

## **GEO-ENVIRONMENTAL CHARACTERISTICS AND LAND SUITABILITY ASSESSMENT FOR AUS RICE CULTIVATION IN COX'S BAZAAR SADAR UPAZILA OF BANGLADESH**

**Abdul Hoque\***

**Abstract:** Based on the overall agro-climatic and agro-edaphic characteristics the land suitability of two Aus rice varieties in Cox's Bazaar Sadar Upazila has been tried to determine under the present study. For this purpose, various landform units of the study area have been identified with a view to determine the unit wise agro-climatic and agro-edaphic criteria. A total of 11 landform units have been recognized, out of which 8 were considered to assess suitability ranges for the cultivation of individual rice categories. Majority of the landform units have been found 'suitable' for Rupa Aus (*Ufshi*) cultivation. However, 'Low Hills and Valley Areas' were identified as 'slightly suitable', while 'Medium High Hilly Areas' found quite 'unsuitable'. On the other hand, 'Piedmont Plain with Highland' and 'Foothill Plain with Medium Highland' of the study area have been identified as 'highly suitable' for Bona Aus (*Local*) cultivation while areas under 'Tidal Floodplain with Medium Highland' have been recognized as 'suitable'. Besides, 'Tidal Floodplain with High and Medium Highland' and 'Tidal Floodplain with Medium High and Medium Lowland' have been identified as 'moderately suitable'. Nonetheless, being open to the sea, maximum of the studied agricultural land in Cox's Bazaar Sadar Upazila has been found significantly affected by recent climate change and increased salinity intrusion which made the area highly restricted to produce satisfactory level of Aus rice varieties.

**Keywords:** Landform Unit, Agro-edaphic Characteristics, Agro-climatic Criteria, Land Suitability, Cox's Bazaar Sadar Upazila

### **INTRODUCTION**

Bangladesh is a low lying country of approximately 1,47,570 square km. area which is situated between 20°34' N and 26°38' N latitudes and 88°01' E and 92°41' E Longitudes (Banglapedia 2003). About 50 percent of the country has an elevation of less than 10 m and the coastal zone is a very flat land within the contour of 3 m, and

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\* Abdul Hoque, Associate Professor, Department of Geography and Environmental Studies, University of Chittagong, Chittagong 4331, Bangladesh

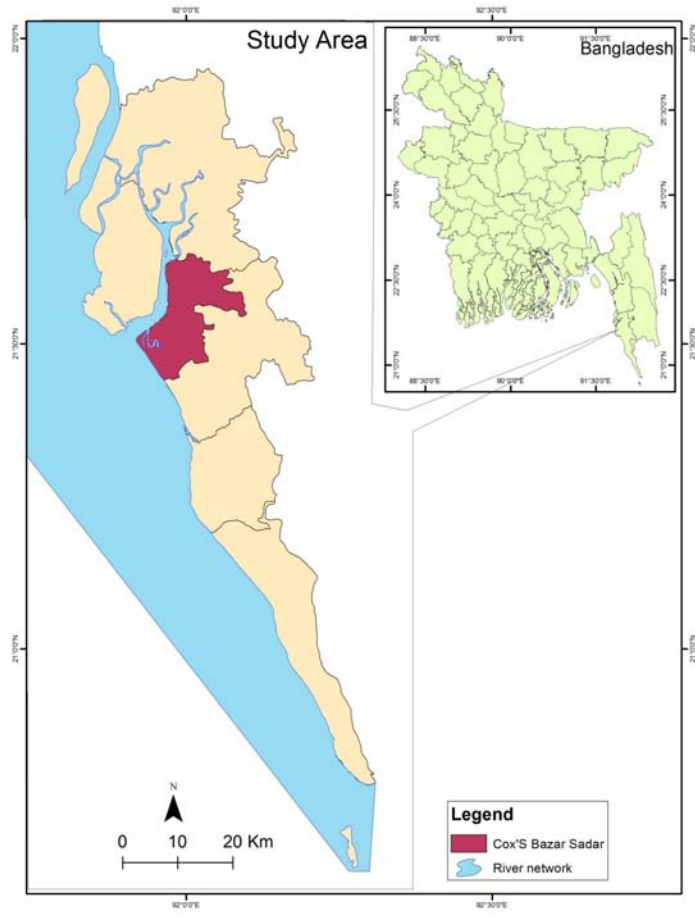
extends over a length of 710 km around the Bay of Bengal between India and Myanmar borders (Rasheed 2008). Having plenty of open agricultural land to the Bay of Bengal Cox's Bazaar Sadar Upazila contains huge amount of highly vulnerable coastal area, particularly in terms of land suitability for traditional rice varieties. Moreover, Bangladesh is at great risk from global climate change (WB 2000; SMRC 2000a, 2000b; MoEF 2002; Agarwala et al. 2003) because of its very low elevation and exposure to various water related hazards. Furthermore, analysis of long-term monthly and annual mean data on maximum and minimum temperature reveals (SMRC, 2000b) a statistically significant increasing trend of annual mean maximum temperature, slightly decreasing trend of annual mean minimum temperature and a slight increasing trend of annual mean temperature. Although the magnitude of these changes in climate phenomena may appear to be small, they could substantially increase the magnitude of existing climatic events like temperature, floods, droughts, cyclones etc., and significantly hamper crop production, including the cultivation of various rice varieties in the region.

The present study is an empirical study to develop a framework for assessing the crops suitability in the eastern coastal region of Bangladesh with reference to changing climate phenomena and its impacts on land use suitability. However, agricultural development of a land unit is significantly dependent on the characteristics related to physiography, climate, soil, drainage, availability of water, surface water quality etc. of the area. Therefore, an attempt has been taken under the present study to classify the whole of the study area (e.g., Cox's Bazaar Sadar Upazila) into various landform units of homogeneous characteristics with the view to determine the unit wise production suitability of individual crops. For this purpose, various geomorphic units of land in the Cox's Bazaar Sadar Upazila have initially been identified from 3D views of aerial photographs, which have later been confirmed by the study of respective satellite imageries (e.g. Landsat), topographic sheets (1:50,000), coastal area maps (1:10,000), and finally by couple of detailed field surveys during the period from October 2014 to April 2015. Ultimately, a total of 11 landform units have been identified within the study area from which 8 units were taken into consideration for further study to determine in-depth geo-environmental characteristics (e.g., agro-edaphic and agro-climatic) for assessing the production suitability of two Aus Rice varieties (e.g., Rupa Aus- *Ufshi* and Bona Aus- *Local*). Thus, geomorphic unit wise land suitability of the study area for selective rice categories have been determined mainly based on various agro-edaphic and agro-climatic characteristics of respective land units.

