots of Surma and Kushiyara rivers are shown in the Figure 2.

RESULTS AND DISCUSSIONS

Quantification of Flow

For surface water resource assessment during dry period condition, rainfall data were analyzed to estimate the rainfall event for different return period. The rainfall data has been fitted to 3-parameter Log Normal distribution for the design year having 80% dependability. The statistical software HYMOS 4.0 has been used for this purpose. All rainfall stations does not represent a unique design year as such district wise rainfall variation was considered. The dry period rainfall varies: 350-450 mm for Netrokona, 450-550 mm for Kishoreganj and Habiganj, and 650-750 mm for Sylhet and Sunamganj districts. It was found that return period for the year 2007 is close to design year return period of 5 years for Netrokona. In similar way, the year 2002 and 2007 represents design year for the districts of Sylhet-Sunamganj and Kishoreganj-Habiganj districts respectively.

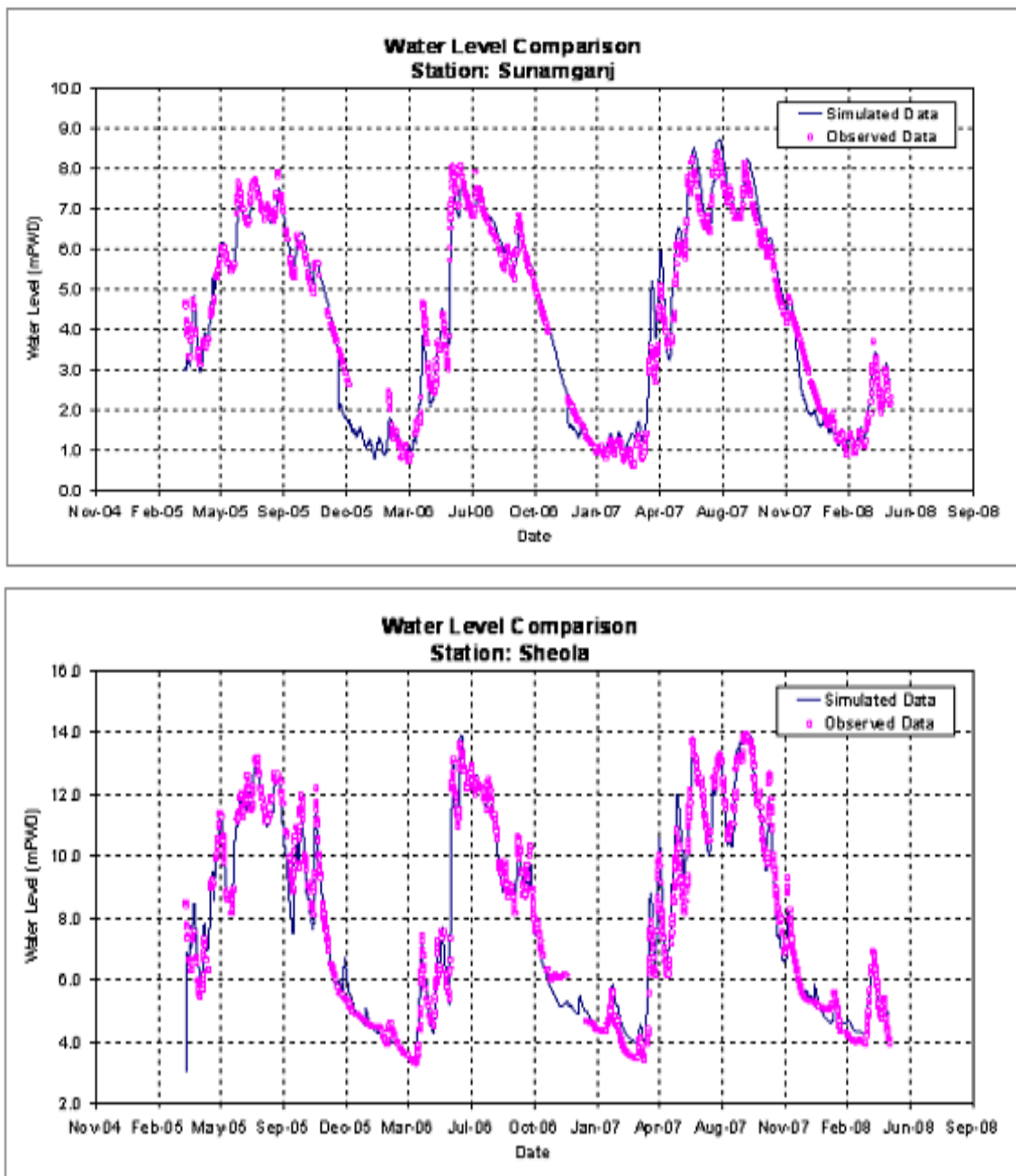


Figure 2: Comparison (Calibration and Validation) against Water Level at Sunamganj on the Surma (Top) and Sheola on the Kushiyara (Bottom) Rivers

The developed model has been simulated for the design years to assess the dry period water availability in different rivers of the study area. The simulation results at key locations of eleven rivers of twenty four upazilas under five districts have been delineated. Table 1 shows the dry period minimum simulated flows of Surma, Kushiyara and Baulai rivers at several locations selected during the field visits made by the authors.

Table 1: Monthly Minimum Simulated Flow of Different River (m³/s)

Location with River Chainage	Monthly Minimum Flows (m ³ /s)			
	Jan	Feb	Mar	Apr
Surma				
1. Charkhai, Beanibazar (ch-26438m)	3.57	3.47	4.26	24.85
2. Bagha Union, Golapganj (ch-46262m)	3.53	3.42	4.53	24.54
3. Chhatak Union, Chhatak (ch-110699m)	24.63	9.24	9.61	107.05
4. Sunamganj S, Sunamganj (ch-156780m)	27.17	17.28	63.25	231.78
Kushiyara				
1. Sheola Union, Beanibazar (ch-4371m)	130.83	94.21	88.86	180.03
2. Badepasha, Gopalganj (ch-31120m)	128.14	91.22	89.4	200.91
