

Diversity of Cropping Systems in Chittagong Region

S M Shahidullah^{1*}, M Nasim¹, M K Quais¹ and A Saha¹

ABSTRACT

The study was conducted over all 42 upazilas of Chittagong region during 2016 using pre-tested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity in the region. The most dominant cropping pattern Boro-Fallow-T. Aman occupied about 23% of net cropped area (NCA) of the region with its distribution over 38 upazilas out 42. The second largest area, 19% of NCA, was covered by single T. Aman, which was spread out over 32 upazilas. A total of 93 cropping patterns were identified in the whole region under the present investigation. The highest number of cropping patterns was 28 in Naokhali sadar and the lowest was 4 in Begumganj of the same district. The lowest crop diversity index (CDI) was observed 0.135 in Chatkhil followed by 0.269 in Begumganj. The highest value of CDI was observed in Banshkali, Chittagong and Noakhali sadar (around 0.95). The range of cropping intensity values was recorded 103–283%. The maximum value was for Kamalnagar upazila of Lakshmipur district and minimum for Chatkhil upazila of Noakhali district. As a whole the CDI of Chittagong region was 0.952 and the average cropping intensity at the regional level was 191%.

Key words: Crop diversity index, land use, cropping system, soybean, and soil salinity

INTRODUCTION

The Chittagong region consists of five districts viz Chittagong, CoxBazar, Noakhali, Feni and Lakshmipur. The area belongs to mainly AEZ-23, AEZ-18, AEZ-19, AEZ-29 and AEZ-17 which characterized by heavy monsoon rainfall, low soil fertility and exposure to cyclone (FAO, 1988). There are many location-specific constraints for agriculture in this region and dispersed over the whole area. The limitations are severe flash floods, dry-season soil salinity, extremely acid soils, lack of irrigation water, poor drainage, bank erosion, very steep slopes and occurrence of peat soil. Among the socio-economic problems difficult communication, remoteness of interior areas from urban markets and input supply, and service centres are focal features.

Cropping system is the crop production activity of a farm, which includes all cropping patterns grown on the farm resources, other

household enterprises and the physical, biological, technological and socioeconomic factors or environments. A cropping pattern is the yearly sequence, temporal and spatial arrangement of crops in a given land area. It is dependent on physical, historical, social, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The cropping pattern and the changes therein depend on a large number of factors like climate, soil type, rainfall, agricultural technology, availability of irrigation facilities and other inputs, marketing and transport facilities and growth of agro-industries (Neena, 1998; Gadge, 2003; Rashid *et al.*, 2005).

The yields of cereal crops are tending to stagnation, even in favourable environments. Moreover, cultivable land area is decreasing day by day in the country. In this context, there is no other alternative but to address less favourable and unfavourable environments. To increase the system productivity of the

¹Rice Farming Systems Division, BRRI, Gazipur; *Corresponding author's E-mail: shahidullah4567@gmail.com

total environment it needs to bring diversity in enterprises for better utilization of limited resources. A detailed information package on land situation and cropping systems is a prerequisite for a fruitful development programme. Diversified cropping pattern may be option for the farmers as a coping strategy against risks (Mandal and Bezbaruah, 2013). Typology of different cropping systems is the base for the managers of these systems to intensify production (Shriar, 2000). There is a strong need for judicious and appropriate use of limited resources in case of intervention selection that does not lead to increased maladaptation or inequity in the society over long term. Existing trends of available agricultural lands is most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The present study was designed with the following specific objectives to:

- Understand the existing cropping patterns scenario in Chittagong region
- Visualize the existing land use pattern at upazila and regional level
- Determine the crop diversity and cropping intensity at local and regional level.

METHODOLOGY

Forty-two upazilas of Chittagong, CoxBazar, Feni, Noakhali and Lakshmipur districts under Chittagong agricultural region were the locale of this study. Data were collected using double stage procedure. At initial stage, data were collected through pre-tested semi-structured questionnaire from 42 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during November 2015 at upazila level. SAAOs were purposively pre-selected by Agriculture Extension Officers

(AEO), Additional Agriculture Officer (AAO) and Upazila Agriculture Officer (UAO) or altogether. Prior to data collection, the pre-tested questionnaire was explained along with proper guidelines to the AEOs or UAOs or both and handed over to them at each Deputy Director's office of Department of Agricultural Extension (DAE) during monthly meeting for the sake of accurate data collection. The filled questionnaires were collected by the scientists of RFS Division, checked and analyzed to find the inconsistencies of the supplied data before validation workshop. All the inconsistencies among the information were documented. The collected data along with documented inconsistencies were discussed in district level workshop for necessary correction and validation. Second stage of data collection was day-long data validation workshop at district level. The workshop dates were 20 January for Feni; 17 February for Lakshmipur; 20 March for Noakhali; 7 August for CoxBazar and 8 August 2016 for Chittagong. Four field-workers i.e. one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRRI Regional Station, Sonagazi, participated in the data validation workshop. The number participants of validation workshop ranged from 51 to 119 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFS scientists to finalize and validate the data and authenticated data were captured. Crop diversity index was calculated by using the following equation described by Kshirsagar *et al.* (1997).

$$CDI_i = 1 - \sum_{j=0}^n \left(\frac{a_{ij}}{A_i} \right)^2$$

Where, CDI_i = Crop Diversity Index
 a_{ij} = Area planted to the j^{th} crop in the i^{th} location
 A_i = Total area planted under all crops

The index is zero for a land area growing only one crop. It approaches unity as the level of diversity increases. Compilation and processing of collected data were done using Micro Soft Excel programme. Descriptive statistics were used to facilitate the presentation of the findings.

