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Problems and Prospects of Rice Based Cropping Patterns in Chittagong Areas

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ABSTRACT

Eight districts represent Chittagong and Rangamati agricultural regions having 30637 sq km areas. These regions face natural calamities like Sidr, Aila, Resmi, salinity and soil erosion. Crops are grown in 852436 ha of land. Single crop is grown in 58.48% areas in Chittagong Hill Tracts (CHT) region, while in Chittagong agriculture region two crops are grown in about 51% areas. Rice production or its expansion is hindered because of factors like excessive or no rainfall in pre-monsoon season, soil and water salinity, water stagnation in wet season, lack of suitable rice varieties and fresh water in dry season, good income source other than farming, soil erosion, absentee farmers etc. Growing of salt tolerant varieties, organic amendments, use of cover crop, improved irrigation system can be adopted among others for land productivity improvement in coastal areas. Sorjan or ditch and pyramid or ridge systems can be utilized in coastal tidal areas. Installing subsurface drainage system and floating beds could be used in water stagnant conditions. Zero or minimum tillage following dibbling/pegging method, rain water harvesting, improved Jhum, community based seepage water harvesting, homestead gardening and floriculture are the adaptation options in hill agriculture.

Keywords: Cropping pattern, problems, prospects, Chittagong

INTRODUCTION

Eight districts (Feni, Noakhali, Laxmipur, Chittagong, Khagrachari, Rangamati, Bandarban and Cox's Bazar) belong to low productive agricultural zone in Bangladesh (Bhuiya and Mohiuddin, 2013). These diverse areas enjoy different edapho-climatic factors-char land to hilly areas, saline to non-saline land, low to high land and water stagnant land to free flowing areas and suffer from different natural calamities like Sidr, Aila, Resmi, Mohasen, flash flood, unfavourable soil moisture regime, soil salinity, etc. Flood water recedes from about 24% areas within October, 53% in November-mid December and 23% areas in late December to early January (Sattar, 2002; Sattar and Mutsaers, 2004). In Bangladesh, about one million ha (more than 30% of cultivable area) land is in coastal areas of which T. Aman is cultivated in about 0.83 million ha (Sattar and Abedin, 2012) and about one million hectares are subjected to variable soil salinity such as very slight (2.0-4.0 dSm^{-1}) to very strong (>15.0 dSm^{-1}) as reported by Karim *et al.* (2010).

The hilly areas cover about 17,342 km^2 (about 12% of total Bangladesh) mostly in the Chittagong Hill Tracts districts, Chittagong, Habiganj and Moulvibazar (Rahman, 2011). Chittagong Hill Tracts districts alone cover about 9% area and low hill areas (about 30%). The high hill ranges (70%), about 200-1,000 m above mean sea level), are steep to very steep hills and usually have a rather youthful soil mantle ranging from a few cm to several meters in thickness over bedrocks. The low hill areas (30%), about 15 to 200 m above mean sea level are nearly flat or rounded topped and usually have old and deep soil. The whole hilly region receives more than 2000 mm precipitation annually of which about 80% is received in June-September.

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Jhum (shifting cultivation following slash and burn method) is being practiced by the tribal people, especially in Chittagong hill tracts and locally in other areas. Jhum involves clearing of forest land after several years (4-5 years) of fallow. However, recently fallow period has been reduced to two years due to non-availability of land. This exposure of land has increased the chance of soil erosion and further degradation of land. Annually the highest soil loss (22.68 t ha^{-1}) with ginger followed by turmeric (16.52 t ha^{-1}), aroid (12.02 t ha^{-1}) and Jhum rice (7.92 t/ha) cultivation can occurred from slope hill (Salahin *et al.,* 2013).

Intensity of Aus, Aman and Boro rice cultivation in Chittagong areas varies depending on land suitability and availability of irrigation water along with severity of salinity. Chittagong areas have prospects of growing more rice, but it needs special care. So, we investigated the prospects and problems of rice based crop cultivation in Chittagong areas.

METHODOLOGY

Sampling technique and size: The study was conducted in Chittagong and Rangamati agriculture regions during March through July 2014. Data were collected from Feni, Noakhali, Laxmipur, Chittagong, Khagrachari, Rangamati, Bandarban and Cox's Bazar districts with the help of Deputy Director, DAE of each district and from the offices of Additional Director, DAE, Chittagong and Rangamati Agriculture Regions. Moreover, data were collected from farmers of Feni and Noakhali districts through group discussion for comparison with DAE data sources. Data have also been collected from literature review.

