Bangladesh Rice J. 21 (2) : 173-184, 2017

Crops and Cropping Sequences in Chittagong Hill Tracts

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ABSTRACT

This study was conducted in all 25 upazilas of Chittagong Hill Tracts during 2016 using a pre-designed and pre-tested semi-structured questionnaire for documenting the existing cropping pattern, crop diversity and cropping intensity. Boro-Fallow-T. Aman was the most dominant cropping pattern in Chittagong Hill Tracts (15.06%) existed in all upazilas except Ruma of Bandarban. Single T. Aman cropping pattern ranked the second position (13.67%) distributed in 21 upazilas. Shifting or *zhum* cultivation was the third cropping pattern in the region (9.24%) distributed to 20 upazilas. Only Rabi vegetables was recorded as the fourth cropping pattern (4.90%) covered 17 upazilas. Vegetables-Fallow-T. Aman cropping pattern ranked fifth (4.23%) in the region and was reported in 22 upazilas. About 30% area was covered by the annual crops mainly with fruits like banana, pineapple and papaya and, spices like ginger and turmeric. The highest number of cropping patterns was recorded in Lama (30) of Bandarban followed by Dighinala (28) of Khagrachhari. The lowest was reported in Ruma (8) of Bandarban. The overall crop diversity index (CDI) for the region was 0.96. The highest CDI was in Rowangchhari (0.99) of Bandarban followed by Lama (0.96) of Bandarban and the lowest in Belaichhari (0.82) of Rangamati. The single, double and triple cropped area in the region was 33.3%, 32.1% and 3.1% of the net cropped area. The average cropping intensity (CI) of the Chittagong Hill Tracts was 139%, the lowest in Ruma (100%) of Bandarban and the highest in Manikchhari and Panchhari (164%) of Khagrachhari.

Key words: Cropping patterns, land use, cropping intensity, diversity index and hill tract

INTRODUCTION

Number of crops grown under different cropping patterns varies from region to region. Cropping pattern influences the consumption pattern as well as health and nutritional status of the people (Barua *et al*., 2015). A cropping pattern is defined as yearly sequences of crop production in a piece of land are grown in the course of a year (Alam, 1994). A large number of factors like climate, soil type, rainfall, insect and disease pressure, agricultural technology; availability of irrigation facilities and other inputs, marketing and transport facilities, subsistence pressure and the growth of agro-industries influence on the cropping pattern and the changes therein (Neema, 1998; Gadge, 2003; Rashid *et al*., 2005).

The Chittagong Hill Tracts (CHT) presents unique biophysical characteristics, ethnic diversity and farming practices following certain cropping pattern that has taken care of the lives support of the hill people including dwelling, food, clothing, health care, festivities and other activities (Khisa, 1998). The CHT districts of the country have generally been identified as a disadvantaged region in terms of poverty, food insecurity, environmental vulnerability and limited livelihood opportunities. The stress environment of the hilly areas of the country received very little attention in the past. The increased pressure of growing population demand more food that brings attention to explore the possibilities of increasing the potential of the hilly lands for increased production of crops. Moreover, cultivable land area is decreasing day by day

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in the country. In this context, there is no other alternative but to address less fabourable and unfavourable environments for food security and to adapt to the climatic variability. The overall strategy for seventh five year plan of Bangladesh is to accelerate the process of transformation from existing semi-subsistence farming to commercialization of agriculture. The strategy requires achieving productivity gains, diversification, value addition and agro-processing commensurate with national environment protection and climate change adaptation strategies. (GED, 2015).

The increased total system productivity of an environment needs diversity in enterprises for better use of limited resources. Detailed information on land use and cropping systems is a pre-requisite for a fruitful development programmes on crop intensification and diversification for food and nutritional security. The Department of Agricultural Extension maintains a statistics on individual crop at upazila level. However, there is lacking of authenticated information on cropping pattern and cropping intensity at upazila and regional level. The present scenario of cropping patterns of a particular area may guide policy makers, researchers and extension personnelfor taking initiative to fulfill the implementation of priority plan of Sustainable Development Goal and Seventh Five year Plan for ending poverty and achieving food security.The present study was designed with the following specific objectives to:

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

METHODOLOGY

Twenty-five upazilas of Bandarban, Rangamati and Khagrachhari districts under Chittagong Hill Tracts 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 25 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during March 2016 at upazila level. The SAAOs were purposively preselected 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 to for necessary correction and validation. Second stage of data collection was daylong data validation workshop at district level during 16 to 18 May 2016. 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 BRRI regional station, Satkhira, Bhanga and Rajshahi participated in the data validation workshop. The number participants of validation workshop ranged from 48 to 63 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFSD 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).

