






## CONTRIBUTING FACTORS OF BORO-RICE PRODUCTION IN HAKALUKI HAOR OF BANGLADESH

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### ABSTRACT

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Bangladesh is a riverside country and *Hakaluki haor* is one of the major wetlands. This research aims to identify the key factors affecting Boro-rice production and also to discover the optimum farming system. Information was collected from 150 respondents through a structured questionnaire and also focus group discussion. Descriptive analysis and factor analysis was applied to identify the key factors of Boro-rice production. Among the problems of Boro-rice production, more than two-thirds of the farmer tackled irrigation-related problems whereas insect and disease problems affect all farmland. The price of inorganic fertilizer is high but two-third of them applies inorganic fertilizer. The rate of applying high yield variety (HYV) was found very low. A remarkable portion of the farmer practices mass media so information should be strengthening for increasing production. The rate of adoption method of modern technology (i.e., crop rotation and practice intercropping) is very poor. The agricultural extension service was not sufficient. More than half of the farmers sell their production in the crisis period. Flash flood was the major natural disaster and most of the farmers claimed that heavy rain and an unexpected misplaced dam was the prime reason for flashflood. In factor analysis, seed plant cost, plow cost, irrigation cost, as well as family size and cultivable lands (last year), were found as significant factors for Boro-rice production. So, the government may give more support to the farmers so that they increase cultivable land as well as sustain their livelihood.

**Contribution/Originality:** This study is one of very few studies which have investigated to identify the key factors affecting Boro-rice production in *Hakaluki haor* and also discover the optimum farming system.

### 1. INTRODUCTION

Bangladesh is a riverside country whose backbone is agriculture. About 60-70% of the people of Bangladesh depend on agriculture which comprises about 15% of the country's GDP and 60% of the total labor force (Bishwajit, Razib, & Sharmistha, 2014). Bangladesh is located between the Himalayas and the Bay of Bengal very prone to natural disasters and one of the most climate-vulnerable countries in the world (World Bank, 2010). Climate change accelerated the intensity and frequency of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods, etc. that resulted from global warming. Global warming is harmful to crops of tropical countries (United Nations Environment Programme (UNEP), 2009). Agricultural production varies from region to region in our country due to different climatic and geological factors. In the country some of the areas are plain

lands, some others are hilly lands, and some others are wetlands. Production practices and outcomes are different in these sectors. Wetlands in Bangladesh have long been facing serious degradation and loss, due to many natural and anthropogenic factors. Besides natural causes, factors like overuse of resources, lack of property rights, human encroachment and conversion to other uses, and also the absence of effective enforcement of laws are some of the most important factors for the decline in wetland biodiversity of the country (CWBMP (Coastal and Wetland Biodiversity Management Project), 2005). There are about 373 haor/wetlands located in the districts of Sunamganj, Habiganj, Netrakona, Kishoreganj, Sylhet, Maulvibazar, and Brahmanbaria. These 373 haors cover an area of about 859,000 ha which is around 43% of the total area of the haor region (CEGIS, 2012). The total cultivated area of these districts is about 1.26 million hectares of which 0.68 million ha (nearly 66%) is under haor. Almost 80% of this area (i.e. 0.68 million ha) is covered by Boro rice, while only about 10% area is covered by T. Aman production (Huda, 2004). The wetlands provide the lion's share of the boro rice production of our country which supplies the maximum portion of our main food.