Analytical techniques: Collected data were edited, summarized, tabulated and analyzed to fulfil the objectives of the study. Descriptive statistics using different statistical tools like averages, percentages and ratios were used in presenting the results.

RESULTS AND DISCUSSION

Chittagong agriculture region

This agriculture region is represented by Feni, Noakhali, Laxmipur, Chittagong and Cox's Bazar districts. Saline area in south-east coastal region is 126353, which is 8.75% of that area (Table 1). Salinity in area varies extremely within a meter to two even in the same field (Sattar and Abedin, 2012). In general, soils are slightly acidic to slightly alkaline having low organic matter content and deficient in nutrient contents (Table 2). These factors result in reduced crop yield (Table 3). Loam and clay loam soils are dominant in Chittagong agriculture region (Table 4). Sandy soil mostly prevails in Chittagong and Cox's Bazar districts. Cultivable area is 7,00,000 ha in which two crops are grown in 356337 ha (Table 5). Single crop is grown in about 24% of cultivable land and 4.7% is current fallow. Cropping intensity is the highest in Laxmipur; however land use intensity is the highest in Feni district followed by Laxmipur district (Fig. 1). Crops are grown as intercrop/mixed crop with rice or even in the bunds (Fig. 2), on the hill top and valley (Fig. 3).

Table 1. Stress prone areas (ha) in some selected districts of Chittagong division

Type of stress	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	Total	Per cent
Salinity	20000	18087	70594	4000	13672	126353	8.75
Coastal	29980	20800	140000	5000	14000	109781	7.60
Flood prone	19500	24737	00	25000	60310	129547	8.97
Drought prone	20000	19947	15500	00	25432	80879	5.60

Source: Adopted from Ali, 2014.

Table 2. Chemical properties of soils in selected saline belt of Bangladesh

District	pH	OM (%)	Total N (%)	CEC	Na	K	Ca	Mg	P (ppm)	Zn (ppm)
				(m. e. %)						
Chittagong	5.0-7.4	1.0-2.9	-	-	-	0.2-0.8	2.7-7.1	2.9-11.3	4-11	0.1-0.9
Noakhali	6.0-7.9	0.8-3.1	0.1-0.3	9.4-19.5	0.4-39.0	0.1-0.5	5.3-12.4	2.3-9.5	8-24	Tr-1.8
Feni	6.0-7.5	0.9-2.9	0.1-0.2	11.8-16.2	0.8-3.8	0.4-0.5	7.8-8.0	5.0-6.8	8-24	Tr-0.9

Sources: Annual reports of BARI, BRRI, BWDB and DU of the coordinated research project on production potentials of the coastal saline soils of Bangladesh (1987-1989).

Table 3. Crop yield loss due to different stress conditions

Vulnerability	Yield loss
Drought prone areas	30- 60% loss in T. Aman, wheat, potato, maize, pulses, oilseeds
Flood- prone crops	20- 60% loss in T. Aman, Boro, wheat, maize, potato, pulses, oil seeds, spices and fruit
Charlands Salinity/ tidal surge and Coastal Char lands	30- 60% loss in T.Aman, Boro, wheat, maize, potato, sweet potato, pulses, oilseeds, spices

Source: Mia, 2011.

Table 4. Dominant soil texture in some selected districts of Chittagong agriculture zone

Texture	Area (ha)					
	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	Total
Loam	114230	23146	106227	46574	25508	315685
Clay loam	45290	5100	95388	23523	21552	190853
Sandy loam	33858	29102	6841	534	50118	120453
Clayey	21655	18000	1351	5291	1250	47547
Sandy	11412	14050	00	00	00	25462

Source: Ali, 2014.

Table 5. Land use pattern in Chittagong areas.

Type	Area coverage (ha)					Total (ha)
	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	
Cultivable land	226445	89398	209807	75922	98428	700000
Net crop land	209120	84312	202966	74720	96065	667183
Current fallow	17325	5086	6841	1202	2363	32817
Single cropped land	60644	20469	71179	9136	8843	170271
Double cropped land	117654	49900	83728	54249	50806	356337
Triple cropped land	30772	13943	48059	11335	36416	140525
More than three crops	50	00	00	00	00	50

Source: Ali, 2014.