RESULTS AND DISCUSSION

Land use

Table 1 presents the status of agricultural land utilization. The net cropped area of the Chittagong region is 655,870 ha. Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in the region were pineapple, sugarcane, banana, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from zero to 1,610 ha. The annual crops area accounted only 1.71 % of the net cropped area (NCA) in the region. At a glance, the region occupied 28% single cropped area (SCA), 49% double cropped area (DCA), 20% triple cropped area (TCA). The quadruple cropped area was also seen as a very negligible area (0.08%) and is limited in only two upazilas viz Raipur of Lakshmipur and Chakaria of CoxBazar district. The SCA had the major share of NCA in Fatikchhari, Mirsharai, Patiya and Sandwip upazilas of Chittagong district; Teknaf upazila of CoxBazar district; Begumganj, Chatkhil, Kabirhat and Sonaimuri upazilas of Noakhali district followed by corresponding double cropped area (DCA). Most of the upazilas were dominated by DCA. The exceptions were Chandanaish of Chittagong district, Kutubdia of CoxBazar district and Kamalnagar of Lakshmipur district where triple cropped area were dominating (Table 1). The area which could not be defined in the form of definite pattern, was considered as others whose coverage is less than 1% of the NCA.

Cropping patterns of Chittagong

In total 93 cropping patterns were observed in Chittagong region of which eight cropping patterns with exclusive rice crop covers about

57% of the NCA. There were 19 cropping patterns with exclusive non-rice crop covering only 2.5% of the NCA. Rest of the NCA i.e. over 40% area was covered by 66 rice - non rice cropping patterns (Appendix 1).

Rice and non-rice crops at a glance

Table 2 presents eight cropping patterns where rice is the only crop round the year. It comprised of about 57% of the NCA in the region. Among them single rice, double rice and triple rice areas represented around 27%, 28% and 2% respectively. It reflected the unparallel dominance of rice in the cropping systems in Chittagong region. In the case of individual pattern Boro-Fallow-T. Aman had the highest coverage (23%) and was recorded in 38 upazilas out of 42. The second dominant pattern single T. Aman area occupied 19% of NCA, which was reported in 32 upazilas. Single Boro covered 7% area with its existence in only 12 upazilas.

In the current investigation, 19 cropping patterns were identified free from rice. Out of these 19 patterns, first 12 were arranged in the descending order in Table 3. The rest seven patterns with negligible area coverage are presented in Table 7 where they are arranged with other patterns of different categories. The total area of the 19 patterns was only 2.51% of NCA. So, it is clear from the study that exclusive rice area is about 23 folds of exclusive non-rice area. Among these 19 patterns, three patterns comprised of year-round vegetables distributed over majority of the upazilas. Year-round vegetable production system was observed about two-thirds of the non-rice cropping area and mainly practiced on or beside the homestead area.

Pulse crops

Twenty cropping patterns were holding different pulse crops (Table 4). Among them grasspea was covering the largest area whereas pea was in the smallest area. Three cropping patterns of grass pea jointly covered more than 7% of NCA. Felon (*Vigna unguiculata*) occupied the second position in pulse crop cultivation in

Table 1. Land use of different upazilas in Chittagong region (area in hectare), 2014-15.

	Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01	Anwara	16413	40	1520	4210	2540	0	130	8440	212
02	Banshkhali	39000	680	2890	9550	4520	0	140	17780	205
03	Boalkhali	13753	10	2600	3270	200	0	130	6210	160
04	Chandanaish	20199	410	2230	3190	3910	0	120	9860	213
05	Fatikchhari	75676	660	12010	8950	300	0	140	22060	144
06	Hathazari	25506	670	3100	6450	0	0	100	10320	163
07	Lohagara	25887	150	2200	8170	300	0	130	10950	181
08	Mirsharai	48800	110	10800	3590	8550	0	110	23160	190
09	Patiya	31647	180	6350	4470	2550	0	130	13680	171
10	Rngunia	34775	300	6100	10780	1200	0	120	18500	172
11	Rauzan	24300	60	4000	7700	520	0	130	12410	171
12	Sandwip	38800	1490	12270	3910	6445	0	125	24240	170
13	Satkania	28240	220	2800	8890	710	0	100	12720	182
14	Sitakunda	48400	200	1350	5100	3040	0	110	9800	215
15	Chakaria	50300	370	900	12270	7810	50	170	21570	231
16	CoxBazar	19965	440	550	8605	210	0	135	9940	192
17	Kutubdia	15102	0	150	400	2755	0	95	3400	279
18	Maheskhali	38850	1610	1110	7510	10	0	120	10360	174
19	Pekua	13968	50	0	4695	3125	0	180	8050	239
20	Ramu	39171	150	940	8950	315	0	145	10500	193
21	Teknaf	34938	520	8000	2630	200	0	120	11470	127
22	Ukhia	26180	690	1600	7620	50	0	130	10090	178
23	Chhagalnaiya	13579	70	2600	7725	50	0	125	10570	175
24	Dagonbhuiyan	14771	50	3250	6130	700	0	120	10250	174
25	Feni	31680	50	1000	14270	1350	0	130	16800	202
26	Fulgazi	10492	30	1800	5210	0	0	90	7130	174
27	Parshuram	9918	60	2050	4290	160	0	100	6660	170
28	Sonagazi	28500	20	5600	12160	2550	0	190	20520	185
29	Kamalnagar	31500	80	0	3450	18000	0	150	21680	283
30	Lakshmipur	48845	70	2000	19450	4450	0	150	26120	209
31	Ramganj	16932	50	3950	6590	590	0	120	11300	169
32	Ramgati	37500	100	150	4020	19650	0	280	24200	281
33	Raipur	26260	100	300	12700	2745	450	305	16600	220
34	Begumganj	23766	20	15000	1300	0	0	100	16420	108
35	Chatkhil	13395	80	7870	160	40	0	80	8230	103
36	Companiganj	32400	50	8200	13835	305	0	110	22500	165
37	Hatiya	210137	40	8000	25800	21500	0	150	55490	224
38	Kabirhat	23924	30	7200	4405	110	0	125	11870	139
39	Noakhali	33621	1200	7150	9750	6460	0	140	24700	192
40	Senbag	15937	80	1840	7760	750	0	150	10580	189
41	Sonaimuri	17353	20	10350	70	200	0	130	10770	104
42	Subarnachar	57600	20	11300	21670	4850	0	130	37970	183
	Chittagong region		11230	183080	321655	133720	500	5685	655870	191