3. Fencuganj S, Fencuganj (ch-49133m)	142.42	105.02	105.85	227.21
4. Balaganj Sadar, Balaganj (ch-67271m)	163.92	127.99	124.23	335.81
Baulai				
1. Jamalganj S, Jamalganj (ch-24366m)	8.32	6.92	9.34	190.56
2. Gaglajure, Mohonganj (ch-36947.05m)	35.12	37.32	50.53	101.1
3. Khaliajoori, Khaliajuri (ch-51317m)	30.58	30.19	44.03	238.82
4. Chatul Itna union, Itna (ch-75836m)	80.76	86.78	100.26	456.52
5. Mitamain S, Mitamain (ch-96377m)	83.29	90.58	101.61	458.99

Based on model results, there is no shortage of water in terms of water availability in Kushiyara and Baulai system. It is found from the model simulation that the monthly minimum flows in the Kushiyara to be around 89 cumec. However, there is some potential scope for surface water development from the river Surma. In the upazilas of Golapganj and Beanibazar, there are two rivers namely Surma and Kushiyara that can provide source of surface water.

Computation of Additional Irrigation Equipments

The useable water resources of the river for irrigation have been considered as 70% of the available resources (IWM, 2006). Upazila wise surface water potentiality has been estimated from the model results along with computed IWR. However, the scope of irrigation expansion in each upazila using resources from river sources is based on the assumption that there is no withdrawal of water any location both at the upstream and downstream of the river reaches.

There might be some changes in water availability at downstream to the given location as presented in the Table 2, if water withdrawal takes place at the upstream of river. In this case(s) support of modelling is necessary. Table 2 indicates that an area of 225,552 ha cultivable land of 24 nos upazilas can be brought under surface water irrigation.

Low lift pumps (LLP) are major mode of technology for surface water irrigation in Haor areas. The capacity of LLP is variable and may range from less than 1.0 cusec to 5.0 cusec. The weighted mean command area for all LLP is assumed to be 10.0 ha in the study area considering that each LLP has a capacity of 1.0 cusec.