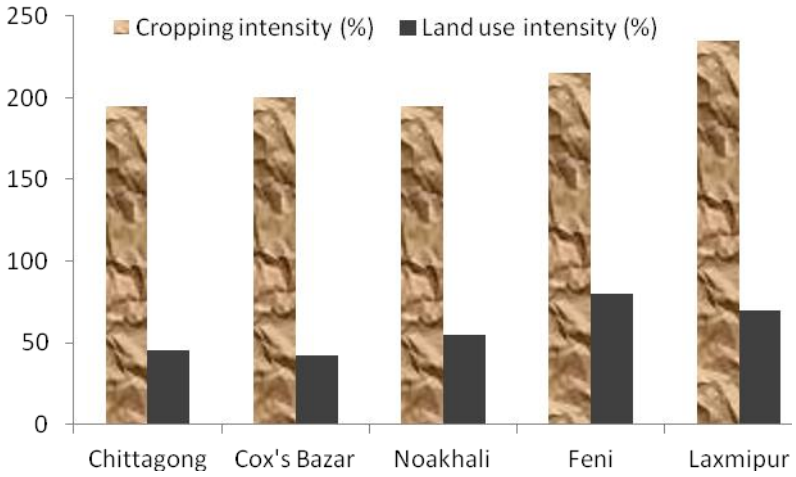

Fig. 1. Cropping and land use intensity in Chittagong areas.

Fig. 2. *Dolichos lablab* (Bean) in the rice field and bunds, Chittagong (Ali, A. 2014).

Fig. 3. Rice cultivation in hilly areas, Chittagong (Ali, 2014)

Boro-Fallow-T. Aman is the dominant cropping pattern (26%) followed by Fallow-Fallow-T. Aman pattern (Table 6). This implies that cropping intensity can be improved in Chittagong agriculture region by adopting suitable rice and non-rice varieties. BRRI dhan28 is the dominant (32% area coverage) Boro variety followed by BRRI dhan29 (Table 7). Lately released Boro rice varieties need to be introduced. MVs cover about 77% area while hybrids and local Boro varieties do the rest. Although BRRI dhan28 has been released as Boro variety, it is the dominant variety in Aus season (9.16%) followed by Purbachi (Table 8). Utmost effort is needed for dissemination of BRRI dhan48 in Aus season because of its high yield potential. Local Aus rice covers about 33% area in Chittagong agriculture region. Area coverage by BR11 is about 16% followed by BR22 in Aman season. MVs are cultivated in 68.19% areas and the rest by local T. Aman varieties (Table 9).

Table 6. Some cropping patterns in Chittagong agriculture zone

pattern	Area coverage (ha)					Percent
	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	
Boro-Fallow-T. Aman	68000	43000	16785	32877	10115	26
Fallow-Fallow-T. Aman	50828	23607	39215	8966	00	18
Oil seeds-Aus-T. Aman	1070	00	35609	748	23281	9
Fallow-Aus-T. Aman	27323	00	12907	14944	500	8
Boro-Fallow-Fallow	00	00	40766	00	3000	7
Vegetable-Aus-T. Aman	00	1264	33821	00	1495	5
Rabi crops-Fallow-T. Aman	10426	4216	00	5978	3292	5
Pulses-Fallow-T. Aman	6084	00	19787	00	00	4
Pulses-Aus-T. Aman	9124	00	00	6725	3150	2.8
Oilseeds-Fallow-T. Aman	00	00	00	00	18685	2.8
Vegetable-Vegetable-T. Aman	2682	843	00	2989	00	1
Boro-Aus-T. Aman	1230	843	00	00	5500	1
Tuber crops-Aus-T. Aman	6043	00	00	751	00	1

Source: Ali, 2014.

Table 7. Area coverage (ha) by dominant Boro rice varieties in Chittagong areas.