*Hakaluki haor* is one of the major wetlands in greater Sylhet, as well as Bangladesh. With a land area of 18,386 hectares, it supports rich biodiversity and provides direct and indirect livelihood benefits to nearly 190,000 people (CWBMP (Coastal and Wetland Biodiversity Management Project), 2005). About 200,000 people live in the area surrounding *Hakaluki haor* (Rana, Sohel, Akhter, & Alam, 2009). The area was once known as the "Fishmine" of the country and due to the critical conditions of the haor ecology, the government of Bangladesh declared *Hakaluki* as an Ecologically Critical Area (ECA) in April 1999. *Hakaluki haor* is a complex ecosystem, containing more than 276 interconnecting *Beels*/Jalmahals (CWBMP (Coastal and Wetland Biodiversity Management Project), 2005). *Hakaluki haor* falls under the two administrative districts (Maulvibazar and Sylhet) and five Upazilas (Barlekha, Kulaura, Fenchuganj, Golapganj, and Juri). The two main sources of livelihood for these people are fisheries and agriculture. Haors and Floodplains in Bangladesh are important sources of fisheries resources for the country. Fish from the wetlands provide about 80 percent of the country's dietary protein, and food, fuel, fiber, fodder, and building materials are also harvested from wetlands (SEMP, 2005). Several interacting factors such as agriculture, forestry, and fisheries all are sensitive to climate change. Land cover by human/natural modifications has largely resulted in deforestation, biodiversity loss, global warming, and an increase of natural disaster-flooding (Mas et al., 2004; Zhao, Lin, & Warner, 2004). Both human-induced and natural land cover changes can influence the global change because of its interaction with the terrestrial ecosystem (Houghton, 1994) biodiversity (Sala et al., 2000) and landscape ecology (Coughenour, Reid, & Thornton, 2000). These factors could result in more local responsibility for those people who are currently vulnerable or who could become so within the foreseeable future. Although short-term food security is achieved, for long-term food security complete supervision of the 1.99 million ha of wetlands is crying need to attain Millennium Development Goal (FAO, 2008). This document attempts to illustrate the factors affecting Boro-rice production in haor areas and take the necessary steps to booster the economic activity of the country.

## 2. MATERIALS AND METHODS

This study was conducted on five Upazilas which encloses *Hakaluki haor* cover two administrative districts of Maulvibazar and Sylhet, Bangladesh from August 2017 to July 2018. A multi-stage cluster sampling was used for the selection of the respondents. Descriptive and multivariate statistical analysis was used for the identification of the key factors of Boro-rice production. Factor Analysis using Principal Component Analysis (PCA) was conducted to reduce the data and check the convergent strength of significant constructs. To find out the factors affecting Boro-rice production, a multiple regression was carried out with the Boro-rice yield as the dependent variable and the factors identified by the Factor Analysis using PCA as the independent variables.

The general expression of a regression model can be written as:  $y=f(x_1, \dots, x_n)+\epsilon$ , in which:  $y$ -dependent variable (outcome variable) randomized;  $x_1, \dots, x_n$  independent variables (factorial) non-randomized;  $\epsilon$ -random error variable.

Random variable  $\epsilon$  summarizes the influences of variables not included in the model that influences the variable  $y$ .

### 3. RESULTS AND DISCUSSION

#### 3.1. Descriptive Analysis

The descriptive statistics Table 1 of different characteristics effects on Boro-rice production are as follows: Almost all respondents (89%) main occupation was agriculture. Generally, it is known that the high yield variety (HYV) gives comparatively more yield which confirms the two-third of the respondents of this study. Seventy-four percent of the farmer applied local paddy variety while 20.7% of farmers used high yield variety (HYV). Among the respondents, 70% used inorganic (chemical) fertilizer and only 6% used organic fertilizer where 24% used both of the fertilizer. Above one-third of the farmer said that the price of chemical fertilizer is not reasonable. In case of problems faced in Boro-rice production, irrigation related problems faced about 71% of the respondents, and all of the farmers faced by insect and disease-related problems. Crop rotation is also an important issue for the fertility of the land and the prevention of the insects. The crop rotation can able to earn income during the wet months when rice farming is not possible due to drowned farmland by water in the *Hakaluki haor* area. But the study results revealed that the farmer had no idea about the crop rotation, where only 3.3% were practiced crop rotation. It's maybe reasons for the land shortage of different seasons. Practicing intercropping is a very well established cultivation technique and essential to meet the demand of the increased population of the country but the farmers of the *Hakaloki haor* only 3.3% practicing intercropping. Around half of the farmer's households were found food insecure throughout the year. So these farmers need to take a loan from different sources to continue their farming and also meet up their basic needs. Around seventy-three percent of farmers of the *Hakaloki haor* area took loans for agricultural production and half of them mentioned that they have faced problems in taking the loan.