### STUDY AREA

Cox's Bazaar was formerly a sub-division of Chittagong District (*Zila*). It became a sub-division in 1854 and was upgraded to a district in 1984. It is located at the fringe

of the Bay of Bengal with an unbroken straight sandy sea-beach which is the longest one in the world (BBS 2012). Cox’s Bazaar District is bounded on the north by Chittagong District, on the east by Bandarban District and Myanmar, and on the south and west by the Bay of Bengal. It lies between 20°43' and 21°56' north latitudes and between 91°50' and 92°23' east longitudes covering a total area of 2,491.85 sq. km. (BBS 2012). The present study area, Cox’s Bazaar Sadar Upazila, is located within Cox’s Bazaar District which was upgraded to an Upazila on the 1st February 1984. Occupying an area of 228.23 sq. km., including 92.60 sq. km. forest area, Cox’s Bazaar Sadar Upazila is located between 21°24' and 21°36' north latitudes, and 91°59' and 92°08' east longitudes (BBS 2012). It is bounded on the north by Chakaria Upazila, on the east by Ramu Upazila, on the south by Ramu Upazila and the Bay of Bengal, and on the west by Moheshkhali Upazila and the Bay of Bengal (Fig. 1).



**Figure 1:** Location of the Study Area

Source: Prepared from Banglapedia (2003) and LGED (2015) using Arc GIS 10

Cox's Bazar Sadar Upazila is rich in natural resources, particularly is abundant with fish. With a large sandy beach and its natural beauty Cox's Bazaar attracts a large number of tourists all the year round. At present huge numbers of residential hotels, motels and cottages have been built to accommodate these tourists. Thus the town of Cox's Bazaar is growing very fast. According to the Population and Housing Census 2011 of the Government of Bangladesh the total enumerated population in Cox's Bazaar Sadar Upazila was 4,59,082 in 2011 while it was counted 3,48,075 during the census conducted in 2001 (BBS 2012). Male female sex ratio of the Upazila in 2011 and 2001 had been calculated 111 and 115, respectively. On the other hand, the urban and rural population male-female ratios in 2011 were found 129 and 102, respectively while in 2001 the urban and rural population male-female ratios were calculated 135 and 112, respectively (BBS 2012).

### **AIM AND OBJECTIVES**

The aim of the present study is to assess the geo-environmental characteristics of the Cox's Bazaar coastal belt for determining the land suitability in Cox's Bazaar Sadar Upazila for selective crops production. The specific objectives of the research to achieve the aim are:

- To identify major geomorphic units of land with the view to determine the unit wise agro-edaphic (e.g., soil permeability, available soil moisture, soil reaction, soil salinity etc.) and agro-climatic (e.g., duration of crop production seasons, standard deviations of their start dates, number of dry days, number of extreme hot and cool days, potential evapo-transpiration etc.) criteria of the study area; and
- To assess the geomorphic unit wise land suitability of selective rice categories, e.g., Rupa Aus (*Ufshi*) and Bona Aus (*Local*), in Cox's Bazaar Sadar Upazila based on the determined agro-edaphic and agro-climatic criteria under the present study.

### **DATA AND METHODOLOGY**

#### **Classifying Landform Units**

For this purpose, various geomorphic units of land in the Cox's Bazaar Sadar Upazila have initially been identified from 3D views of aerial photographs which have later

been verified by the study of respective satellite imageries (e.g., Landsat TM and ETM+), topographic sheets and coastal area maps (Table 1) of Bangladesh. Ultimately, identified landform units were confirmed and finalized by couple of detailed field surveys during the period from October 2014 to April 2015. Following the method, a total of 11 landform units have been recognized within the study area, out of which 8 were taken into consideration for further study. However, finally, in-depth geo-environmental characteristics (e.g., agro-edaphic and agro-climatic criteria) of various landform units have been determined through a number of detailed field investigations for assessing the production suitability of selective rice varieties, e.g., Rupa Aus (*Ufshi*) and Bona Aus (*Local*), within the study area.

### Determining Crop Suitability

Potential crop production capacity of an area generally depends on agro-edaphic and agro-climatic characteristics of the region. So, the agro-edaphic and agro-climatic characteristics of identified land units (Fig. 2) of Cox's Bazaar Sadar Upazila have been used in the present study for crop suitability assessment. Process of assessing crop suitability in this study is, in some extent, consistent with the method followed by Bangladesh Agricultural Research Council (BARC 2013). However, the detailed procedure and expositions to determine agro-edaphic and agro-climatic characteristics of various landform units of the study area have been explained below.

**Table 1:** Particulars of various Maps, Aerial Photographs and Satellite Imageries used for Identifying various Geomorphic Units within the Study Area

Data Category	Source / Producing Authority	Identifying Code / No.	Date / Year	Scale /Series/ Resolution	Other Relevant Information
Aerial Photographs	BIWTA & FINNMAP	[CCNS4] BANGLA1 COAST1 38 (017-022)	Nov 1998	1:50,000	3-38 (0573-0578)
Topographic Sheets	SoB, Government of Bangladesh	84 C/2; 84 C/3 (Chittagong & CHT Districts)	1978 (Reprinted in1996)	1:50,000	3 <sup>rd</sup> Edition
		79 O/14 (Chittagong District)	1969 (Reprinted in1984)	1:50,000	2 <sup>nd</sup> Edition
		79 O/15 (Chittagong District)	1969 (Reprinted in1974)	1:50,000	2 <sup>nd</sup> Edition

Data Category	Source / Producing Authority	Identifying Code / No.	Date / Year	Scale /Series/ Resolution	Other Relevant Information
Bangladesh Map of Coastal Area	BIWTA, FINNIDA (Finland) & CEC	COX'S BAZAR DHa (2365 700 + 2370 700); DHa 2365 710; DHa 2370 705; DHa 2370 710; DHa 2375 705; DHa 2375 710; DHa 2380 705; and DHa 2380 710	2000	1:10,000	1 <sup>st</sup> Edition
Satellite Imageries	LANDSAT	LT51360451988315 BKT00	10 Nov 1988	Grid Cell Size: 30m (Reflective & Thermal)	Datum- WGS84; UTM Zone- 46; WRS Path- 136; WRS Row- 045; Data Type: TM L1T
		LT51360451997307 BKT00	03 Nov 1997	Grid Cell Size: 30m (Reflective & Thermal)	Datum- WGS84; UTM Zone- 46; WRS Path- 136; WRS Row- 045; Data Type: TM L1T
		LE71360452014314 EDC00	10 Nov 2014	Grid Cell Size: 30m (Reflective & Thermal); 15m (Panc-hromatic)	Datum- WGS84; UTM Zone- 46; WRS Path- 136; WRS Row- 045; Data Type: ETM+L1T

Notes: BIWTA- Bangladesh Inland Water Transport Authority; FINNMAP- An International Consulting Company with Major Activities in Land Management and Administration, Remote Sensing, Digital Mapping, Surveying and GIS; SoB- Survey of Bangladesh; FINNIDA- Finnish International Development Agency; CEC- Commission of the European Communities; LANDSAT- Global Land-Imaging Mission, A Joint Program of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA).