Variety	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	Total	Percent
Hira1-6	1800	2478	16335	727	1215	22555	10.0
ACI-1	534	205	3719	405	841	5704	2.5
BADC	2061	1073	400	463	00	3997	1.8
All hybrids	6403	8322	32100	2175	3566	52566	23.0
BRRI dhan28	23588	20415	4828	13031	11533	73395	32.0
BRRI dhan29	6870	4591	6960	10419	7713	36553	16.0
BR16	5175	2755	5961	1680	1178	16749	7.4
BRRI dhan33	2734	3235	00	00	00	5969	2.6
BRRI dhan47	1888	3060	75	250	306	5579	2.5
All MVs	54547	44856	21845	27897	25052	174197	76.7
All local	00	649	00	00	52	701	0.3

Source: Adopted from Ali, 2014.

Table 8. Area coverage (ha) by dominant Aus rice varieties in Chittagong areas.

Variety	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	Total	Percent
All hybrids	3845	00	00	40	00	3885	2.55
BRRI dhan28	3123	3245	3270	4052	275	13965	9.16
Purbachi	3735	00	00	2789	6240	12764	8.38
BRRI dhan27	1999	403	5190	906	2110	10608	6.96
BR26	3836	169	2363	395	1277	8040	5.28
BRRI dhan43	1479	60	6280	15	158	7992	5.24
BR14	2934	00	1560	650	805	5949	3.90
BR16	2084	188	2870	160	548	5850	3.84
BR20	2700	00	2367	00	193	5260	3.45
BRRI dhan42	2053	425	2255	00	40	4773	3.13
BR21	505	45	3610	130	295	4585	3.01
All MVs	34039	6260	31200	12164	14060	97723	64.10
Shaita	00	00	11930	300	6855	19085	12.50
Boilam	3545	00	6840	00	813	11198	7.35
All local Aus	8580	70	27150	4446	10530	50776	33.30

Source: Adopted from Ali, 2014.

Table 9. Area coverage (ha) by dominant T. Aman rice varieties in Chittagong areas.

Variety	Chittagong	Cox's Bazar	Noakhali	Feni	Laxmipur	Total	Percent
BR11	22308	12647	4508	13914	9204	62581	16.40
BR22	26509	3430	4666	11263	5963	51831	13.60
BRRI dhan40	7420	2439	19125	3728	9024	41736	11.00
Pajam	28027	7569	00	793	96	36485	9.58
BRR dhan41	7577	2504	8163	4830	6545	29619	7.78
BR23	6085	1133	10609	4067	7161	29055	7.63
BRRI dhan32	9110	7141	600	2971	4794	24616	6.47
BRRI dhan49	9965	3460	631	2780	1402	18238	4.79
BR10	6587	6405	114	875	562	14543	3.82
BRRI dhan33	3150	10304	165	00	13	13632	3.58
All MVs	147185	69140	53342	59450	51595	380712	68.19
Kajalshail	800	00	38790	1855	9518	50963	9.13
Rjashail	10665	00	20240	855	2997	34757	6.23
Ghigaj	00	00	10150	431	2270	12851	2.30
All local T. Aman	32320	7210	103200	8185	26685	177600	31.81

Source: Adopted from Ali, 2014.

Chittagong Hill Tracts agriculture region

Chittagong Hill Tracts (CHT), consisting of Bandarban, Khagrachari, and Rangamati districts is situated in the south-east of Bangladesh. Area of this region is 13,295 sq. km. It is marked by chains of hills running from the south to north-west and deep valleys formed by the rivers of Feni, Karnafuli, Sangu and Matamuhuri and their tributaries. The rivers are subject to severe flash floods if heavy rainfall occurs during monsoon. Alternative hills and valleys are covered with forests, bushes and other vegetation. The relative reliefs are about 457 to 884 meters above sea level in the south and 305 to 610 m in the north. The Chengi, the Myani and the Kassalong valies in the north are flat and fertile land in the region. Average precipitation is 2700 mm. However annual rainfall varies from 1836 to 3043 mm. Maximum temperature ranges between 30° to 37°C and minimum from 12° to 21°C. Soils are mostly clay loam, sandy loam and silty clays. Silty clay loam is the dominant texture, which covers 67% of the total area. The hill soils are mainly yellowish brown having one to four feet depth.