Table 2. Cropping patterns with exclusive rice in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Boro-Fallow-T. Aman	150280	22.92	38
02	Fallow-Fallow-T. Aman	125600	19.15	32
03	Boro-Fallow-Fallow	48710	7.43	12
04	Fallow-Aus-T. Aman	27140	4.14	20
05	Boro-Aus-T. Aman	16070	2.45	18
06	Boro-B.Aman	2850	0.43	3
07	Fallow-Aus-Fallow	1000	0.15	1
08	Boro-Aus-Fallow	900	0.14	5
	Total	372550	56.82	

Table 3. Cropping patterns with exclusive non-rice in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetab-Vegetab-Vegetab	5235	0.80	15
02	Vegetab-Fallow-Fallow	3920	0.60	11
03	Vegetab-Vegetab-Fallow	2560	0.39	10
04	Soybean-Fallow-Fallow	2000	0.30	1
05	Tobacco-Sesbania	600	0.09	1
06	Groundnut-Fallow-Fallow	440	0.07	3
07	Chilli-Fallow-Fallow	300	0.05	3
08	S.Potato-Fallow-Fallow	300	0.05	3
09	Felon-Fallow-Fallow	260	0.04	2
10	Coriander-Fallow-Fallow	250	0.04	8
11	W.Melon-Fallow-Fallow	195	0.03	3
12	Chilli-Vegetab-Fallow	130	0.02	5
13-19	Other seven patterns (in Table 7)	280	0.04	-
	Total	16470	2.51	

Table 4. Area for pulse crops in cropping systems in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Grasspea-Fallow-T. Aman	30640	4.67	13
02	Grasspea-Aus-T. Aman	16740	2.55	11
03	Felon-Fallow-T. Aman	14630	2.23	28
04	Mungbean-Aus-T. Aman	7040	1.07	9
05	Felon-Aus-T. Aman	5045	0.77	11
06	Mungbean-Fallow-T. Aman	4335	0.66	15
07	Lentil-Fallow-T. Aman	2440	0.37	8
08	Pea-Fallow-T. Aman	730	0.11	5
09	Lentil-Aus-T. Aman	500	0.08	4
10	Felon-Aus-Fallow	420	0.06	2
11	Felon-Fallow-Fallow	260	0.04	2
12	Grasspea-B.Aman	250	0.04	1
13-20	Other eight patterns (in Table 7)	290	0.04	-
	Total pulse crops	83320	12.71	

Chittagong region. There were four cropping patterns for felon where two were dominants viz Felon-Fallow-T. Aman and Felon-Aus-T. Aman. These felon containing cropping patterns in-together occupy over 3% of NCA. In the documentation of pulse cropping felon reported its widest spreading in the region. One pattern was available in 28 upazilas and the other existed in 11 upazilas. Finally the aggregate area of the pulse cropping systems stood for approximately 13% of the NCA in Chittagong region. Relatively stress-tolerant pulse crops like grasspea, felon, cowpea are easy to cultivate during pre-monsoon in the dry land (FAO, 1988).

Oil-seed crops

Soybean is the most important one among the oil-seed crops in Chittagong region. There were 17 cropping patterns for oil-seed crops among which six patterns had been led by soybean alone (Table 5). The total share of oil-seed cropping patterns was about 14% of NCA whereas soybean absolutely occupies over 10%. The second prevailing groundnut covered over 2%. However, the dominance of oil-seed crops and its spreading over the region are not running in the same direction. The soybean, with its highest coverage, is available only in six upazilas out of 42. In Bangladesh there is a vast market of soybean seeds for feed industries. Loam and sandy soils of the coastal area were found very suitable for soybean cultivation (FAO, 1988). Area under soybean cultivation in Chittagong region is equivalent to the 90% of the national acreage for the crop.