Different types of the problem faced by the farmer to take the loan for Boro-rice production among them they feel high-interest rate are the topmost problems (60%). Also, most of the farmers of the *Hakaloki haor* said the interest rate of the loan is not reasonable. The farmer must have the knowledge and practice of modern technology for increasing the yield which has a significant impact on production. The study revealed that the adaptation rate of modern technology is low (58%) of the *Hakaloki haor* basin farmer. In Bangladesh, agricultural production rapidly increases due to strengthening the extension service from the agricultural extension department. But only 46% of the farmer of this haor area said that they got the extension service from an agricultural extension officer. A large portion of the farmers (83.3%) was not satisfied with the visiting frequency of agricultural extension agents. A greater portion of the farmer (68%) mentioned that they practicing mass media for watching agricultural-related programs and weather information which is an important input in making farm decisions and almost all of them monitor the weather/climate regularly. The most useful climate information for them is on rainfall, temperature. As a climate indicator rainfall is very important for agricultural production. According to the farmers' perception, 82% of the farmers said that the rainfall increased, which has a positive sign for Boro-rice production although it harms loses the Boro-rice by the flash flood.

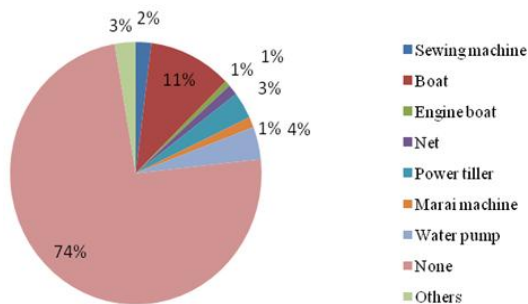


Figure-1. Equipment related to increase Boro-rice production. Source: Field survey, 2018.

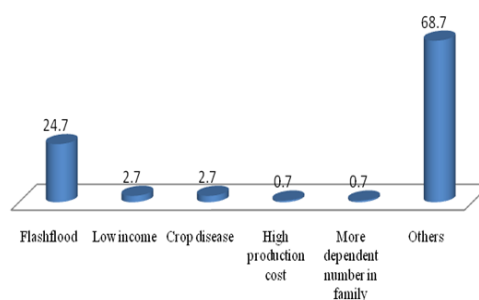


Figure-2. Causes of food insecurity. Source: Field survey, 2018.

Table-1. Descriptive analysis of different factors affecting Boro-rice production.

Characteristics	Frequency	Percent	Cumulative Percent
<i>Occupation of the respondents</i>			
Agriculture	133	88.7	88.7
Fishery	6	4.0	92.7
Others	11	7.3	100.0
<i>Practicing any mass media</i>			
Yes	102	68.0	68.0
No	48	32.0	100.0
<i>Household food secure throughout the year</i>			
Yes	78	52.0	52.0
No	72	48.0	100.0
<i>Irrigation related problems</i>			
Yes	106	70.7	70.7
No	44	29.3	100.0
<i>Facing of insect and disease problems</i>			
Yes	150	100.0	100.0
No	0	0	0
<i>Types of fertilizer use</i>			
Organic	9	6.0	6.0
Inorganic (chemical)	105	70.0	76.0
Both	36	24.0	100.0
<i>Types of paddy variety applied</i>			
Local	111	74.0	74.0
High yield variety	31	20.7	94.7
Others	8	5.3	98.7
<i>Perception about using HYV</i>			
Increased yield	110	73.3	73.3
Decreased yield	10	6.7	80.0
Constant yield	30	20.0	100.0
<i>Ever use crop rotation</i>			
Yes	5	3.3	3.3
No	145	96.7	100.0
<i>Practicing inter cropping</i>			
Yes	5	3.3	3.3
No	145	96.7	100.0
<i>Get enough rain in the last production year</i>			
Yes	56	37.3	37.3
No	94	62.7	100.0
<i>Activities out of farmland</i>			
Yes	61	40.7	40.7
No	89	59.3	100.0
<i>Loan access for agricultural production</i>			
Yes	109	72.7	72.7
No	41	27.3	100.0
<i>Adoption rate of modern technology</i>			
High	2	1.3	1.3
Average	54	36.0	37.3
Low	87	58.0	95.3
None	7	4.7	100.0
<i>Extension service from agricultural extension officer</i>			
Yes	69	46.0	46.0
No	81	54.0	100.0
<i>Local perception on Rainfall of Hakaloki haor</i>			
Increased	123	82.0	82.0
Decreased	19	12.7	94.7
Constant	7	4.7	99.3
Don't know	1	.7	100.0

Source: Field survey, 2018.

Figure 1 shows that the equipment related to increasing agricultural (Boro rice) production is not good enough for all of the farmers. Flashflood is the highest (24.7%) mentionable cause of food insecurity whereas 68.7% of farmers seemed that other causes are responsible for food insecurity Figure 2.