There are 1,52,436 ha total cultivable land in CHT, in which single cropped area is dominant (Table 10). Efforts are needed to convert these lands to double or even triple cropped areas. A large area (67,191 ha) remains fallow, might be due to lack of irrigation facilities. Cropping intensity is only 140%. Hybrid rice covers 7,110 ha in Boro season (Table 11), Hira being the dominant variety (40% of hybrid area). BRRI dhan28 is dominant variety followed by BRRI dhan29. Local cultivar Gelong and Binni is dominant in Aus season- Gelong is dominant followed by Bini (Table 12). BR11 is dominant in T. Aman season followed by BRRI dhan33 (Table 13). Local T. Aman cultivar covers about 5% area in Aman season.

Table 10. General land use pattern in Chittagong Hill Tracts agriculture region

Item	Rangamati	Khagrachari	Bandarban	Total
Total cultivable land (ha)	56208	41833	54395	152436
Single cropped area (ha)	35630	24587	28930	89147
Double cropped area (ha)	11738	24587	15478	51803
Triple cropped area (ha)	1874	13380	3172	18426
Current fallow	34496	25880	6815	67191
Total cropped area	81746	62945	69402	214093
Cropping intensity (%)	123	150	146	140
Forest area (ha)	469872	146058	273050	888980
Irrigated land (ha)	6510	13500	6457	26467

Source: Ali, 2014.

Table 11. Area coverage (ha) of Boro rice in Chittagong Hill Tracts agriculture region

Variety	Rangamati	Khagrachari	Bandarban	Total
Hira	1137	1020	692	2849
ACI	379	352	283	1014
Rajkumar	233	46	-	279
Gold	105	-	33	138
All hybrids	2700	2867	1543	7110
Modern variety				
BRRI dhan28	2255	2642	1845	6742
BRRI dhan29	625	2199	491	3315
BR16	311	290	444	1045
Purbachi	221	259	-	480
BR10	195	-	55	250
BRRI dhan50	181	181	20	382
All MVs	4195	8010	4720	16925
Bini	0	0	37	37
All Boro rice	6895	10877	6300	24397

Source: Ali, 2014.

Table 12. Aus area (ha) coverage in CHT agriculture region

Variety	Rangamati	Khagrachari	Bandarban	Total
Hybrid				
Hira	-	-	408	408
ACI	-	-	243	243
All hybrids	-	-	786	786
Modern variety				
BR1	204	80	-	284
Purbachi	197	301	153	651
BR26	135	448	157	740
BRRI dhan27	133	132	133	398
BR24	124	76	3	203
All MV Aus	1090	2772	2841	6703
Local Aus				
Gelong	1284	380	1171	2835
Bini	538	137	1294	1969
Kockra	0	0	1137	1137
Pidi	0	0	912	912
Kobrak	832	46	-	878
Chakachikan	0	0	808	808
Badoia	431	69	-	500
Kamarang	415	50	0	465
All local Aus	4760	1484	8990	15234
All Aus	5850	4256	12617	22723

Source: Ali, 2014.

Table 13. Area coverage (ha) of T. Aman rice in Chittagong Hill Tracts agriculture region

Variety	Rangamati	Khagrachari	Bandarban	Total
HYV				
BR11	2404	9188	2935	14527
BRRI dhan33	57	2902	1432	4391
Pajam	2228	491	1118	3837
BR10	1097	1155	1356	3608
BRRI dhan40	527	2306	676	3509
BRRI dhan39	510	1909	373	2792
BRRI dhan41	314	1919	455	2688
BRRI dhan49	548	1743	270	2561
All MVs	9719	25240	11520	46479
Local T. Aman				
Bini	225	349	140	714
Sonali Pajam	-	513	-	513
Kalijira	32	403	5	440
All local T. Aman	351	2089	286	2538
All T. Aman	10070	27329	11806	49205

Source: Ali, 2014.

PROBLEMS WITH RICE CULTIVATION

Aus rice

- Excessive or no rainfall in April
- Salinity, especially 60,000 ha in char areas
- Inadequate turnaround time after groundnut (100% area) and soybean (50% area) harvest in char areas
- Farmers are reluctant to cultivate Aus rice because of probable flash flood in Porshuram,
- Fulgazi and Chhagalnaiya upazilas
- Water stagnation

T. Aman rice

- Water stagnation (3-4 ft) in Chatkhil, Sonaimuri, Begungang and partial areas of Noakhali sadar, Senbug and Kabirhat
- Lack of suitable variety

Boro rice

- Inadequate irrigation facilities
- Salinity
- Inadequate availabilty of salt tolerant varieties