The proposed number of LLP has been estimated in such a way that total number of LLP will not be able to irrigate more than cultivable area minus the present irrigated area even if the resource permits. Accordingly, the number of additional LLPs for 24 upazilas becomes 22,555.

Table 2: Upazila-Wise Expandable Area for Irrigation

Upazila	Main Source of SW	Useable River Flow ¹ (cumec)	Gross Irrigation Area Using River Flow ² (ha)	Net Cultivable Area ³ (ha)	Irrigated Area ⁴ (ha)	Expansion Area ⁵ (ha)
Fenchuganj	Kushiyara	73.51	91,893	7,000	580	6,420
Balagonj	Kushiyara	86.96	111,991	31,260	6,220	25,040
Golapgonj	Surma	2.39	2,993	25,487	3,000	22,487
	Kushiyara	62.58	79,818			
Beanibazar	Surma	2.43	3,036	16,600	6,220	10,380
	Kushiyara	62.20	82,434			
Zakigonj	Kushiyara	72.72	91,420	26,932	1,530	25,402
Gowainghat	Sarigowain	8.62	12,023	44,002	6,522	12,023
Sunamganj S.	Surma	12.10	15,120	65,244	5,901	15,120
Chhatak	Surma	6.47	8,085	33,324	5,661	8,085
Taherpur	Jadukata	4.93	7,040	37,100	3,464	7,040
Jamalgonj	Baulai	4.84	6,055	51,803	5,041	6,055
Dharmapasha	Patniganj	9.35	15,380	61,657	8,181	15,380
Lakhai	Dhaleswari	118.42	195,450	16,784	9,542	7,242
Baniachanj	Ratnasat	15.83	25,830	35,378	20,188	15,190
Azmariganj	Kalni	84.05	145,720	14,302	6,724	7,578
Itna	Baulai	56.53	80,760	28,450	25,000	3,450
Austagram	Dhaleswari	118.76	195,940	25,889	22,050	3,839
Mithamain	Baulai	58.30	83,290	17,089	14,725	2,364
Nikli	Ghorautra	74.16	105,940	15,450	13,170	2,280
Bajitpur	Ghorautra	81.23	116,040	15,862	12,000	3,862
Kuliarchar	Ghorautra	87.67	125,240	7,618	6,035	1,583
Khaliajuri	Baulai	21.13	30,190	19,000	4,730	14,270
Mohanganj	Baulai	24.58	24,584	17,400	5,244	12,156
Madan	Dhanu	4.40	6,344	20,128	9,645	6,344
Atpara	Dhanu	5.44	7,315	24,500	7,920	7,315

Note: 1 - Monthly minimum useable flow; 2 - Possible area that can be brought under irrigation based on monthly useable flow and corresponding monthly maximum irrigation water requirement which gets lowest value during dry period; 3&4- Information collected from different organizations like BARI (2008), LGED (2006) and DAE (2001); 5 - Gross area brings under irrigation not more than difference between net cultivable and irrigated area.

CONCLUSIONS

The study has been carried out based on the limited primary data surveyed and the secondary data collected from different sources. One dimensional hydrodynamic model has been developed to fulfil the study objective.

The study area is mainly a mono-cropped area with dominating dry period crop Boro rice. Surface water irrigation is being practiced extensively for its cultivation. The scheme water requirement corresponding to critical month was computed with a conveyance efficiency of 85% as the area is with silty clay type soil. The maximum value of SWR is 0.8 l/s/ha. Model simulation reveals that there is huge potential for surface water development during dry periods in the study area as a whole.

There is no shortage of water in Kushiyara and Baulai system. The monthly minimum flow in the Kushiyara is around 89 cumec and more than 30 cumec in the Baulai. As resources are available, the adjacent areas of the rivers would be benefited using surface water resources. However, there is some potential for surface water development from the river Surma with dry period flow ranging around 5 cumec.

Upazila wise surface water potentiality has been estimated from the model results along with the computed SWR. There are 24 nos upazilas in the study area which has been ascertained during the field visits. It was estimated that an area of 225,552 ha cultivable land can be brought under surface water irrigation.

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