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

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 approaches unity as the level of diversity increase. Data were compiled and processed using Micro Soft Excel programme. Descriptive statistics were used to facilitate the presentation of the findings.

RESULTS AND DISCUSSION

Land use

Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in Chittagong hill tracts were banana, turmeric, ginger, pineapple, papaya and sugarcane (Table 1). The area under annual crops in different upazilas ranged from 480 to 4,550 ha. The annual crops area accounted about 30% of the net cropped area (NCA) in the region. Among the annual crops, banana was widely distributed with higher area coverage. Ginger was distributed in 23 upazilas ranged 120 to 520 ha. Turmeric was reported in all upazilas except Naikhongchhari with a range of 130 to 980 ha. Pineapple was found in 19 upazilas with a major contribution from Ruma, Nannerchar, and Rowangchhari. Papaya was reported in 17 upazilas with an area coverage of five to 300 ha. Sugarcane was also reported in all upazilas except Barkal with a narrow area coverage (5-85 ha).

The single cropped area (SCA) had the major share in NCA in Ruma, Thanchi, Matiranga, Baghaichhari, Barkal, Belaichhari, Kawkhali, Langadu and Rangamati sadar followed by corresponding double cropped area (DCA). The rest of the upazilas were dominated by DCA (Table 2). The proportion of triple cropped

Table 1. Upazila wise area coverage under annual crops in Chittagong Hill Tracts, 2014-15.

	Upazila	Banana (ha)	Ginger (ha)	Papaya (ha)	Pineapple (ha)	Sugar-cane (ha)	Turmeric (ha)	Total (ha)	% NCA in the region
01	Alikadam	1400	0	300	200	30	0	1930	1.50
02	Bandarb.sadar	560	190	30	160	30	130	1100	0.85
03	Lama	800	300	250	60	60	300	1770	1.36
04	Naikhongch.	1520	-	40	10	40	-	1610	1.25
05	Rowangchhari	730	120	-	555	15	160	1580	1.23
06	Ruma	1910	350	150	1800	20	320	4550	3.53
07	Thanchi	200	450	70	50	20	350	1140	0.89
08	Dighinala	560	520	65	245	85	695	2170	1.68
09	Khagra. sadar	80	340	5	10	80	615	1130	0.88
10	Lakshmichhari	210	370	-	20	50	350	1000	0.78
11	Mohalchhari	350	370	50	110	60	530	1470	1.14
12	Manikchhari	-	210	-	-	10	260	480	0.38
13	Matiranga	-	550	-	-	30	980	1560	1.21
14	Panchhari	200	360	30	-	-	550	1140	0.89
15	Ramgarh	400	300	10	30	30	500	1270	0.99
16	Baghaichhari	-	180	-	-	20	300	500	0.39
17	Barkal	1500	170	-	-	-	250	1920	1.49
18	Belaichhari	1200	250	30	10	10	210	1710	1.33
19	Juraichhari	230	170	15	10	25	200	650	0.50
20	Kaptai	501	250	30	35	24	350	1190	0.92
21	Kawkhali	750	450	-	25	25	570	1820	1.41
22	Langadu	1020	240	40	150	40	130	1620	1.26
23	Nannerchar	755	150	160	1000	15	250	2330	1.81
24	Rajasthali	510	200	30	15	15	150	920	0.72
25	Rangam. sadar	1200	360	-	-	25	135	1720	1.34
	Total	16586	6850	1305	4495	759	8285	38280	29.73

Table 2. Upazila-wise land use pattern of Chittagong Hill Tracts (area in hectares), 2014-15