**Table 2:** Land Factors with their Codes, Descriptions and Ratings

Factors	Codes	Land Factor Descriptions	Ratings
Soil Permeability	p1	Slow (< 12 cm d <sup>-1</sup> )	1
	p2	Moderate (12-305 cm d <sup>-1</sup> )	2
	p3	Rapid (> 305 cm d <sup>-1</sup> )	3
Effective Soil Depth	d1	< 0.25 m	1
	d2	0.25 – 0.60 m	2
	d3	0.60 – 0.90 m	3
	d4	0.90 - 1.22 m	4
	d5	> 1.22 m	5
	d6	Very firm/hard ploughpan	6
Available Soil Moisture	m1	< 100 mm	1
	m2	100-200 mm	2
	m3	200-300 mm	3
	m4	300-400 mm	4
	m5	> 400 mm	5
Nutrient Status	n1	Low	1
	n2	High	2
Soil Reaction (pH)	a1	< 4.5	1
	a2	4.5-5.5	2
	a3	5.5-7.3	3
	a4	7.3-8.4	4
	a5	> 8.4	5
Soil Salinity	s1	< 2 dS m <sup>-1</sup> or < 2 mMohs cm <sup>-1</sup>	1
	s2	2-4 dS m <sup>-1</sup> or < 2-4 mMohs cm <sup>-1</sup>	2
	s3	4-8 dS m <sup>-1</sup> or < 4-8 mMohs cm <sup>-1</sup>	3
	s4	8-15 dS m <sup>-1</sup> or < 8-15 mMohs cm <sup>-1</sup>	4
	s5	> 15 dS m <sup>-1</sup> or > 15 mMohs cm <sup>-1</sup>	5

Factors	Codes	Land Factor Descriptions	Ratings
Soil Consistency	t1	Not more than slightly firm, slightly sticky, slightly plastic, hard	1
	t2	Firm, very firm, sticky, plastic, hard, very hard	2
	t3	Extremely firm, very sticky, very plastic, extremely hard	3
	t4	Organic material to at least 25 cm below the surface	4
Drainage	w1	Well drained	1
	w2	Moderately well-drained	2
	w3	Imperfectly drained	3
	w4	Poorly drained, surface drains < 15 Nov	4
	w5	Poorly drained, surface drains > 15 Nov	5
	w6	Very poorly drained	6
Depth of Inundation	i1	No inundation	1
	i2	< 30 cm	2
	i3	30-90 cm	3
	i4	90-180 cm	4
	i5	180-300 cm	5
	i6	> 300 cm	6
Flood Hazards	f1	None	1
	f2	Once in 10 years	2
	f3	Twice in 10 years	3
	f4	3-4 times in 10 years	4
	f5	5 times or more in 10 years	5
Slope	e1	< 3 percent	1
	e2	3-8 percent	2
	e3	8-16 percent	3
	e4	16-30 percent	4
	e5	30-45 percent	5
	e6	> 45 percent	6

Source: BARC, 2012



### Agro-edaphic Suitability

In this method, involving the desired land and soil distinctiveness with major crops productions in Bangladesh, 11 agro-edaphic factors (Table 2) were selected. Based on the verification of individual crop productivity demand the respective level of land and soil quality have been assessed using a 5 degree (0-4) limitations scale for different ranges of agro-edaphic factors, shown in table 3. For this purpose, regarding respective crops production, the degrees of limitation with respect to crop requirements of individual land factors were assessed. Accordingly, for different land units (Fig. 1) the degrees of limitation of various crops for assorted land factors were imposed (Table 4) based on the expert judgment from the National Agricultural Research System (NARS) scientists and other experts who have wide knowledge base and field experience on crops cultivation. A wide range of literatures published by BARC, BRRI, SRDI, UNDP and FAO etc. (e.g., BARC 2012; BARC 2013; SRDI 1996; and UNDP & FAO 1988) were also reviewed for this purpose. Finally, relationships between suitability rating, and number and degrees of limitations were determined to identify ranges of suitability (e.g., highly suitable, suitable, moderately suitable, slightly suitable, and not suitable) for individual crops.

**Table 3:** Five Degree Limitations Scale for Different Ranges of Agro-edaphic Factors to Assess the Crops Suitability of various Landform Units

Numbers	Degree of limitations
0	No limitation, representing the most favorable condition
1	Slight limitation
2	Moderate limitation
3	Severe limitation
4	Very severe limitation; the soil is unsuitable for the land use type or particular crop under consideration at the specified level of management

Source: BARC, 2013

**Table 4:** Degrees of Limitations Imposed on Different Land Factors for Aus (Rupa-Ufshi and Bona- local) Rice

Code	Degree of Limitations	Code	Degree of Limitations	Code	Degree of Limitations
p1	0	a3	0	i1	2
p2	1	a4	0	i2	0
p3	2	a5	2	i3	0
d1	3	s1	0	i4	2
d2	1	s2	1	i5	3
d3	0	s3	2	i6	4
d4	0	s4	3	f1	0
d5	0	s5	4	f2	0
d6	0	t1	1	f3	1
m1	4	t2	0	f4	2
m2	1	t3	0	f5	3
m3	0	t4	3	e1	0
m4	0	w1	4	e2	2
m5	0	w2	2	e3	4
n1	1	w3	0	e4	4
n2	0	w4	0	e5	4
a1	3	w5	0	e6	4
a2	1	w6	1		

Source: BARC, 2013

**Agro-climatic Suitability**

In general, a tropical monsoon climate with hot, wet summers and cool, dry winters prevails in Bangladesh. So, only those crops that can be grown under these climatic conditions warrant the emphasis of being evaluated for our food security. However, in case of agro-climatic zoning in Bangladesh the area wise duration of crop production seasons, standard deviations of their start dates, number of dry days, excessive rain, number of extreme hot and cool days, and potential evapo-transpiration (PET) are generally considered. Thus, considering respective climate constraints in a region, the following four precipitations and temperature related determinants are identified in

different areas of Bangladesh with the view to ensure better planning strategy for various crops production (SRDI 1996):

- a) Duration of Pre-kharif transition period, or time frame of uncertain and discontinuous rainfall;
- b) Average duration of rain-fed Kharif and Rabi crops production periods;
- c) Average number of days with minimum temperature  $<15^{\circ}\text{C}$  which is very much important for major Rabi crops in particular; and
- d) Average number of days with maximum temperature  $>40^{\circ}\text{C}$ , when the potential evapo-transpiration (PET) rate reaches to harmful level.