Jhum rice

- Continuous soil and nutrient loss in hill soils, which is accelerated by open cultivation system on steep to very steep land
- Soils are very acidic and require relatively heavy use of fertilizer for sustainable agricultural production
- Lack of suitable varieties and/or dissemination activities
- Language problem for communication in Chittagong Hill Tracts region
- Water scarcity during Aus and Boro season
- Sand deposition in crop land after heavy rainfall
- Improper Jhum cultivation

General problem for rice cultivation

- Inadequate quality seed and/dissemination activities
- Sandy soil in Chittagong and Cox's Bazar areas
- Shrimp cultivation in Chittagong and Cox's Bazar areas
- Absentee farmers
- Earnings of foregin currencies- better livelihood than rice farmers
- Lack of technical knowledge

SUGGESTIONS FOR SOLUTIONS OF PROBLEMS

Coastal agriculture

- There exist elevation differences in certain parts of coastal areas having standing water depth of 15- 90 cm where BRRI dhan40, BRRI dhan41, BRRI dhan53 and BRRI dhan54 can be cultivated in T. Aman season. Felon can be relayed with T. Aman.
- Rain water harvesting reservoirs can be constructed for supplemental irrigation in wet season and for growing dry season crops.
- Keeping land covered in winter and summer months. Ground water is saline and present at a shallow depth (about 1.0 meter). Keeping lands fallow leads to high salinity in soil due to evaporation of excessive soil moisture. Therefore, it is recommended to avoid fallowing of lands during dry season. Salt tolerant crops should be grown. This will lower the profile salinity.
- Growing salt tolerant crops like BRRI dhan47, BARI Tishi, Sunflower, etc. BARI Tishi can tolerate up to 16 dS m^{-1} salinity.
- Land should be properly levelled to prevent accumulation of water in the low-lying patches with shallow ground water tables and to facilitate uniform drainage of excess water. It will help to apply irrigation water uniformly in dry season, facilitate uniform germination of seeds and better growth of crops.
- Organic matter build up in tropical environment is very difficult because of its rapid decomposition rate. So, organic matter addition annually provides beneficial effects for growing crops in coastal belt. For example, use of organic materials like *Sesbania, Lathyrus sativas* (L.) and red clover *(Melilotus alba,* L.) is beneficial for higher grain yield of rice in coastal flooded soil (Islam *et al.,* 2010). Shah *et al.* (2004) also reported higher grain yield of rice with additional potassium and ash application compared to soil test based fertilizer management in coastal areas of Bangladesh
- Provision of sub-surface drainage. In many parts of the coastal area, salinity is very high. To grow crops successfully in those areas, it is necessary to bring down the salinity by leaching the salts. It is also necessary to lower down the water table and maintain it blow the critical depth to prevent salt effect on crops grown. To achieve the objective, a proper sub-surface drainage has to be installed to keep the ground water at least one meter below the soil surface. This technology is effective but somewhat expensive.
- Improved irrigation technique along with improved land preparation helps in growing crops successfully in saline areas (Islam and Rashid, 2011).
- Sorjan or ditch system can be followed for growing crops in coastal tidal areas.
- Pyramid/ridge cropping system can be utilized for crop cultivation in saline areas (Sattar and Abedin, 2012). The height of pyramid will depend on the depth of water in Kharif season.

- Use of drought tolerant or escaping crops (eg Felon, Lentil, etc) and use of mulch for moisture preservation (Ali, 2014).
- Dibbling method of crop establishment. The advantage of this system is to escape the detrimental effects of surface soil salinity during germination and seedling growth.
- Protective embankment having sluice gates. Land may be protected from inundation of saline water through establishment of embankment of suitable size. The recommended size should be one meter high above the high tide level. Excess water can be removed and intrusion of saline water during high tide can be controlled through proper sluice gate operation.