	Upazila	Area of upazila	SCA	DCA	TCA	Other	Annual crops	NCA (ha)
01	Alikadam	57800	760	2120	-	70	1930	4880
02	Bandarban sadar	50199	1740	1820	80	110	1100	4850
03	Lama	67184	2750	4660	220	120	1770	9520
04	Naikhongchhari	46361	2000	3840	500	60	1610	8010
05	Rowangchhari	44289	270	750	100	80	1580	2780
06	Ruma	49210	2280	10	-	110	4550	6950
07	Thanchi	102082	2310	170	30	90	1140	3740
08	Diginala	69413	2440	3190	125	95	2170	8020
09	Khagrachhari sadar	11243	1065	2825	150	110	1130	5280
10	Lakshmichhari	22015	1030	1480	-	90	1000	3600
11	Mohalchhari	25132	2780	2400	600	70	1470	7320
12	Manikchhari	16835	1180	2170	210	140	480	4180
13	Matiranga	49589	2550	2010	480	110	1560	6710
14	Panchhari	33411	345	1935	175	95	1140	3690
15	Ramgarh	24087	1750	1950	430	120	1270	5520
16	Baghaichhari	191403	4480	3200	300	120	500	8600
17	Barkal	76100	1500	435	10	105	1920	3970
18	Belaichhari	74593	2410	100	-	90	1710	4310
19	Juraichhari	60600	980	140	40	40	650	1850
20	Kaptai	27336	800	590	150	60	1190	2790
21	Kawkhali	33943	1405	1080	0	65	1820	4370
22	Langadu	52059	1860	890	350	50	1620	4770
23	Nannerchar	38793	2400	2180	-	70	2330	6980
24	Rajasthali	12551	640	900	60	100	920	2620
25	Rangamati sadar	54640	1150	495	-	55	1720	3420
	Total	-	42875	41340	4010	2225	38280	128730

SCA= Single cropped area, DCA = Double cropped area, TCA =Triple cropped area.

Table 3. Cropping patterns with exclusive rice in Chittagong Hill Tracts, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
1	Boro−Fallow−T. Aman	19400	15.07	24
2	Fallow−Fallow−T. Aman	17610	13.68	21
3	Boro−Fallow−Fallow	4950	3.85	11
4	Fallow−Aus−T. Aman	1320	1.03	9
5	Boro−Aus−Fallow	700	0.54	3
6	Boro−Aus−T. Aman	480	0.37	5
	Total	44460	34.54	

area (TCA) was lesser than SCA and DCA in all upazilas. The SCA and DCA were more or less similar, 33.29 and 32.10% of the NCA. The area which could not defined under SCA, DCA, TCA was considered as others.

Cropping patterns of Chittagong Hill Tracts

In total 72 cropping patterns were observed in Chittagong hill tract of which six cropping patterns with exclusive rice crop covers about 35% of the NCA. There were 20 cropping patterns with exclusive non-rice crop covering 11% of the NCA. Rest of the NCA i.e. about 54% area is covered by 46 rice - non rice cropping patterns (Appendix 1).

Rice and non-rice crops at a glance

Table 3 presents six cropping patterns where rice is the only crop round the year. It comprises 34.54% of the NCA in the region. Among them single rice, double rice and triple rice areas represent 17.53%, 16.64% and

Table 4. Cropping patterns of non-rice exclusive in Chittagong Hill Tract, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetab−Fallow−Fallow	6310	4.90	17
02	Vegetab−Vegetab−Fallow	4890	3.80	14
03	Groundnut−Fallow−Fallow	480	0.37	8
04	Tobacco−Fallow−Fallow	470	0.37	4
05	Vegetab−Vegetab−Vegetab	450	0.35	2
06	S.Potato−Fallow−Fallow	410	0.32	12
07	Chilli−Fallow−Fallow	170	0.13	6
08	Chilli−Vegetab−Fallow	150	0.12	4
09	Potato−Chilli−Fallow	130	0.10	2
10	Felon−Fallow−Fallow	120	0.09	2
11	W.Melon−Fallow−Fallow	120	0.09	3
12	Maize−Fallow−Fallow	110	0.09	6
13	Mustard−Fallow−Fallow	85	0.07	6
14	Maize−Sesame−Fallow	80	0.06	2
15	Coriander−Fallow−Fallow	75	0.06	6
16-20	Other five patterns (in Table 7)	125	0.10	-
	Total	14175	11.01	

Table 5. Cropping patterns of pulses and oil-seed crops in Chittagong Hill tract, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Groundnut−Fallow−Fallow	480	0.37	8
02	Felon−Fallow−T. Aman	370	0.29	9
03	Mustard−Fallow−T. Aman	175	0.14	9
04	Felon−Fallow−Fallow	120	0.09	2
05	Mustard−Fallow−Fallow	85	0.07	6
06	Felon−Aus−Fallow	50	0.04	1
07	Pea−Fallow−T. Aman	45	0.03	6
08	Lentil−Fallow−T. Aman	30	0.02	5
09-17	Other nine patterns (in Table 7)	110	0.09	-
	Total pulses and oil-seed crops	1465	1.14	

0.37%, respectively. It reflects the unparallel dominance of rice in the cropping systems in Chittagong Hill Tracts. In case of individual pattern Boro−Fallow−T. Aman has the highest coverage (15.07%) and was recorded in 24 upazilas out of 25. The second dominant pattern single T. Aman area occupied 13.68% of NCA which was distributed over 21 upazilas. Single Boro covered 3.85% area with its considerable existence in 11 upazilas.