Vegetables and spices crops

Table 6 presents 35 cropping patterns arranged in descending order according to area coverage. Potato and other vegetables of Rabi, Kharif-I and Kharif-II; spices viz chilli, onion, garlic and coriander are included in this list. The most contributing cropping pattern was Vegetab-Fallow-T. Aman covering about 3% of NCA, which was distributed over 28 upazilas. The second one is Chilli-Fallow-T. Aman covering over 1% of NCA and it is the most available pattern recorded in 30 upazilas out of 42. The aggregate area allotted for vegetables and

spices crops was 76,590 hectares that was equivalent to 11.69% of NCA in the region. The main spices crop is chilli grown in an area of 13,120 ha (2% of NCA). Probably two friendly factors encourages the famers for growing chilli viz favourable environments of *charland* and easy availability of women labour for harvesting and post harvest management of the crop (FAO, 1988).

Sporadic and distinct cropping patterns

There were some cropping patterns extremely location-specific, however, with a large area coverage. These were Soybean-B. Aman, Soybean-Fallow-Fallow and Soybean-Jute-T. Aman (Table 5). The Soybean-B. Aman is grown on 4,300 hectares in Raipur upazila of Lakshmipur district. Single soybean crop is limited to only Lakshmipur sadar upazila (2,000 ha). Soybean-Jute-T. Aman is available in Kamalnagar (6,400 ha) and Ramgati (13,000 ha) of Lakshmipur district.

Rare cropping patterns

In the present investigation, 24 cropping patterns have been identified as rare cropping patterns with a negligible area coverage with seldom existence (Table 7). These are location specific system and are limited in one or two or in some cases three upazilas of the region. Total area coverage of the 24 patterns is far less than 1% of NCA. Among them, the highest area was allotted for Sweet potato-B. Aman and Wheat-Fallow-T. Aman (100 ha for each). The smallest area was recorded for four cropping patterns whose coverage was five hectares for each (Table 7).

Most dominant cropping pattern

Boro-Fallow-T. Aman was the most dominant cropping pattern in Chittagong region. It covers 22.92% of NCA in the region and is available in 38 upazilas out of 42 (Table 8). The highest area under this cropping was recorded 13,700 hectares in Lakshmipur sadar upazila represents 9.12% of the total Boro-Fallow-T. Aman area of the region. In consideration of individual upazila CoxBazar sadar has stood

Table 5. Cropping patterns with oil-seed crops in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Soybean-Aus-T. Aman	22600	3.45	5
02	Soybean-Jute-T. Aman	19400	2.96	2
03	Soybean-Fallow-T. Aman	18670	2.85	6
04	Groundnut-Fallow-T. Aman	8630	1.32	16
05	Groundnut- Aus-T. Aman	8350	1.27	6
06	Soybean-B.Aman	4300	0.66	1
07	Mustard-Fallow-T. Aman	2370	0.36	15
08	Soybean-Fallow-Fallow	2000	0.31	1
09	Soybean-Aus-Fallow	700	0.11	1
10	Vegetab-Groundnut-T. Aman	700	0.11	1
11	Mustard-Boro-T. Aman	660	0.10	9
12	Groundnut-Fallow-Fallow	440	0.07	3
13	Mustard-Aus-T. Aman	345	0.05	5
14	Mustard-Boro-Aus-T. Aman	270	0.04	3
15	Potato-Sesame-T. Aman	200	0.03	1
16	Sesame-Fallow-T. Aman	175	0.03	5
17	Fallow-Sesame-T. Aman	10	0.00	2
	Total oil-seed crops	89820	13.72	

Table 6. Cropping patterns with vegetables and spices crops in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetab-Fallow-T. Aman	17715	2.70	28
02	Chilli-Fallow-T. Aman	9450	1.44	30
03	Vegetab-Vegetab-T. Aman	8505	1.30	18
04	Vegetab-Boro-T. Aman	8150	1.24	5
05	Vegetab-Vegetab-Vegetab	5235	0.80	15
06	Potato-Fallow-T. Aman	4555	0.69	22
07	Vegetab-Fallow-Fallow	3920	0.60	11
08	Vegetab-Aus-Fallow	2900	0.44	7
09	Vegetab-Vegetab-Fallow	2560	0.39	10
10	Chilli-Aus-T. Aman	2450	0.37	6
11	Boro-Vegetab-T. Aman	1900	0.29	3
12	Vegetab-Boro-Fallow	1800	0.27	2
13	Potato-Boro-T. Aman	1650	0.25	6
14	Fallow-Vegetab-T. Aman	1480	0.23	8
15	Chilli-Aus-Fallow	770	0.12	3
16	Vegetab-Groundnut-T. Aman	700	0.11	1
17	Garlic-Fallow-T. Aman	535	0.08	10
18	Coriander-Fallow-T. Aman	475	0.07	13
19	Chilli-Fallow-Fallow	300	0.05	3
20	Coriander-Fallow-Fallow	250	0.04	8
21	Vegetab-Boro-Aus-T. Aman	250	0.04	1
22	Onion-Fallow-T. Aman	245	0.04	10
23	Potato-Sesame-T. Aman	200	0.03	1
24	Potato-Aus-T. Aman	165	0.03	4
25	Chilli-Vegetab-Fallow	130	0.02	5
26-35	Other 10 patterns (in Table 7)	300	0.05	-
	Total for vegetables and spices	76590	11.69	