Ultimately, based on the critical analysis of the information related to precipitation, temperature, evapo-transpiration and exhaustion of soil moisture two main crops production periods- *Kharif* and *Rabi*- are identified in Bangladesh which are highly festooned by three prominent climate seasons, viz. pre-monsoon, monsoon and winter. Thereby, three major crops growing periods (viz., Pre-kharif transition period, Kharif growing period, and Rabi growing period) and two major thermal zones (viz., Rabi or cool temperature zones, and Extreme summer temperature zones) are recognized (BARC 2012) which play significant role to determine crops agro-climatic suitability of a region.

#### **Agro-climatic Criteria of Cox's Bazaar Sadar Upazila**

The study reveals that whole of the area under the present study is located within the crop production based agro-climatic unit code K6 P4 (Fig. 2) where Pre-kharif crop growing period is generally started on 24 March with an average end date of 8 May (SRDI 1996). Standard deviations (SD) of start date and end date of this period ranges 5-25 days and 10-30 days, respectively. Average length of this period in Cox's Bazaar Sadar Upazila is 40-50 days of which, on an average, 24-32 days remain dry. Besides, Kharif crops growing period in this area persists from 3 May to 14 December and the standard deviations of the start and end date of this period in the region may be 10-30 days and 20-35 days, respectively (SRDI 1996). The average length of this period is 220-230 days of which comparatively wetter condition prevails from the middle of May to the 3<sup>rd</sup> week of October. Average duration of wet Kharif period in the region is 140-170 days while usually excessive rainfall (800 mm - 2,000 mm) occurs. Furthermore, Rabi crops growing period in Cox's Bazaar Sadar Upazila prevails from 21 October to 2 March which may be started 15-30 days earlier or later (SRDI 1996). The standard deviation of the end date of this period is 20-35 days, and the average duration of Rabi growing period of the area is 120-145 days, in general.

The study also recognizes that based on thermal condition the areas under Cox's Bazaar Sadar Upazila can be divided into three units, viz. T1 E1, T2 E1 and T3 E1 (SRDI 1996) (Fig. 2) of which T3 E1 contains a small area at the eastern part mainly covering the landform unit of 'medium high hilly areas'. Land units of 'low hills and valley areas' along with some other adjacent areas, located at the eastern part of the Upazila, falls under thermal zone T2 E1 while the rest of the complete study area has been considered under T1 E1 zone (Fig. 2). During Rabi crops growing period, within the areas under T1 E1 thermal zone, the time of  $<15^{\circ}\text{C}$  lowest temperatures prevails from 16 December to 20 January (with an average length of 30-40 days) while the time of  $<17.5^{\circ}\text{C}$  lowest temperatures exists from 2 December to 12 February for an average length of 65-80 days (SRDI 1996). Days with minimum temperature  $<10^{\circ}\text{C}$  never happen within this thermal zone. On the other hand, average number of days in Kharif/Summer with maximum temperature  $>40^{\circ}\text{C}$  in this zone takes place not more than once in two years which might increase up to 5 days in a year, rarely (SRDI 1996). Moreover, within T2 E1 thermal zone in Cox's Bazaar Sadar Upazila, during Rabi growing period, the time of  $<15^{\circ}\text{C}$  minimum temperatures also exists from 16 December to 20 January with an average length of 40-45 days while the time of  $<17.5^{\circ}\text{C}$  minimum temperatures exists from 26 November to 12 February for an average length of 70-85 days. Days with minimum temperature  $<10^{\circ}\text{C}$  happen within this thermal zone 0-5 in a year and average number of days in Kharif/Summer with maximum temperature  $>40^{\circ}\text{C}$  in this zone takes place not more than once in two years (SRDI 1996). Furthermore, within T3 E1 zone the time of  $<15^{\circ}\text{C}$  minimum temperatures during Rabi growing period exists from 6 December to 4 February with an average length of 50-70 days while the time of  $<17.5^{\circ}\text{C}$  minimum temperatures endures from 24 November to 14 February with an average length of 80-105 days (SRDI 1996). However, days with minimum temperature  $<10^{\circ}\text{C}$  happen within this thermal zone 5-15 in a year and average number of days in Kharif/Summer with maximum temperature  $>40^{\circ}\text{C}$  in this zone is not more than once in two years.

## RESULTS AND DISCUSSION

Following the above explained methods various landform units (e.g., Medium High Hilly Areas, Low Hills and Valley Areas, Foothill Plain with Medium Highland, Tidal Floodplain with High and Medium Highland etc.) in the Cox's Bazaar Sadar Upazila have been identified. Considering agro-climatic (e.g., rainfall based crops growing periods, and thermal zones) and agro-edaphic (e.g., Soil Permeability, Effective Soil

Depth, Available Soil Moisture, Nutrient Status, Soil Reaction (pH), Soil salinity, Drainage Condition etc.) characteristics of individual landforms, the unit wise land suitabilities of Rupa Aus (*Ufshi*) and Bona Aus (*Local*) rice cultivations in the study area have been assessed which are discussed below in details.