In the current investigation, 20 cropping patterns were identified that was free from rice. Among these 20 patterns first 15 have been arranged in descending order in Table 4. The rest five patterns with negligible area (Table 7) where they are arranged with other patterns of different categories. Aggregate of the 20 patterns have had 11.01% of NCA. In critical comparison it is clear that exclusive rice area is three folds of exclusive non-rice area.

Pulses and oil-seed crops

There are 17 cropping patterns of pulses and oil-seed crops where sole groundnut is the dominating one with 480 ha area (Table 5). Felon−Fallow−T. Aman is the second covering 370 hectares of land. Total area for pulses and oil-seed crops were calculated as 1,465 ha, which is only 1.14% of NCA.

Vegetables and spices crops

Thirty-two cropping patterns have been arranged in descending order according to area coverage in Table 6. Potato and other vegetables of Rabi, Kharif-I and Kharif-II; Spices viz chilli,

Table 6. Cropping patterns of vegetables and spices crops in Chittagong Hill Tract, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetab−Fallow−Fallow	6310	4.90	17
02	Vegetab−Fallow−T. Aman	5450	4.23	22
03	Vegetab−Vegetab−Fallow	4890	3.80	14
04	Vegetab−Vegetab−T. Aman	1850	1.44	7
05	Vegetab−Aus−Fallow	910	0.71	6
06	Fallow−Vegetab−T. Aman	520	0.40	5
07	Potato−Fallow−T. Aman	520	0.40	12
08	Vegetab−Vegetab−Vegetab	450	0.35	2
09	Chilli−Fallow−T. Aman	380	0.30	12
10	Potato−Aus−T. Aman	340	0.26	7
11	Garlic−Aus−Fallow	300	0.23	1
12	Onion−Aus−Fallow	300	0.23	1
13	Boro−Vegetab(Float/Norm)	290	0.23	3
14	Potato−Maize−T. Aman	180	0.14	4
15	Chilli−Fallow−Fallow	170	0.13	6
16	Chilli−Vegetab−Fallow	150	0.12	4
17	Potato−Vegetab−T. Aman	140	0.11	2
18	Potato−Aus−Fallow	130	0.10	2
19	Potato−Chilli−Fallow	130	0.10	2
20	Vegetab−Aus−T. Aman	130	0.10	4
21	Chilli−Aus−Fallow	120	0.09	3
22	Chilli−Aus−T. Aman	120	0.09	2
23	Coriander−Fallow−T. Aman	120	0.09	8
24	Coriander−Fallow−Fallow	75	0.06	6
25-32	Other eight patterns (in Table 7)	230	0.18	-
	Total	24205	18.80	

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

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Maize−Aus−Fallow	40	0.03	2	Rowangchhari+Longadu
02	Maize−Vegetab−T. Aman	40	0.03	2	Lama+Rajesthali
03	Onion−Fallow−T. Aman	40	0.03	3	Dighinala+Mahalchhari+Naniarchar
04	Chilli−Vegetab−T. Aman	30	0.02	1	Ramgarh
05	Lentil−Fallow−T. Aman	30	0.02	3	Dighinala+Panchhari+Bandarban
06	Maize−Vegetab−Fallow	30	0.02	1	Bandarban sadar
07	Onion−Vegtab−Vegetab	30	0.02	1	Thanchi
08	Garlic−Fallow−Fallow	25	0.02	2	Thanchi+Barkal
09	Lentil−Vegetab−T. Aman	20	0.02	1	Mahalchhari
10	Millet(Kaon)+Sesame−F	20	0.02	1	Rangamati sadar
11	Mungbean−Fallow−T. Aman	20	0.02	3	Bandarban+Dighinala+Khagra
12	Muskmelon−Fallow−Fallow	20	0.02	1	Thanchi
13	Mustard−Aus−T. Aman	20	0.02	1	Mahalchhari
14	Garlic−Fallow−T. Aman	15	0.01	2	Dighinala+Panchhari
15	Grasspea−Fallow−T. Aman	15	0.01	3	Dighinala+Panchhari+Khagra
16	Chickpea−Fallow−T. Aman	10	0.01	2	Bandarban+Naniarchar
17	Fallow−Sesame−T. Aman	10	0.01	1	Matiranga
18	Mustard−Boro−T. Aman	10	0.01	2	Dighinala+Panchhari
19	Boro−Fallow−Blackgram	5	0.00	1	Panchhari
20	Groundnut−Fallow−T. Aman	5	0.00	1	Barkal
21	Mustard−Aus−Fallow	5	0.00	1	Rowangchhari
	Total	440	0.34		