Table 7. Rare cropping patterns covering non-significant area in Chittagong region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Freq.	Upazila
01	S.Potato-B.Aman	100	0.02	1	Lakshmipur
02	Wheat-Fallow-T. Aman	100	0.02	3	Chhagalnaiya+Parshuram+Companiganj
03	Fallow-Fallow-Blackgram	80	0.01	3	Anwara+Chhagalnaiya+Noakhali sadar
04	Boro-Sesbania-T. Aman	70	0.01	1	Raipur
05	Coriander-Vegetab-Fallow	70	0.01	3	Sitakunda+Ramgati+Maheshkhali
06	Lentil-Vegetab-T. Aman	60	0.01	1	Parshuram
07	Blackgram-Aus-T. Aman	60	0.01	2	Rauzan+ Sitakunda
08	Muskmelon-Fallow-Fallow	55	0.01	2	Banshkhali+ Ramu
09	Fallow-B.Aman	50	0.01	1	Kabirhat
10	Vegetab-Fallow-Blackgram	50	0.01	2	Fulgazi+ Parshuram
11	Onion-Aus-T. Aman	45	0.01	3	Sandwip+Sitakunda+Ramgati
12	W.Melon-Aus-T. Aman	35	0.01	2	Sandwip+ Kutubdia
13	Chilli-Vegetab-T. Aman	20	0.00	1	Mirsharai
14	Garlic-Aus-T. Aman	20	0.00	1	Ramgati
15	Mungbean-Aus-Fallow	20	0.00	1	Lohagara
16	Garlic-Vegetab-Vegetab	15	0.00	2	Maheshkhali+Ramu
17	Boro-Vegetab(Float/Norm)	10	0.00	1	Kutubdia
18	Chickpea-Fallow-T. Aman	10	0.00	1	Rangunia
19	Maize-Maize-T. Aman	10	0.00	1	Chakaria
20	Fallow-Sesame-T. Aman	10	0.00	2	Companiganj+ Kabirhat
21	Blackgram-B.Aman	5	0.00	1	Kabirhat
22	Chickpea-Aus-T. Aman	5	0.00	1	Companiganj
23	Garlic-Jute-Fallow	5	0.00	1	Sandwip
24	Onion-Vegetab-Vegetab	5	0.00	1	Maheshkhali
	Total	910	0.14		

for the sixth position in area coverage, however, it has allocated the highest share i.e. 68% of its NCA for this pattern alone. Chatkhil, Sitakunda and Sonaimuri upazila had a negligible area coverage for this pattern. In some portion of the double rice area some short duration Rabi crops can be grown before Boro transplanting if appropriate varieties and other related technologies are made available (FAO, 1988). In the country-wide compilation of data it was observed that Boro-F-T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

Second dominant cropping pattern

The second dominant cropping pattern in Chittagong region was Fallow-Fallow-T. Aman. It belongs to 19.15% of NCA of the region and spread over 32 upazilas (Table 9). Fatikchhari and Sandwip upazila of Chittagong district hold the highest are (12,000 ha for

each) under this single T. Aman cropping. These two upazilas jointly contribute 19% share of single T. Aman cropping area in the region. Teknaf stands in the sixth position, however, this upazila of CoxBazar district has allocated the biggest share i.e. about 70% surface of its NCA. Soil salinity is a constraint for the cultivation of Boro rice and Rabi crops in Sandwip, Subarnachar, Hatiya and other saline-prone area. A large area of this pattern is distributed on the valley where irrigation water is not sufficiently available in winter season. All these are the limiting factors for the crop intensification (FAO, 1988). Some stress-tolerant Rabi crops like grasspea, felon, cowpea, sesame etc may undergo for trial to intensify the land-use of the aforesaid system. In the country-wide compilation of data it was observed that the single T. Aman was the 3rd dominant cropping pattern in Bangladesh covering 5.09 lac ha (6% of NCA in the country) with its distribution in 162 upazilas of 36 districts (Nasim *et al.*, 2017).

Table 8. Distribution of the most dominant Boro–Fallow–T. Aman cropping pattern in Chittagong region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Lakshmipur	13700	52.45	9.12
02	Chakaria	10000	46.36	6.65
03	Feni	9500	56.55	6.32
04	Rngunia	9100	49.19	6.06
05	Maheskhali	7000	67.57	4.66
06	Senbag	7000	66.16	4.66
07	CoxBazar	6800	68.41	4.52
08	Ramu	6700	63.81	4.46
09	Fatikchhari	6500	29.47	4.33
10	Ukhia	6200	61.45	4.13
11	Chhagalnaiya	5700	53.93	3.79
12	Rauzan	5300	42.71	3.53
13	Dagonbhuiyan	5100	49.76	3.39
14	Satkania	5000	39.31	3.33
15	Raipur	4800	28.88	3.19
16	Hathazari	4600	44.57	3.06
17	Pekua	4500	57.54	2.99
18	Fulgazi	4300	60.31	2.86
19	Parshuram	3600	54.05	2.40
20	Anwara	3300	39.10	2.20
21	Lohagara	3300	30.14	2.20
22	Banshkhali	3000	16.87	2.00
23	Patiya	2600	19.01	1.73
24	Subarnachar	2000	5.27	1.33
25	Boalkhali	1600	25.76	1.06
26	Ramganj	1500	13.27	1.00
27	Mirsharai	1400	6.04	0.93
28	Teknaf	1200	10.46	0.80
29	Kabirhat	1200	10.11	0.80
30	Companiganj	1100	4.88	0.73
31	Chandanaish	700	7.10	0.47
32	Begumganj	700	4.26	0.47
33	Sonagazi	600	2.92	0.40
34	Noakhali	400	1.62	0.27
35	Kamalnagar	200	0.92	0.13
36	Sonaimuri	50	0.46	0.03
37	Sitakunda	20	0.21	0.01
38	Chatkhil	10	0.12	0.00
	Chittagong region	150280	22.92	100.00