### **Major Landform Units in Cox's Bazaar Sadar Upazila**

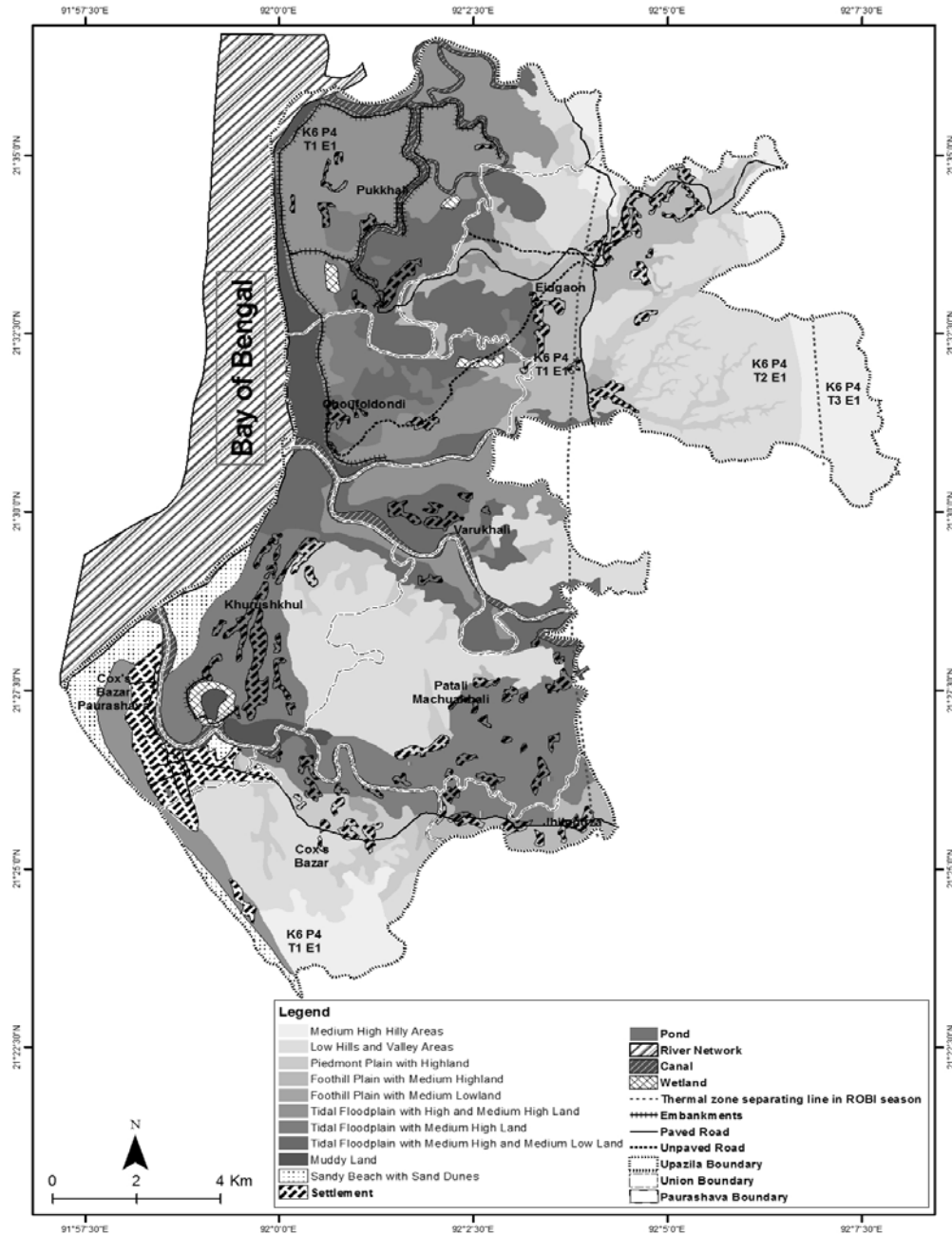
Identified major landform categories in Cox's Bazaar Sadar Upazila are: Medium High Hilly Areas; Low Hills and Valley Areas; Piedmont Plain with Highland; Foothill Plain with Medium Highland; Foothill Floodplain with Medium Lowland; Tidal Floodplain with High and Medium Highland; Tidal Floodplain with Medium Highland; Tidal Floodplain with Medium High and Medium Lowland; Sandy Beach with Sand Dunes; Muddy Land; and Wetlands. Major geomorphic characteristics of considered landform units for the present study are discussed below in brief.

#### **Medium High Hilly Areas**

This land unit includes approximately 1,500 hectares area which covers near about 7.5% of the total study area. Maximum of these areas (900 ha) are distributed over the eastern part of Eidgaon Union at seven locations (Fig. 2). Remainders of the areas are located at the southern most part of the Upazila under Jhilonga Union (525 ha) while a small portion (60 ha) is located within Pukkhali Union at north. Almost the entire areas under this land unit are comprised of medium high hills which are mainly constructed by hard rocks. These hills are elongated north-south and separated by tiny valleys from each other. Around 25%, 40% and 35% of these hills are very highly, highly and moderately cliffed, respectively. Identified major soil groups in this landform unit are Sitakund, Tamabil, Barkal, Subalong and Dhum.

#### **Low Hills and Valley Areas**

Total area under this landform unit is around 4,600 hectares that covers approximately 23% of the Cox's Bazaar Sadar Upazila. These hills and valley areas are scattered over 6 major and a few minor segments of lands (Fig. 2) in Eidgaon, Patali Machuakhali, Jhilongja, Khuruskhul and Varuakhali Unions, and Cox's Bazaar Pourashava. About 3,400 hectares of lands under this landform unit are low hills which are mainly consisted of unconsolidated rocky basement. Roughly 1000 hectares of the remaining areas under this category are covered by valleys. The rest of the areas under this landform unit include mainly low hills with settlements. Slope of nearly 90% hills under this landform category is moderate while it is very gentle for the rest of the hills.



**Figure 2:** Various Geomorphic/Landform Units in Cox’s Bazaar Sadar Upazila of Cox’s Bazaar District, Bangladesh

Source: Prepared on the basis of Landsat RS Data; SoB, LGED and SRDI Maps; and Field Survey 2015

The rain water, particularly during the monsoon, is to be drained well through the valleys and creeks in this area. Lama, Rangamati and Rangapani are the major soil groups in the hills under this landform unit while Pahartali and Mirsharai are the main soil groups identified in the high and moderately high land of the valleys, respectively.

#### **Piedmont Plain with Highland**

Total areas under this category of landform unit include a total of approximately 1900 hectares land covering about 9.5% area of the Upazila and distributed over the study area by 10 isolated pieces of land, maximum of which are located within Eidgaon, Jhlongja, Patali Machuakhali, Khuruskhul, Varuakhali, and Pukkhali Unions. Almost whole of these land masses are agricultural land containing 74% high land with a combination of about 23% medium high and a small amount of lowland. High lands never experience rain water stagnation even during the monsoon while maximum of the medium and low lands within this landform unit can suffer from up to 90 cm flooding for 3-4 months during sturdy rainy season. Identified soil groups in high land areas of this landform unit are Pahartali and Bijipur, while medium high lands of the unit contain mainly Pahartali along with few Mirsharai soil groups.

