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Cropping Patterns in Mymensingh Region: Diversity, Constraint and Potential

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ABSTRACT

A consistent and comprehensive database on cropping pattern, cropping intensity and crop diversity of a particular area is the prime importance for guiding policy makers, researchers, extentionists and development agencies for the future research and development planning. The study was carried out all the upazilas of Mymensingh region during 2015-16 using pre-designed and pre-tested semi-structured questionnaire with a view to document the existing cropping pattern, crop diversity and cropping intensity. The most dominant cropping pattern Boro−Fallow−T. Aman occupied about one-half of net cropped area (NCA) of the region distributed to 46 out of 47 upazilas. Single Boro cropping pattern ranked the second position which covered 23% of NCA distributed in 45 upazilas. A total of 129 cropping patterns were identified in the whole area of Mymensingh region under this investigation. The highest number of (30) cropping patterns were identified in Pakundia upazila of Kishoreganj and the lowest was (10) in Sreebardi of Sherpur. The lowest crop diversity index (CDI) was reported (0.111) in Mithamoin of Kishoreganj followed by 0.114 at Khaliajuri in Netrokona. The highest value of CDI was observed 0.933 at Dewanganj in Jamalpur followed by 0.920 at Bhairab in Kishoreganj. The range of cropping intensity values was recorded 101-249%. The maximum value was for Hossainpur and minimum for Itna and Mithamoin in Kishoreganj. At a glance the calculated CDI of Mymensingh region was 0.840 and the average cropping intensity was 187%.

Key words: Cropping patterns, diversity index, cropping intensity, Madhupur tract and Sylhet Basin

INTRODUCTION

In Bangladesh total cultivable land is 8.5 million hectare and it is shrinking day by day. The annual loss of agricultural land is about 0.73% per annum due to construction of houses, roads and industrial infrastructure (BBS, 2014). There is no other alternative but need to increase total productivity per unit area of the prevailing lands. To increase system productivity it needs to bring diversity in enterprises for better utilization of limited resources. The production of the cropping patterns could be increased by changing cultivars and improving cultural management practices. There is some scope of increasing cropping intensity from existing level by improving the existing cropping patterns by incorporating short duration crops viz mustard, potato, mungbean and aus rice in the rice based cropping system. Sustainable crop production in Bangladesh through improvement of cropping intensity in rice based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation and creation of job opportunity. The main challenge of the new millennium is to increase 50% yield per unit land area through manipulating the limited land resource. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing three or more crops over the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices (Mondal *et al*., 2015).

Actually, rice based monoculture exists in agriculture of the country. Rice monoculture gives us self-sufficiency in food production to some extent but it creates many problems.

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Only rice based cropping pattern has been facing a number of problems like reduction of soil fertility, pests and diseases outbreaks in the crop fields, decline in water table, reduced production of non-rice crops, erodes biodiversity, creates nutritional imbalance (Hussain *et al.*, 2001; Rahman, 2010). Crop diversification is considered as a strategy of reducing the reported problems. It is also considered as an effective approach to utilize scarce land and valuable water resources, which makes agriculture sustainable and environment friendly (Kumari *et al.*, 2010).

Due to non-availability of information on cropping systems, researchers, development agencies and policy makers cannot rightly identify research areas. Depending on physiographic, soil, hydrological and climatic characteristics, thirty agro ecological zones (AEZ) have been identified in Bangladesh. Mymensingh region is one of the most distinctive regions in Bangladesh and it represents the agriculture and climatic situation of five districts i.e. Mymensingh, Netrokona, Kishoreganj, Jamalpur and Sherpur. In the context of physiography it belongs to seven different agroecological zones viz Young Brahmaputra and Jamuna Floodplain (AEZ-8), Old Brahmaputra Floodplain (AEZ-9), Middle Meghna River Floodplain (AEZ-16), Old Meghna Estuarine Floodplain (AEZ-19), Sylhet Basin (AEZ-21), Northern and Western Piedmont Plains (AEZ-22) and Madhupur Tract (AEZ-28). Lion-share of the region frequently faces the occurrence of early flood, seasonal flood, late flood and also flash flood. In the basin area predominance of heavy clays and slow drainage and the dominance of noxious weeds are the critical parameters. Low moisture holding capacity, complex relief and soil pattern, erodibility of sloping soils and upland edges are main limitations for agricultural practices. Poor road communications in interior areas specially in the rainy season are big problems that mainly affect the marketing of produces.