coriander, onion and garlic are included in this list. Vegetab−Fallow−Fallow is the most dominating pattern covering 6,310 ha (4.90% of NCA) distributed over 17 upazilas. The second one is Vegetab−Fallow−T. Aman with 5,450 ha area, however, it is more widely distributed over 22 upazilas in the region. The total for vegetables and spices crops is 24,205 ha that represents 18.80% of NCA.

Sporadic and distinct cropping patterns

There are some cropping patterns which are extremely location-specific, however, with a large area coverage. These are Vegetables−Vegetables−Vegetables, Garlic−Aus−Fallow and Onion−Aus−Fallow (Table 6). The Vegetables−Vegetables−Vegetables cropping pattern is cultivated in Baghaichhari (300 ha) and in Kaptai (150 ha) in Rangamati district. The second and the third one both are available in Lama upazila of Bandarban district with an area of 300 ha for each.

Most dominant cropping pattern

Boro-Fallow-T. Aman cropping pattern was the most dominant one in Chittagong Hill Tracts existed in all upazilas except Ruma. The contribution of these upazilas in the existence of the cropping pattern ranged from 0.05 to 10.31% of the total Boro-Fallow- T. Aman cropping pattern. The largest area coverage under this cropping pattern was in Naikhongchhari (10.31% of the total) followed by Nannerchar, Dighinala and Khagrachhari sadar upazila. The potentiality of the intensification might be explored consulting other determinants with the stakeholders. The least area coverage was reported in Barkal, Thanchi and Belaichhari (Table 8). 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

Fallow-Fallow-T. Aman cropping pattern ranked the second position in the region distributed to 21 out of 25 upazilas. However, their magnitude of contribution to the region was different, ranging 0.45 (Rowangchhari) to 11.36% (Dighinala and Naikhongchhari) of the cropping pattern in the region. The major shares from other upazilas were Matiranga, Mohalchhari, Lama, Bandarban, Ramgarh and Manikchhari upazilas (Table 9). In the country-wide data compilation 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).

Third dominant cropping pattern

The third cropping pattern in the Chittagong Hill Tracts was *zhum* cultivation (9.24% of the NCA), which was distributed to 20 upazilas with different level of contribution (0.84 to 15.97%). The major shares of the cropping pattern belong to Ruma followed Belaichhari, Thanchi and Nannerchar (Table 10). In consideration of individual upazila Ruma upazila has allocated highest area and it is 79.17% of its NCA for this pattern alone. Lama of Bandarban district and Lakshmichhari upazila of Khragrachhari district had a negligible area coverage for this pattern. *Zhum* involves clearing of forest following slash and burn method. In February the hilly slopes area cleared. Seeds of sesame and millet are broadcasted mixing with ash before the first shower. Rice, maize and cotton seeds are dibbled later in the month of April after first shower and vegetables such as cucumber seeds are sown in the pit after germination of rice seeds (FAO, 1988).

Fourth dominant cropping pattern

Vegetables-Fallow-Fallow cropping pattern was recorded as the fourth one in the region covered 17 upazilas ranging 0.16 to 31.70% contribution in the region (Table 11). The major contributing upazilas for this cropping pattern were Baghaichhari (31.70%) followed by Mohalchhari (11.09%) and Kawkhali (9.51%). Rowangchhari, Bandarban sadar and Khagrachhari sadar upazila had a negligible area for this pattern.