Third dominant cropping pattern

Single Boro cropping pattern holds the third largest area coverage 48,710 hectares in Chittagong region. This area is an equivalent to 7.43% of NCA in the region. This pattern Boro–Fallow–Fallow is distributed over only 12 upazilas. Begumganj has an area of 15,000 ha for single Boro which stands for 30.79% of the total area under this pattern in the region (Table 10). Chatkhil ranks

in third position for single Boro area coverage, however, this upazila has allotted the biggest share (94.78%) of its NCA. Diversified cropping pattern may be resort for the farmer as a coping strategy with flood related risk (Mandal and Bezbaruah, 2013) but scope of diversification is limited due to environmental and climatic condition (FAO, 1988).

Table 9. Distribution of the 2nd dominant F-F-T. Aman cropping pattern in Chittagong region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Fatikchhari	12000	54.40	9.55
02	Sandwip	12000	49.50	9.55
03	Subarnachar	11300	29.76	9.00
04	Mirsharai	10800	46.63	8.60
05	Companiganj	8200	36.37	6.53
06	Teknaf	8000	69.75	6.37
07	Hatiya	8000	14.42	6.37
08	Patiya	6200	45.32	4.94
09	Rangunia	6100	32.97	4.86
10	Sonagazi	5600	27.29	4.46
11	Rauzan	4000	32.23	3.18
12	Kabirhat	3500	29.49	2.79
13	Hathazari	3100	30.04	2.47
14	Dagonbhuiyan	3000	29.27	2.39
15	Boalkhali	2600	41.87	2.07
16	Satkania	2550	20.05	2.03
17	Chhagalnaiya	2400	22.71	1.91
18	Banshkhali	2300	12.94	1.83
19	Chandanaish	2200	22.31	1.75
20	Lohagara	2200	20.09	1.75
21	Parshuram	1800	27.03	1.43
22	Fulgazi	1800	25.25	1.43
23	Noakhali	1300	5.26	1.04
24	Ukhia	1200	11.89	0.96
25	Feni	1000	5.95	0.80
26	Maheshkhali	800	7.72	0.64
27	Senbag	600	5.67	0.48
28	Sitakunda	450	4.59	0.36
29	CoxBazar	250	2.52	0.20
30	Kutubdia	150	4.41	0.12
31	Ramgati	150	0.62	0.12
32	Ramganj	50	0.44	0.04
	Chittagong region	125600	19.15	100.00

Fourth dominant cropping pattern

Fourth dominant cropping pattern Grasspea-Fallow-T. Aman has occupied 30,640 hectares representing 4.65% share of NCA in Chittagong region (Table 11). This pattern is distributed over 14 upazilas where Hatiya ranked in top position. This upazila has 8,000 ha area Grasspea-Fallow-T. Aman which is only 14.42% of upazila NCA. Companiganj upazila ranks in second position with 7,700 ha area for this pattern, however, this upazila has allotted the biggest share (34.15%) of its NCA. Grasspea is a relatively stress-tolerant pulse crop. So, it is extensively cultivated during pre-monsoon in the dry land (FAO, 1988).

Fifth dominant cropping pattern

Fifth dominant cropping pattern Fallow-Aus-T. Aman had been covering 27,140 hectares representing 4.14% share of NCA in Chittagong region (Table 12). This pattern is distributed over 20 upazilas where Hatiya ranked in top position. This upazila had 8,000 ha area for Fallow-Aus-T. Aman pattern which is only 14.42% of upazila NCA. Sitakunda upazila had the 4th largest area 2,800 ha for this cropping, however, this upazila had allotted the biggest share (28.57%) of its NCA. Scarcity of irrigation water compelled the farmers to shift their rice season. They left Boro and selected rainfed Aus (FAO, 1988). In this situation, some stress-

Table 10. Distribution of the 3rd dominant Boro–F–F cropping pattern in Chittagong region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Begumganj	15000	91.35	30.79
02 Sonaimuri	10100	93.78	20.73
03 Chatkhil	7800	94.78	16.01
04 Noakhali	5200	21.05	10.68
05 Ramganj	3900	34.51	8.01
06 Kabirhat	3700	31.17	7.60
07 Senbag	1200	11.34	2.46
08 Chakaria	700	3.25	1.43
09 Anwara	400	4.74	0.82
10 Raipur	300	1.81	0.06
11 Parshuram	250	3.75	0.05
12 Maheshkhali	160	1.54	0.03
Chittagong region	48710	7.43	100.00

Table 11. Distribution of the 4th dominant Grasspea–Fallow–T. Aman cropping pattern in Chittagong region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Hatiya	8000	14.42	26.11
02 Companiganj	7700	34.15	25.13
03 Subarnachar	5700	15.01	18.60
04 Sonagazi	5000	24.37	16.32
05 Kabirhat	1600	13.48	5.22
06 Mirsharai	1100	4.75	3.59
07 Feni	900	5.36	2.94
08 Noakhali	500	2.02	1.63
09 Dagonbhuiyan	100	0.98	0.33
10 Anwara	10	0.12	0.03
11 Patiya	10	0.07	0.03
12 Rauzan	10	0.08	0.03
13 Senbag	10	0.10	0.03
Chittagong region	30640	4.67	100.00