#### **Foothill Plain with Medium Highland**

Areas calculated under this category of land unit are 1180 hectares which cover 6% of the total study area. These are distributed over 6 Unions and located at two comparatively larger and three smaller pieces of lands. Maximum of these land masses are located in Eidgaon and Jhlongja Unions, while the rests of the lands are located in Pukkhali, Chaufaldandi and Patali Machuakhali Unions (Fig. 2). Maximum (above 75%) of these land masses are cultivable medium high land, while the rests are high land with settlements. Identified soil groups in the medium high lands of this land unit are Pahartali, Bijipur and Mirsharai, while major soil groups found in the highland areas are Mirsharai, Pahartali and Muhuri. Water stagnation does not take place in the highland areas of this landform unit, while up to 90cm flooding for 3-4 months period is a common scenario during rainy season in the medium high lands.

#### **Foothill Plain with Medium Lowland**

The total area under this category of land unit in Cox's Bazaar Sadar Upazila is around 45 hectares which covers only 0.2% of the total area under study. Maximum areas of these landform units are located in Jhlongja (22 ha) and Eidgaon (12 ha) Unions. During rainy season the medium lowlands under this landform category are usually flooded from 90 to 180 cm for 5-6 months period. Identified soil groups within these land masses are Mirsharai and Muhuri.

### **Tidal Floodplain with High and Medium Highland**

Total areas under this category of landform unit are approximately 2800 hectares covering around 14% of the whole study area. These lands are separated into 7 segments and distributed over 8 Unions of Cox's Bazaar Sadar Upazila. More than half (1,545 ha) of these areas are located in Pukkhali Union while 365, 360, 180, 77, 55 and 50 hectares of lands are located in Varuakhali, Choufoldondi, Jhlongja, Patali Machuakhali, Eidgaon, and Khurushkul Unions, respectively (Fig. 2). Almost the entire areas under this landform unit are medium highland while a small portion (160 ha) of land is identified as highland. All of these lands are cultivable. Rainwater does not stand over the highlands while medium highlands in Jhlongja Union and Cox's Bazaar Pourashava areas are usually flooded up to 90 cm for 1-2 months period during rainy season. The rest of all medium highlands in various unions are also flooded for 4-5 months during rainy season, up to 90 cm, which might increase in the cases of exceptionally high tide and rainfall intensity.

### **Tidal Floodplain with Medium Highland**

Covering approximately 12% of the Upazila the total area of this land unit is around 2,500 hectares. It is divided into 10 pieces of lands which are located in Eidgaon (570 ha), Choufoldondi (550 ha), Pukkhali (485 ha), Varuakhali (469 ha), Patali Machuakhali (200 ha) and Khurushkul (185 ha) Unions. The whole area under this land unit is medium highland almost all of which are quite cultivable. These lands remain inundated by rainwater up to 90 cm for 3-4 months in the monsoon. Major soil groups identified in this land unit are Chakaria, Kutubdia, Harbang, Chiringa and Badarkhali.

### **Tidal Floodplain with Medium High and Medium Lowland**

Total area under this land unit is approximately 2180 hectares which covers roughly 11% of the present study area. These lands are divided into 6 segments and located mainly in Patali Machuakhali (1,000 ha), Khurushkul (670 ha), Jhlongja (285 ha) and Choufoldondi (175 ha) Unions (Fig. 2). Rests of the areas are located in Eidgaon and Pukkhali Unions, and Cox's Bazaar Pourashava. Entire lands under this category are cultivable except nearly 50 hectares of settlement areas located in Choufoldondi Union. Almost all the lands under this landform unit are medium high and usually flooded up to 90 cm for 3-4 months period, particularly during the monsoon. Identified major soil groups in this category of lands are Chakaria, Kutubdia and Harbang.



### **Land Suitability Assessment for selective Rice Categories in Cox's Bazaar Sadar Upazila**

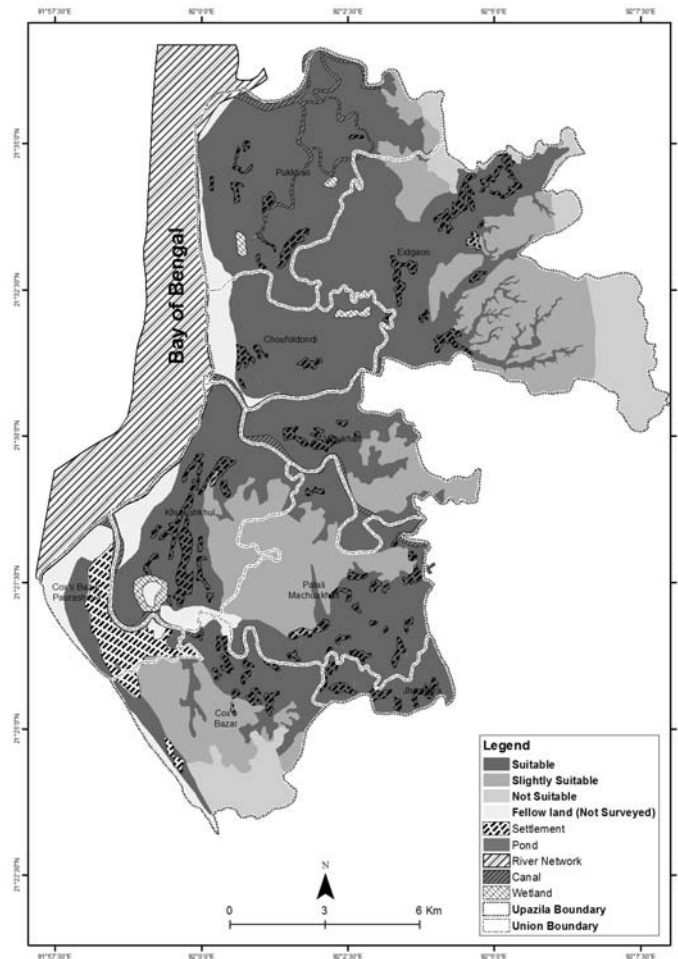
Rice is the dominant crop cultivated throughout the year in Bangladesh though the methods of cultivation vary with seasonal changes. It is grown in three distinct rice growing seasons namely, 'Aus' (April - August), 'Aman' (July - November), and 'Boro' (December - May). However, based on the various agro-edaphic and agro-climatic characteristics the suitability of Rupa Aus (*Ufshi*) and Bona Aus (*Local*) has been determined in Cox's Bazaar Sadar Upazila area under the present study. For this purpose, under the prevailing climate conditions, considered crops production controlling land and soil characteristic factors of various landform units (Fig. 2) are soil permeability, effective soil depth, available soil moisture, nutrient status, soil reaction (pH), soil salinity, soil consistency, drainage condition, depth of inundation, flood hazards, and slope (Table 2). Three levels suitability grades (e.g., 1- suitable; 2- moderately suitable; and 3- not suitable), introduced by Soil Resources Development Institute (SRDI 1996), for various soil and land factor components have been used to determine the potential areas under different suitability classes (i.e. highly suitable, suitable, moderately suitable, slightly suitable, and not suitable) on the basis of overall suitability ranges calculated for individual rice categories in various landform units (Fig. 2) of the study area.