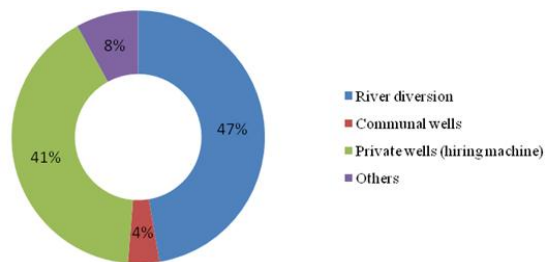


Figure-3. Source of water for irrigation. Source: Field survey, 2018.

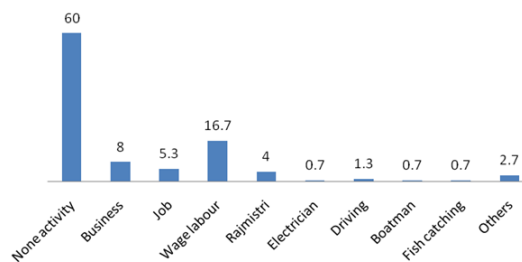


Figure-4. Farmers' activities out of farm land. Source: Field survey, 2018.

Sources of water for irrigation are a very important factor for Boro-rice production. In this case, around half (forty-seven percent) of the farmers depended on the river diversion and forty-one percent of the farmers were dependent on the private wells (hiring machine) for irrigation Figure 3. Out of farm activities is essential for improving the socio-economic conditions of a farmer. But Figure 4 indicates that a large number of the farmer (60%) did not participate in any off-farm activities. Only 16.7% were engaged in wage labor, 8% were in business 5.3% were in a job and 4% were in rajmistri.

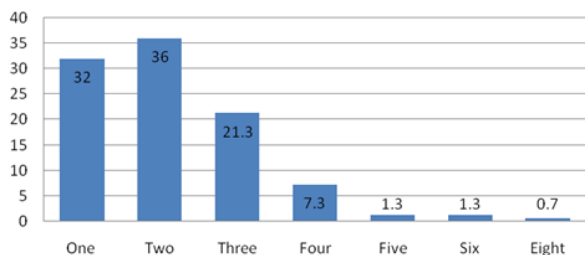


Figure-5. Number of earning persons. Source: Field survey, 2018.

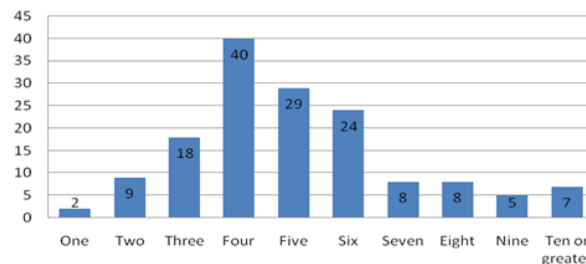


Figure-6. Number of dependent persons. Source: Field survey, 2018.

The total number of earning persons and the number of dependent persons is a very crucial factor for agricultural production as well as the economic condition of a family. A large number of farmers (sixty-eight percent) said that their family had only one or two earning persons Figure 5. Figure 6 shows that more than 70% of the farmer of the Hakaluki haor basin area had four or greater dependent persons in their family.

### 3.2. Factor Analysis (PCA)

The initial step in factor analysis was to assess the suitability. The Mayer-Kaiser-Olkin (KMO) measure of sampling adequacy gives a value of 0.523 (>0.5), which suggests that correlations between pairs of variables can be explained by other variables and also, the null hypothesis that the correlation matrix is an identity matrix is rejected (p<0.1) by Bartlett's Test of Sphericity. Therefore, factor analysis is appropriate for the data set.

Table 2 represents the initial and extracted value for every variable in the communality tables. This table of communalities shows the amount of common variation shared with the remaining variables after the desired numbers of factors have been extracted. According to this table, the variables comprise at least 50% of the variation in each of the variables, represented a highly acceptable result.

**Table-2.** Communalities of variables.

Variables	Initial	Extraction
Age of the respondent (years)	1.000	0.751
Years of schooling	1.000	0.662
Size of family (No)	1.000	0.623
Cultivable land last year in care(30 decimals)	1.000	0.632
Seed plant cost in care(30 decimals)	1.000	0.560
Plough cost in care(30 decimals)	1.000	0.610
Pesticides cost in care(30 decimals)	1.000	0.703
Fertilizer use kg in care(30 decimals)	1.000	0.689
Irrigation cost in care(30 decimals)	1.000	0.408

Source: Field survey, 2018.