Table 12. Distribution of the 5th dominant Fallow–Aus–T. Aman cropping pattern in Chittagong region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Hatiya	8000	14.42	29.48
02 Sonagazi	3800	18.52	14.00
03 Sandwip	2900	11.96	10.69
04 Sitakunda	2800	28.57	10.32
05 Noakhali	2800	11.34	10.32
06 Banshkahli	2000	11.25	7.37
07 Ramganj	1200	10.62	4.42
08 Kabirhat	700	5.90	2.58
09 Senbag	600	5.67	2.21
10 Fatikchhari	400	1.81	1.47
11 Satkania	350	2.75	1.29
12 Anwara	300	3.55	1.11
13 Kutubdia	250	7.35	0.92
14 Chandanaish	200	2.03	0.74
15 Chhagalnaiya	200	1.90	0.74
16 Dagonbhuiyan	200	1.96	0.74
17 Mirsharai	150	0.65	0.55
18 Patia	150	1.11	0.55
19 Companiganj	100	0.44	0.37
20 Hathazari	40	0.41	0.15
Chittagong region	27140	4.14	100.0

tolerant Rabi crops like grasspea, felon, cowpea, sesame etc may undergo for trial to intensify the land-use of the aforesaid system.

Crop diversity and cropping intensity

Higher number of available crops under cultivation in an area dictates its higher diversity. Number of cropping patterns is also a gross indicator of crop diversity. A total of

93 cropping patterns were identified in the whole area of Chittagong region under this investigation. The highest number of cropping patterns was identified 28 in Naokhali sadar upazila and that was 26 in Companiganj and Kabirhat; and 25 in Mirsharai (Table 13). The lowest number of cropping patterns was identified four in Begumganj followed by seven in Chatkhil and Fulgazi both. The higher

Table 13. Crop diversity and cropping intensity in Chittagong region, 2014-15.

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Anwara	20	13	0.752	0.877	212
02 Banshkhali	15	11	0.889	0.945	205
03 Boalkhali	12	10	0.724	0.853	160
04 Chandanais	19	14	0.884	0.950	213
05 Fatikchhari	24	20	0.609	0.767	144
06 Hathazari	17	15	0.697	0.806	163
07 Lohagara	12	9	0.810	0.896	181
08 Mirsharai	25	18	0.739	0.846	190
09 Patiya	13	10	0.716	0.868	171
10 Rngunia	17	16	0.637	0.793	172
11 Rauzan	18	15	0.692	0.826	171
12 Sandwip	18	17	0.723	0.890	170
13 Satkania	16	11	0.782	0.879	182
14 Sitakunda	18	16	0.843	0.932	215
15 Chakaria	17	15	0.684	0.863	231
16 CoxBazar	18	14	0.509	0.733	192
17 Kutubdia	9	7	0.413	0.776	279
18 Maheskhali	13	13	0.521	0.687	174
19 Pekua	11	12	0.598	0.852	240
20 Ramu	16	17	0.546	0.758	193
21 Teknaf	11	11	0.484	0.673	127
22 Ukhia	10	8	0.586	0.746	178
23 Chhagalnaiya	16	15	0.639	0.781	175
24 Dagonbhuiyan	17	18	0.652	0.799	174
25 Feni	11	11	0.647	0.827	202
26 Fulgazi	7	7	0.551	0.726	174
27 Parshuram	12	11	0.611	0.760	170
28 Sonagazi	18	12	0.819	0.916	185
29 Kamalnagar	10	9	0.655	0.872	283
30 Lakshmipur	17	14	0.691	0.859	209
31 Ramganj	17	14	0.786	0.892	169
32 Ramgati	16	15	0.640	0.864	281
33 Raipur	12	10	0.784	0.908	220
34 Begumganj	4	5	0.151	0.269	108
35 Chatkhil	7	7	0.084	0.135	103
36 Companiganj	26	23	0.737	0.857	165
37 Hatiya	15	13	0.872	0.938	224
38 Kabirhat	26	23	0.776	0.867	139
39 Noakhali	28	18	0.886	0.944	192
40 Senbag	13	12	0.523	0.738	189
41 Sonaimuri	8	9	0.091	0.155	104
42 Subarnachar	23	18	0.833	0.926	183
Chittagong region	93	31	0.893	0.952	191

number of cropping patterns is generally related to higher level of crop diversity indices. The upazilas having lower number of cropping patterns were related to either salinity or water logging or both. Begumganj and Chatkhil face both the limitations. The lowest diversity index for cropping pattern was recorded 0.084 in Chatkhil followed by 0.151 in Begumganj. In a study Shahidullah *et al.* (2006) also found lowest values for all the diversity and intensity parameters in salt affected areas of greater Noakhali. The highest value of diversity index for cropping pattern was found 0.889 in Banshkhali upazila of Chittagong district that was followed by 0.886 in Noakhali sadar upazila. The lowest CDI was reported 0.135 in Chatkhil followed by 0.269 in Begumganj. The highest value of CDI was observed 0.945 in Banshkhali followed by 0.944 in Noakhali sadar upazila. The range of cropping intensity values was recorded 103-283%. The maximum value was for Kamalnagar upazila of Lakshmipur district and minimum for Chatkhil upazila of Noakhali district. As a whole the CDI of Chittagong region was calculated 0.952 and the average cropping intensity at regional level was 191%. In a simultaneous study, the investigators identified 316 cropping patterns for whole Bangladesh; where the CDI value was 0.952 at national level and the national average of cropping intensity was 200% (Nasim *et al.*, 2017). Diversified cropping pattern might enable the farmers compulsion of extracting the maximum possible use of land in the flood free period (Mandal and Bezbaruah, 2013). Singh and Sidhu (2006) reported that a number of crops like sun hemp, cluster beans and sorghum had almost disappeared and there is reduced varietal diversification in rice and wheat. Crop diversification index of wheat-rice system decreased from 0.75 in 1975-76 to 0.58 in 2006-07 in Punjab though diversification forces pests to continuously relocate and re-colonize their preferred host plants from year to year (Tschardt *et al.*, 2005, 2007).