#### **Land Suitability of Rupa Aus (*Ufshi*) Cultivation**

Following the method explained above, identified land suitability classes for Rupa Aus (*Ufshi*) in Cox's Bazaar Sadar Upazila are suitable, slightly suitable, and not suitable that fit in to the overall suitability ranges of 1.26-1.50, 1.76-2.00, and 2.01-3.00, respectively. No 'highly suitable' and 'moderately suitable' lands were found for this category of rice cultivation within the study area. On the other hand, due to the lack of sufficient agricultural credence, a levelheaded amount of fellow lands had been recognized within the study area which were not considered for survey as because they were occupied by sandy beach, sand dunes, and muddy or wet lands (Fig. 2).

The study reveals that majority of the landform units of the study area contain the overall suitability range 1.26-1.50 which are suitable for Rupa Aus (*Ufshi*) cultivation. Most of these land categories are located in Eidgaon (2817 ha) Jhilongja (1162 ha), Patali Machuakhali (1497 ha), Khuruskhul (1090 ha), Varuakhali (894 ha), Pukkhali (2074 ha), and Choufoldandi (185 ha) Unions (Fig. 2). On the other hand, lands under 'Low Hills and Valley Areas' have been identified as 'slightly suitable' for Rupa Aus (*Ufshi*) cultivation which contain the overall suitability range 1.76-2.00. Areas under this land suitability class cover approximately 23% of the total study area which are

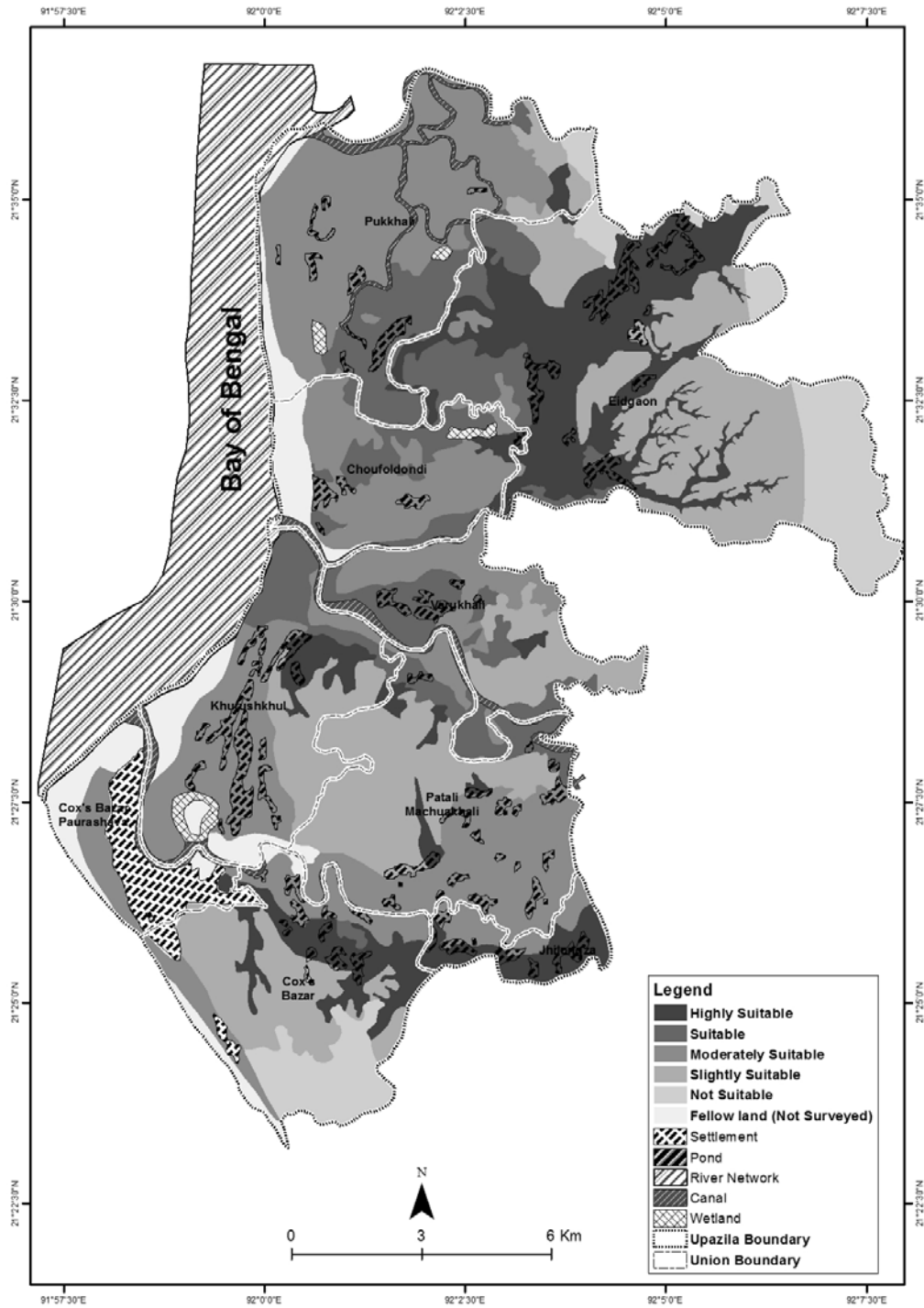
located in Eidgaon (1780 ha), Patali Machuakhali (965 ha), Jhilongja (795 ha), Khurushkhul (450 ha) and Varuakhali (440 ha) Unions, and Cox's Bazaar Pourashava (6 ha). Moreover, holding the overall land suitability range of 2.01-3.00, areas under landform unit of 'Medium High Hilly Areas' of the study area found quite 'unsuitable' for Rupa Aus (*Ufshi*) cultivation. Maximum of these areas (900 ha) are distributed over the eastern part of Eidgaon Union at seven locations (Fig. 3), while rests of the areas are located at the southern most part of the Upazila under Jhilongja Union (525 ha). Nonetheless, a significant amount of lands under several landform units (e.g., Sandy Beach, Sand Dunes, Coastal Muddy or Wet Lands etc.) of the study area have been identified as 'fellow land' (Fig. 3) which were not considered for detailed survey so that the direct field observations were adequate to identify these areas as 'completely unsuitable' for cultivating any of our traditional crops.