Stagnant water areas

- Ways to improve drainage. In the long term, some options like re-shaping the layout of the field, improving surface drainage, installing subsurface drainage could be considered to improve drainage of the affected fields. Underground drainage systems including conventional mole and gravel mole systems, in combination with surface drainage, also have the potential to significantly increase grain production in many of the areas prone to waterlogging (Johnston, 1999)
- Vegetable can also be grown in raise beds or even in floating beds (www.coastalcooperation.net). Floating beds are made of water hyacinth, deep water rice straw and different types of aquatic vegetations like *Lemna trisulca, Azolla pinnata* and *Bluxa japonica* and bamboo poles (Practical Action: www.practicalaction.org). Initially farmers lay a bamboo pole on dense water hyacinth to stand on and then pile more water hyacinth to make it compact. The thickness depends on the duration of water logging, as it needs to float for the whole time of inundation. The bed is movable so the farmer can choose suitable locations for better management. After selecting a good location, the beds are usually fixed with bamboo poles. After 10-15 days, the farmers may transplant seedlings or broadcast vegetable seeds. More than 20 vegetable varieties like red amaranth, Indian spinach, coriander leaves, cauliflower, cabbage, tomato, lady's finger, cucumber, bitter gourd, bottle gourd, snake gourd, ash gourd, sweet pumpkin, bean, radish, eggplant, potato, chilli, onion, garlic, turmeric and mustard are grown on floating beds in different locations of Bangladesh (www.coastalcooperation.net/part-III).
- In certain areas, delay in Boro harvesting or early floods after Boro crop delays or no scope of deepwater rice crop planting. Integration of Boro-deepwater rice farming is needed for such type of areas. Direct seeding (45 kg ha^{-1}) of sprouted seeds of deepwater rice in a standing crop of Boro rice (which is usually a transplant crop) 15 day before the harvesting of Boro rice is one of the possibilities (Abedin and Bool, 2004). Transplanting of 30-60 day-old deep water rice seedlings after Boro harvest (Hossain and Haque, 1987) is another option of crop intensification.

Hill area problems

- More than 60% farmers had no formal education in hilly areas (www.bioscience-associates.com/2013/04/survey-of-cropping-and-livelihood-in.html). So, a hand on training on modern cultivation is essential. Fallow-Fallow-T. Aman is the dominant pattern, which needs to be converted to double or triple cropped areas. Mia (2011) reported that innovative practices like agro-forestry farming, zero or minimum tillage following dibbling/pegging method (ginger, turmeric, maize, tomato), rain water harvesting, improved Jhum, community based seepage water harvesting, homestead gardening, floriculture, etc, are the adaptation options in hill agriculture.
- In the drought-prone areas, fallow lands after T. Aman might be used for growing crops with zero tillage (Maize), mulching (Potato), priming (Chickpea) and dry

land farming, cultivation of sesame (Mia, 2009).

- High water table indicator flora eg wild banana, ferns, zinzibers, canes and bamboos etc. should be re-established. Right plant (crop) at right place according to their habit and habitat is needed be cultured.
- Post harvest management of crops like jackfruit, citrus and lemons, litchi, Kao *(Garcinia)* and pineapple etc, and vegetables are needed to get better price by the growers.
- Farmers should be made aware of and encouraged to adopt improved agricultural practices and soil conservation measures to enhance productivity:
- An improved Jhum can be created by selectively weeding the fields and enriching them by planting species that increase the rate of return of organic matter to the soil and have some commercial interest for the farmer (such as commercial bamboos and various leguminous shrubs).
- Use of mulch prevents soil degradation and excessive weed emergence. This technique can be used by farmers for growing ginger and taro in hilly areas of this region.
- Contour plantation is a common practice in the Hill Tracts which facilitate soil erosion with the onset of heavy rains. Existing system needs to be modified by cultivating plants along the contours to prevent soil loss.
- Use of cover crops and use of strip cropping: Row crops such as rice, tobacco, maize etc are not effective as soil conserving crops. Using legumes in the existing cropping system will provide better cover and protection to soil by way of minimizing the impact of raindrop erosion and acting as an obstruction to runoff.
- Crop diversification: Crop diversification from low value to high value crops; from water loving crop to water saving crop and from single crop to multiple/mixed crop can provide adequate income and employment to the farmers.

CONCLUSIONS

Chittagong area belongs to low agricultural productive zone in which two crops are generally grown in about 51% areas. Expansion of rice production is limited because of either excessive or no water for its cultivation, soil erosion and lack of salt tolerant along with many other bottlenecks. Introduction of drought and salt tolerant varieties, pyramid or ridge methods of crop establishment, rain water harvesting, organic amendments and improved Jhum system can be adopted in hill agriculture.

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