**Table-3.** Total variance explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.702	18.913	18.913	1.702	18.913	18.913	1.608	17.864	17.864
2	1.396	15.509	34.422	1.396	15.509	34.422	1.348	14.980	32.844
3	1.346	14.957	49.379	1.346	14.957	49.379	1.343	14.918	47.761
4	1.194	13.263	62.642	1.194	13.263	62.642	1.339	14.880	62.642
5	0.847	9.416	72.057						
6	0.722	8.027	80.084						
7	0.663	7.362	87.445						
8	0.609	6.769	94.214						
9	0.521	5.786	100.000						

Note: Extraction Method: Principal Component Analysis.

Table 3 depicts the eigenvalues for each factor variable. The eigenvalue for a factor explains the power of variance. The eigenvalue for variable V1 (age of the respondent), V2 (Years of schooling), V3 (Size of the family) and V4 (Cultivable land last year) are 1.702, 1.396, 1.346, and 1.194, respectively which had 18.913, 15.509, 14.957 and 13.263 percent power of variance, respectively. Using this factor analysis, four factors were extracted, accounting for 62.64% of the total variation in the data. From the table, it can be observed that the first extracted factor accounts for a large part of the total variance explained in the data, followed by the other factors which account for lesser and lesser of the total variance. It also represented extracted variables i.e. the number of variables retained. The rotated sum of squared loadings was considered because the result from rotation is more reliable than without rotated solution in factor analysis.

**Table-4.** Factor component matrix.

	Component			
	1	2	3	4
Age of the respondent (years)				0.595
Years of schooling			0.539	
Size of family (Number)		0.585		
Cultivable land last year in care(30 decimals)				0.509
Seed plant cost in care(30 decimals)	0.575			
Plough cost in care(30 decimals)	0.618			
Pesticides cost in care(30 decimals)			0.503	
Fertilizer use kg in care(30 decimals)		0.612		
Irrigation cost in care(30 decimals)	0.593			

Source: Field survey, 2018.

The factor component matrix is disclosed in Table 4. The matrix exhibited the relationship between the factors and individual relationships. To estimate a more suitable result, it was essential to establish a rotated factor matrix.

**Table-5.** Rotated factor matrix: Varimax with kaiser normalization.

	Component			
	1	2	3	4
Age of the respondent (years)				0.846
Years of schooling				-0.740
Size of the family (Number)		0.776		
Cultivable land last year in care (30 decimals)		0.743		
Seed plant cost in care (30 decimals)	0.708			
Plough cost in care (30 decimals)	0.725			
Pesticides cost in care (30 decimals)			-0.792	
Fertilizer use kg in care (30 decimals)			0.795	
Irrigation cost in care (30 decimals)	0.623			

Source: Field survey, 2018.

From this rotated factor matrix [Table 5](#), it would be easy and possible to interpret the extracted factors with percentage variations explained. Now, these 4 factors can be considered:

Factor 1 (F1): Factor 1 was regrouping into V5, V6, and V9 variable i.e. Seed plant cost in care (30 decimals), Plough cost in care (30 decimals), and Irrigation cost in care (30 decimals) respectively.

Factor 2 (F2): Factor 2 was regrouping into V3 and V4 variable i.e., Size of the family (Number) and Cultivable land last year in care (30 decimals) respectively.

Factor 3 (F3): Factor 3 was regrouping into V7 and V8 variable i.e. Pesticides cost in care (30 decimals) and Fertilizer use kg in care (30 decimals) respectively.

Factor 4 (F4): Factor 4 was regrouping into V1 and V2 variable i.e. Age of the respondent (years) and Years of schooling respectively.

### 3.3. Factors affecting on Boro-Rice Production

All extracted factors together explained 62.64% of the rice production. The remaining 27.36% was explained by some other intrinsic factors. The overall regression equation was also found to be significant ( $F= 4.25$ ,  $p < 0.03$ ) indicating that these factors together significantly influenced the production. Among the four factors accounting for yield, factor 1 and factor 2 was highly significant [Table 6](#) which means that production of Boro-rice will be averagely increased by 0.938 unit and 1.30 unit with one unit increase of factor 1 ((i.e. Seed plant cost in care (30 decimals), Plough cost in care (30 decimals) and Irrigation cost in care (30 decimals)) and factor 2 ((i.e. Size of the family (Number family person) and Cultivable land last year in care (30 decimals)) if other things remaining same.