Table 8. Distribution of most dominant Boro-Fallow-T. Aman cropping pattern in Chittagong Hill Tracts, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Naikhongchhari	2000	31.25	10.31
02	Nannerchar	1630	35.05	8.40
03	Dighinala	1500	25.64	7.73
04	Khagrachhari	1500	36.14	7.73
05	Panchchhari	1500	58.82	7.73
06	Matiranga	1300	25.24	6.70
07	Baghaichhari	1300	16.05	6.70
08	Mohalchhari	1270	21.71	6.55
09	Lama	1200	15.48	6.19
10	Bandarban sadar	1000	26.67	5.15
11	Manikchhari	900	24.32	4.64
12	Ramgarh	900	21.18	4.64
13	Alikadam	750	25.42	3.87
14	Lakshmichhari	700	26.92	3.61
15	Kawkhali	600	23.53	3.09
16	Kaptai	300	18.75	1.55
17	Rajasthali	300	17.65	1.55
18	Rangamati sadar	230	13.53	1.19
19	Langadu	200	6.35	1.03
20	Rowangchhari	190	15.83	0.98
21	Juraichhari	60	5.00	0.31
22	Thanchi	30	1.15	0.15
23	Belaichhari	30	1.15	0.15
24	Barkal	10	0.49	0.05
	Hill tract	19400	15.07	100.00

Table 9. Distribution of second dominant Fallow-Fallow-T. Aman cropping pattern in Chittagong Hill Tracts, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Naikhongchhari	2000	31.25	11.36
02	Dighinala	2000	34.19	11.36
03	Matiranga	1700	33.01	9.65
04	Mohalchhari	1500	25.64	8.52
05	Lama	1300	16.77	7.38
06	Ramgarh	1300	30.59	7.38
07	Manikchhari	1150	31.08	6.53
08	Baghaichhari	1000	12.35	5.68
09	Bandarban sadar	950	25.33	5.39
10	Lakshmichari	800	30.77	4.54
11	Alikadam	700	23.73	3.98
12	Khagrachhari sadar	600	14.46	3.41
13	Kawkhali	600	23.53	3.41
14	Nannerchar	550	11.83	3.12
15	Langadu	450	14.29	2.56
16	Kaptai	320	20.00	1.82
17	Barkal	250	12.20	1.42
18	Rajasthali	140	8.24	0.80
19	Belaichhari	120	4.62	0.68
20	Juraichhari	100	8.33	0.57
21	Rowangchhari	80	6.67	0.45
	Hill tract	17610	13.68	100.00

Table 10. Distribution of third dominant Fallow-Aus+non-rice (*zhum*) cropping pattern in Chittagong Hill Tracts, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Ruma	1900	79.17	15.97
02	Belaichhari	1850	71.15	15.55
03	Thanchi	1300	50.00	10.92
04	Nannerchar	950	20.43	7.98
05	Bndarban sadar	600	29.27	5.04
06	Barkal	600	16.00	5.04
07	Mohalchhari	580	9.91	4.87
08	Langadu	550	17.46	4.62
09	Juraichhari	500	41.67	4.20
10	Rajasthali	500	29.41	4.20
11	Rangamati sadar	470	27.65	3.95
12	Kaptai	380	23.75	3.19
13	Khagrachhari	350	8.43	2.94
14	Dighinala	300	11.76	2.52
15	Panchhari	300	5.13	2.52
16	Matiranga	250	4.85	2.10
17	Ramgarh	150	3.53	1.26
18	Kawkhali	140	5.49	1.18
19	Lakshmichhari	130	5.00	1.09
20	Lama	100	1.29	0.84
	Hill tract	11900	9.24	100.00

Table 11. Distribution of fourth dominant Vegetables-Fallow-Fallow cropping pattern in Chittagong Hill Tracts, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Baghaichhari	2000	24.69	31.70
02	Mohalchhari	700	11.97	11.09
03	Kawkhali	600	23.53	9.51
04	Matiranga	580	11.26	9.19
05	Thanchi	540	20.77	8.56
06	Ramgarh	300	7.06	4.75
07	Barkal	300	14.63	4.75
08	Rangamati sadar	250	14.71	3.96
09	Ruma	240	10.00	3.80
10	Lama	200	2.58	3.17
11	Belaichhari	200	7.69	3.17
12	Dighinala	100	1.71	1.58
13	Lakshmichhari	100	3.85	1.58
14	Kaptai	100	6.25	1.58
15	Khagra. sadar	60	1.45	0.95
16	Rowangchhari	30	2.50	0.48
17	Bandarban sadar	10	0.27	0.16
	Hill tract	6310	4.90	100.00

Fifth dominant cropping pattern

Vegetables-Fallow-T. Aman cropping pattern ranked fifth in the region which was reported in 22 upazilas ranged 10 to 680 ha (Table 12). This was majorly in Naikhongchhari, Khagrachhari sadar, Lakshmichhari and Baghaichhari upazilas. Thanchi, Matiranga, Rowangchhari and Belaichhari had a very negligible area for this cropping system.