CONCLUSION

The cropping intensity of the Chittagong region was little bit lower than the national average.

Boro-Fallow-T. Aman, Single T. Aman, single Boro, Grasspea-Fallow-T. Aman, Fallow-Aus-T. Aman were the dominant cropping patterns in the region. Exclusive rice area is about 23 folds of exclusive non-rice area. The non-rice based cropping patterns were either few or area under those cropping patterns were much lower which are challenges to food and nutritional security for the people of the Chittagong region. Based on the findings of the study, the following recommendations can be made.

- Initiative has to be taken to increase productivity of exclusive rice based cropping pattern as rice is the synonym of the primary food security. The high yielding varieties of rice along with recommended crop management packages to be adopted.
- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.
- Effort might be invested so that a portion of single T. Aman area could be brought under Fallow-T. Aman and/or Grasspea-T. Aman cropping systems.
- In the single Boro area suitable vegetables might be grown on floating bed system in wet season.

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Appendix 1. List of cropping patterns in Chittagong region, 2014-15.

	Cropping pattern	Area(ha)		Cropping pattern	Area (ha)
01	Boro-Fallow-T. Aman	150280	36	Boro-Vegetab-T. Aman	1900
02	Fallow-Fallow-T. Aman	125600	37	Vegetab-Boro-Fallow	1800
03	Boro-Fallow-Fallow	48710	38	Potato-Boro-T. Aman	1650
04	Grasspea-Fallow-T. Aman	30640	39	Fallow-Vegetab-T. Aman	1480
05	Fallow-Aus-T. Aman	27140	40	Fallow-Aus-Fallow	1000
06	Soybean-Aus-T. Aman	22600	41	Boro-Aus-Fallow	900
07	Soybean-Jute-T. Aman	19400	42	Chilli-Aus-Fallow	770
08	Soybean-Fallow-T. Aman	18670	43	Pea-Fallow-T. Aman	730
09	Vegetab-Fallow-T. Aman	17715	44	Soybean-Aus-Fallow	700
10	Grasspea-Aus-T. Aman	16740	45	Vegetab-Groundnut-T. Aman	700
11	Boro-Aus-T. Aman	16070	46	Mustard-Boro-T. Aman	660
12	Felon-Fallow-T. Aman	14630	47	Tobacco-Sesbania	600
13	Chilli-Fallow-T. Aman	9450	48	Maize-Fallow-T. Aman	595
14	Groundnut-Fallow-T. Aman	8630	49	Garlic-Fallow-T. Aman	535
15	Vegetab-Vegetab-T. Aman	8505	50	Lentil-Aus-T. Aman	500
16	Groundnut- Aus-T. Aman	8350	51	Coriander-Fallow-T. Aman	475
17	Vegetab-Boro-T. Aman	8150	52	Groundnut-Fallow-Fallow	440
18	Mungbean-Aus-T. Aman	7040	53	Felon-Aus-Fallow	420
19	Vegetab-Aus-T. Aman	5500	54	Tobacco-Fallow-T. Aman	400
20	Vegetab-Vegetab-Vegetab	5235	55	Muskmelon-Fallow-T. Aman	345
21	Felon-Aus-T. Aman	5045	56	Mustard-Aus-T. Aman	345
22	Potato-Fallow-T. Aman	4555	57	Chilli-Fallow-Fallow	300
23	S.Potato-Fallow-T. Aman	4390	58	S.Potato-Fallow-Fallow	300
24	Mungbean-Fallow-T. Aman	4335	59	Mustard-Boro-Aus-T. Aman	270
25	Soybean-B.Aman	4300	60	Felon-Fallow-Fallow	260
26	Vegetab-Fallow-Fallow	3920	61	Coriander-Fallow-Fallow	250
27	Vegetab-Aus-Fallow	2900	62	Grasspea-B.Aman	250
28	Boro-B.Aman	2850	63	Vegetab-Boro-Aus-T. Aman	250
29	W.Melon-Fallow-T. Aman	2790	64	Onion-Fallow-T. Aman	245
30	Vegetab-Vegetab-Fallow	2560	65	Potato-Sesame-T. Aman	200
31	Chilli-Aus-T. Aman	2450	66	W.Melon-Fallow-Fallow	195
32	Lentil-Fallow-T. Aman	2440	67	Sesame-Fallow-T. Aman	175
33	Mustard-Fallow-T. Aman	2370	68	Potato-Aus-T. Aman	165
34	S.Potato-Aus-T. Aman	2150	69	Chilli-Vegetab-Fallow	130
35	Soybean-Fallow-Fallow	2000	70-93	Other 24 patterns (Table 7)	910