**Table-6.** The coefficients of Multiple Regression and their significance.

Parameters	Coefficient	t-value	P-value
Factor 1	0.938	2.342	0.021
Factor 2	1.301	3.248	0.001
Factor 3	0.336	0.838	0.403
Factor 4	0.206	0.514	0.608

## 4. CONCLUSION

The study was undertaken to determine the significant factors that affect the Boro-rice production of the *Hakaluki Basin*, Bangladesh. Farmers' view about weather information is an important effort in making farm decisions. The maximum portion of the farmers seemed that the climatic indicator rainfall is irregular but the sudden flash flood is a prime cause of food insecurity. Farmers who were vulnerable due to flash flood and their agricultural production and also fodder for livestock damage drastically. Seed plant cost, plow cost, irrigation cost, size of family, and cultivable land last year were found as the significant contributing factors to the Boro-rice production of the *Hakaluki Basin*. So, different government and non-government organizations can take part in an important role by assisting the farmers in these areas

of weakness. Especially the department of Agricultural Extension may take steps to offer training and extension service to the farmers on the diverse aspects of Boro-rice production.

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## REFERENCES

- Bishwajit, G., Razib, B., & Sharmistha, G. (2014). Reviewing the status of agricultural production in Bangladesh from a food security perspective. *Russian Journal of Agricultural and Socio-Economic Sciences*, 25(1), 19-27.
- CEGIS. (2012). Master plan of haor area (Vol. 1). Summary Report. Bangladesh Haor and Wetland Development Board (BHWDB), Ministry of Water Resources, Government of the People's Republic of Bangladesh.
- Coughenour, M., Reid, R., & Thornton, P. (2000). *The savanna model*. Washington, D.C: Future Harvest.
- CWBMP (Coastal and Wetland Biodiversity Management Project). (2005). Strategic aspects of plant biodiversity management in Hakaluki Haor, Department of environment. Government of the People's Republic of Bangladesh.
- FAO. (2008). Report of the fao expert workshop on the use of wild fish and/or other aquatic species as feed in aquaculture and its implications to food security and poverty alleviation," Kochi, India, 16–18 November 2007. FAO Fisheries Report No. 867, Rome.
- Houghton, R. A. (1994). The worldwide extent of land-use change. *BioScience*, 44(5), 305-313.
- Huda, M. (2004). *Experience with modern and hybrid rice varieties in haor ecosystem: Emerging technologies for sustainable rice production*. Paper presented at the Twentieth National Workshop on Rice Research and Extension in Bangladesh. Bangladesh Rice Research Institute. Gazipur-1701, 19-21 April 2004.
- Mas, J.-F., Velázquez, A., Díaz-Gallegos, J. R., Mayorga-Saucedo, R., Alcántara, C., Bocco, G., . . . Pérez-Vega, A. (2004). Assessing land use/cover changes: A nationwide multivariate spatial database for Mexico. *International Journal of Applied Earth Observation and Geoinformation*, 5(4), 249-261. Available at: 10.1016/j.jag.2004.06.002.
- Rana, M. P., Sohel, M. S. I., Akhter, S., & Alam, M. S. (2009). Haor based livelihood dependency of a rural community: A study on Hakalukihaor in Bangladesh. *Proceedings of the Pakistan Academy of Sciences*, 47(1), 1-10.
- Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Kinzig, A. (2000). Global biodiversity scenarios for the year 2100. *Science*, 287(5459), 1770-1774.
- SEMP. (2005). *Rapid internal evaluation of the community based haor and floodplain resource management project (Draft Final Report)*. Dhaka: IUCN-Bangladesh.
- United Nations Environment Programme (UNEP). (2009). Caribbean environment outlook.
- World Bank. (2010). *World development report 2010: Development and climate change*. Washington, DC: World Bank.
- Zhao, G., Lin, G., & Warner, T. (2004). Using thematic mapper data for change detection and sustainable use of cultivated land: A case study in the Yellow River delta, China. *International Journal of Remote Sensing*, 25(13), 2509-2522.

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