**Figure 3:** Land Suitability of Cox's Bazaar Sadar Upazila for Rupa Aus (*Ufshi*) Cultivation

### **Land Suitability of Bona Aus (*Local*) Cultivation**

Based on the overall land suitability ranges calculated from the agro-climatic condition and surveyed agro-edaphic factors of individual landform units, recognized land suitability classes for Bona Aus (*Local*) cultivation in Cox's Bazaar Sadar Upazila are 'highly suitable', 'suitable', 'moderately suitable', 'slightly suitable', and 'not suitable'. Overall suitability ranges for these land suitability classes are 1.00-1.25, 1.26-1.50, 1.51-1.75, 1.76-2.00, and 2.01-3.00, respectively. The study reveals that areas within landform units of 'Piedmont Plain with Highland' and 'Foothill Plain with Medium Highland' have to be identified as 'highly suitable' land class, containing an overall crop suitability range 1.00-1.25, for Bona Aus (*Local*) cultivation. A total area of 3415 hectares land has been found under this land suitability class covering more than 15% of the study area. Most of these lands are distributed over Eidgaon (2180 ha) and Jhlongja (675 ha) Unions while the rests (560 ha) of the lands are located in Patali Machuakhali, Khuruskhul, Varuakhali, Pukkhali and Choufoldandi Unions (Fig. 4). On the other hand, covering a total of 2500 hectares land in Eidgaon (570 ha), Choufoldondi (550 ha), Pukkhali (485 ha), Varuakhali (469 ha), Patali Machuakhali (200 ha) and Khuruskul (185 ha) Unions of the study area, 'Tidal Floodplain with Medium Highland' contains the overall land suitability range 1.26-1.50 and recognized as 'suitable' for Bona Aus (*Local*) cultivation. A very tiny amount of land (0.2%) under 'Foothill Plain with Medium Lowland' has also been identified as 'suitable' that are located in Jhlongja and Eidgaon Unions. Besides, covering 25% of the study area, about 5000 hectares land has been identified as 'moderately suitable' for Bona Aus (*Local*) cultivation with an overall land suitability range of 1.51-1.75. These lands include two landform units, viz. 'Tidal Floodplain with High and Medium Highland' and 'Tidal Floodplain with Medium High and Medium Lowland', which are mainly located in Pukkhali (1545 ha.), Patali Machuakhali (1,077 ha), Khuruskhul (720 ha), Jhlongja (465 ha), Varuakhali (365 ha), Choufoldondi (175 ha) and Eidgaon (55 ha) Unions.



**Figure 4:** Land Suitability of Cox's Bazaar Sadar Upazila for Bona Aus (*Local*) Cultivation

Moreover, ‘Low Hills and Valley Areas’ have been recognized as ‘slightly suitable’ land class for Bona Aus (Local) cultivation, covering a total of 4,600 hectares land. These lands occupy approximately 23% of the study area and located in Eidgaon (1780 ha), Patali Machuakhali (965 ha), Jhilongja (795 ha), Khuruskhul (450 ha) and Varuakhali (440 ha) Unions (Fig. 4).

Finally, lands under ‘Medium High Hilly Areas’ of the study area have been found quite unsuitable for Bona Aus (*Local*) cultivation that fit in to the overall crop suitability range 2.01-3.00 and located at the eastern part of the Eidgaon (900 ha) and southern most part of the Jhilonga (525 ha) Unions (Fig. 4). Nevertheless, similar to the case of Rupa Aus (*Ufshi*), a considerable amount of lands under some landform categories (e.g., sandy beach, sand dunes, coastal muddy land and wetlands) of the study area have been identified as fellow land (Fig. 4). Areas under these landform units were not considered for detailed survey to determine the suitability of Bona Aus (Local) cultivation, so that during field observations these areas were found quite unsuitable for the cultivation of any of our traditional crops.

## CONCLUSION

Rice is the most essential food of Bangladesh mainly because of its high domestic consumption rather than economic importance. So, it is produced almost everywhere in the country, particularly to meet local demand. Bangladesh consumed its entire domestic production and imported around 0.087 million tonnes rice during 2009-2010 (BARC 2012). Being the fourth largest rice producer in the world its attachment with rice is more than in any other countries of the world. Statistics show that about 77% agricultural land of Bangladesh grow rice and more than 70% of the rural population engage themselves in rice production activities (BARC 2013). On the other hand, growing, selling and eating rice is integral to the culture of Bangladesh like many other countries of the world. For example, *Nobanno* (new rice harvest) is one of the cheerful folk festivals which is strongly observed in rural Bangladesh with lots of fanfare after the new crop comes to home in *Agrahayan* (Bangla month). Thus, bio-physical (e.g., edaphic and climatic) suitability of a crop is not the only criterion for selection of cultivable crops in Bangladesh but food security and cultural backgrounds sometimes force the farmers in decision making. Choice of crops also might be influenced by price, infrastructure, marketing facilities etc. Such as, in Munshiganj potato has become a major crop since the farmers are rich enough to apply high inputs for producing more and store potatoes using the local cold storage facilities, though agro-ecologically Munshiganj does not have so much area which are very suitable for potato cultivation (BARC 2012). Nonetheless, usually farmers in Bangladesh are not

encouraged to grow crops other than rice if they do not get good price for their crops or do not have a market for those products.

However, it is important to encourage farmers to cultivate appropriate crops in their land mainly considering the agro-ecological suitability to ensure highest yield, particularly with the view to face the challenges of feeding continuously growing population, year after year. In that case, by dint of developing technologies for adaptation of various crops to adverse conditions like flood, drought and salinity, the suitability of crops in a particular region may also be changed. For example, technologies like introgression of flood and salt tolerant genes into rice varieties might make them somewhat tolerant to flood and salinity in the flood prone areas or in the saline coastal areas of the country. Moreover, some areas may become free of flooding in case polders are built around low lying area and crops can be grown there throughout the year. In addition, varietal development of crops, including management and agronomic manipulation, can offset the impact of hazards like high or low temperatures, floods, salinity, etc. On the other hand, areas which are very suitable or suitable at present can become unsuitable due to change in geo-physical or biotic factors like changes in climatic parameters (viz. rainfall pattern, temperature regime etc.) or emergence of new pests and diseases. Hence, the local or micro level outcomes of the researches like present study to determine cultivation suitability of our lands for various crops, including different rice varieties, will enable the country to develop a sustainable agriculture planning to ensure food security for the next generation.

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