Crop diversity and cropping intensity

Number of cropping pattern is a gross indicator of crop diversity. The highest number of cropping patterns were recorded in Lama (30) followed by Dighinala (28), Khagrachari sadar (25), Ruma (24), Panchari (23) and Bandarban sadar and Matiranga(20). The number of cropping patterns in Mahalchari, Nannerchar, Langadu, Barkal and Thanchi were 18, 18, 16,

Table 12. Distribution of fifth dominant Vegetables-Fallow-T. Aman cropping pattern in Chittagong Hill Tracts, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Naikhongchhari	680	10.63	12.48
02	Khagrachhari sadar	500	12.05	9.17
03	Lakshmichari	450	17.31	8.26
04	Baghaichhari	400	4.94	7.34
05	Kawkhali	350	13.73	6.42
06	Langadu	350	11.11	6.42
07	Rajasthali	330	19.41	6.06
08	Manikchhari	300	8.11	5.50
09	Bandarban sadar	260	6.93	4.77
10	Barkal	250	12.20	4.59
11	Nannerchar	230	4.95	4.22
12	Mohalchhari	220	3.76	4.04
13	Alikadam	200	6.78	3.67
14	Lama	200	2.58	3.67
15	Ramgarh	200	4.71	3.67
16	Kaptai	200	12.50	3.67
17	Dighinala	120	2.05	2.20
18	Rangamati sadar	100	5.88	1.83
19	Belaichhari	50	1.92	0.92
20	Rowangchhari	30	2.50	0.55
21	Matiranga	20	0.39	0.37
22	Thanchi	10	0.38	0.18
	Hill tract	5450	4.23	100.00

15, and 15, respectively. The lowest number of cropping patterns(8) was reported in Ruma. Higher number of cropping pattern is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were related to hill slope, lack of irrigation water and remoteness. Table 13 presents the calculated diversity indices (CDI) for cropping pattern. The overall crop diversity index for the region was 0.96. The highest CDI was in Rowangchhari (0.99) followed by Lama, Kaptai, Langadu and Rangamati sadar with same CDI, 0.96 and the lowest CDI was in Thanchi (0.76). Average CI for the Chittagong Hill Tracts was 139%. The lowest CI was recorded in Ruma (100%) and the highest was in Manikchhari and Panchhari (164%). 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).

CONCLUSION

The cropping intensity of the Chittagong Hill Tracts was much lower than the national average. About 30% of the NCA was covered by annual crops mainly with fruits, namely, banana, pineapple, and papaya and the spices, ginger and turmeric.Boro-Fallow-T. Aman, single T. Aman, *zhum* cultivation, Rabi vegetables and Vegetables-Fallow-T. Aman were the major cropping patterns that covered near about half of the NCA. The large number of existing absolute rice, combination of rice and non-rice based cropping patterns and non-rice-based cropping patterns indicated higher crops and cropping diversity and have the potential of biodiversity conservation, and scope for providing food and nutritional security for the people of the region. The following recommendations were made based on the findings of the study.

- Rice provisioning in the synonym of food security. Therefore, initiative to be taken to increase productivity of exclusive rice based cropping pattern.

Table 13. Crops and cropping pattern and their diversity indicesin Chittagong Hill Tracts, 2014-15.

	Upazila	Identified cropping pattern (no.)	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01	Alikadam	09	07	0.93	0.95	144
02	Bandarb. sadar	22	16	0.89	0.92	142
03	Lama	30	15	0.94	0.96	154
04	Naikhongchhari	10	08	0.86	0.91	161
05	Rowangchhari	24	14	0.99	0.99	135
06	Ruma	08	07	0.92	0.92	100
07	Thanchi	15	15	0.85	0.76	106
08	Dighinala	28	20	0.89	0.92	143
09	Khagra. sadar	25	16	0.89	0.92	160
10	Lakshmichhari	12	09	0.89	0.92	142
11	Mohalchhari	18	13	0.90	0.94	150
12	Manikchhari	13	09	0.85	0.91	164
13	Matiranga	20	13	0.88	0.92	145
14	Panchhari	23	17	0.82	0.87	164
15	Ramgarh	12	08	0.90	0.93	152
16	Baghaichhari	13	10	0.86	0.92	145
17	Barkal	15	11	0.96	0.96	112
18	Belaichhari	09	07	0.81	0.82	102
19	Juraichhari	12	09	0.90	0.91	112
20	Kaptai	09	08	0.95	0.96	133
21	Kawkhali	12	09	0.94	0.94	125
22	Langadu	16	12	0.94	0.96	134
23	Nannerchar	18	16	0.90	0.91	132
24	Rajasthali	09	07	0.93	0.95	140
25	Rangam. sadar	14	11	0.96	0.96	115
	Chittagong Hill Tract	72	27	0.94	0.96	139

- Short duration high yielding potential Aus rice varieties in suitable for *zhum* cultivation along with other species of crops for mixed and relay cropping with improved production practices to be extensively adopted for increasing system productivity.
- Initiatives to be taken to expand area under fruit crops in the hilly slope and the demand driven varieties to be adopted considering organic principles.
- The cropping patterns with major area coverage and narrow existence and minor area coverage with minor existence might be sustained for diversified food demand and adaptation to climatic hazard.
- The upazilas having higher cropping pattern index might be studied in depth to extrapolate potential cropping patterns to other upazilas of similar environments.
- Research and development activities can be taken in hand to diversify the single and double cropped cropping pattern with the inclusion of new crops and crop varieties.
- Coordinated programme needs to be taken to conserve the biodiversity and natural resources.

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Appendix 1. List of cropping patterns in Hill tract, 2014-15

	Cropping pattern	Area (ha)		Cropping pattern	Area (ha)
01	Boro−Fallow−T. Aman	19400	27	Onion−Aus−Fallow	300
02	Fallow−Fallow−T. Aman	17610	28	Boro−Vegetab(Float/Norm)	290
03	Fallow−Aus+Non-rice(*zhum*)	11900	29	Potato−Maize−T. Aman	180
04	Vegetab−Fallow−Fallow	6310	30	Mustard−Fallow−T. Aman	175
05	Vegetab−Fallow−T. Aman	5450	31	Chilli−Fallow−Fallow	170
06	Boro−Fallow−Fallow	4950	32	Chilli−Vegetab−Fallow	150
07	Vegetab−Vegetab−Fallow	4890	33	W.Melon−Aus−T. Aman	150
08	Tobacco−Aus−Fallow	2250	34	Maize−Aus−T. Aman	140
09	Vegetab−Vegetab−T. Aman	1850	35	Potato−Vegetab−T. Aman	140
10	Tobacco−Fallow−T. Aman	1540	36	Potato−Aus−Fallow	130
11	Fallow−Aus−T. Aman	1320	37	Potato−Chilli−Fallow	130
12	Vegetab−Aus−Fallow	910	38	Vegetab−Aus−T. Aman	130
13	Boro−Aus−Fallow	700	39	Chilli−Aus−Fallow	120
14	Fallow−Vegetab−T. Aman	520	40	Chilli−Aus−T. Aman	120
15	Potato−Fallow−T. Aman	520	41	Coriander−Fallow−T. Aman	120
16	Boro−Aus−T. Aman	480	42	Felon−Fallow−Fallow	120
17	Groundnut−Fallow−Fallow	480	43	W.Melon−Fallow−Fallow	120
18	Tobacco−Fallow−Fallow	470	44	Maize−Fallow−Fallow	110
19	Vegetab−Vegetab−Vegetab	450	45	Mustard−Fallow−Fallow	85
20	S.Potato−Fallow−Fallow	410	46	Maize−Sesame−Fallow	80
21	Maize−Fallow−T. Aman	400	47	Coriander−Fallow−Fallow	75
22	Chilli−Fallow−T. Aman	380	48	W.Melon−Fallow−T. Aman	75
23	Felon−Fallow−T. Aman	370	49	Boro−Maize−Fallow	60
24	Potato−Aus−T. Aman	340	50	Felon−Aus−Fallow	50
25	S.Potato−Fallow−T. Aman	320	51	Pea−Fallow−T. Aman	45
26	Garlic−Aus−Fallow	300	52-72	Other 21 patterns (Table 7)	440