Cropping pattern is defined as the yearly sequence, temporal and spatial arrangement of crops in a given land area. The Cropping pattern of a region reflects the geoclimatic, sociocultural, economic, historical and political conditions of a region (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 (Shahidullah *et al*., 2006; Neena, 1998; Gadge, 2003). According to Hossain (1996), the cropping pattern and the potential productivity of the crops of Bangladesh are determined by four climatic factors which are rainfall, evaporation, temperature and hours of light. Cropping patterns which depend not only on agro-ecological conditions but also on the spread of agricultural technologies especially irrigation technology. Total crop production has been changing due to changes in area under cultivation, yield rates, cropping pattern and prices of different crops. Shifting cropping pattern indicates changes in the composition of crops as well as their relative contribution to the total output growths due to proportionate change in areas. Changes in cropping pattern are pursued by either having technological backup in production of crops or supported by relative price advantages of the outputs or being influenced by the both. It is important to understand the changing pattern of crops over a longer period of time and identify the factors that caused changes in areas of the crops for taking appropriate policy measures in boosting and sustaining crop sector growth (Alam and Abedin, 1996).

Information on crops, major cropping patterns, area coverage by each pattern, rice yield in the pattern, level of adoption of modern rice variety in pattern by season across different land types in relation to their system productivity is lacking in compiled form. Detailed information on land situation and cropping systems is a precondition for a successful development programme. Department of Agricultural Extension (DAE)

maintained upazila-wise information on individual crops, land use patterns and other related data. It's very difficult to understand the real agricultural situation of a region from these data. Generation of information will help to develop resource and demand based program for sustainable improvement of agricultural production system. Therefore, the present study was designed with an attempt to attain the following objectives to:

- Visualize the existing land use pattern at upazila and regional level
- Understand the existing scenario of cropping patterns in Mymensingh region
- Find out the crop diversity and cropping intensity at local and regional level.

METHODOLOGY

Forty-seven upazilas of Mymensingh, Kishoreganj, Netrokona, Jamalpur and Sherpur districts under Mymensingh agricultural region were the locations of this study. Data were collected using double stage procedure. At initial stage, data were collected through pre-tested semi-structured questionnaire from 47 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during August 2015 at upazila level. SAAOs were 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 Directorate of Agricultural Extension (DAE) during monthly meeting. 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 daylong data validation workshop at district level. The workshop dates were 14 October for Jamalpur; 19 October for Kishoreganj; 17 November for Sherpur; 28 December 2015 for Netrokona and 5 January 2016 for Mymensingh. 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) participated in the data validation workshop. The number of participants of validation workshop ranged from 55 to 96 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. 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

The agricultural land utilization scenario of Mymensingh region is presented in Table 1. The net cropped area (NCA) of this region is 950,580 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,

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

	Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01	Baksiganj	20438	190	750	8210	6240	70	130	15590	235
02	Dewanganj	26618	1350	0	11490	5400	0	110	18350	222
03	Islampur	35367	300	550	21900	2900	0	150	25800	208
04	Jamalpur sadar	48924	590	1310	30280	5960	0	150	38290	211
05	Madarganj	22548	40	1940	7500	10190	0	170	19840	242
06	Melandaha	25843	320	830	14280	5780	20	190	21420	222
07	Sarishabari	27313	20	2570	12680	6130	0	120	21520	217
08	Astogram	35553	10	24490	920	290	0	100	25810	106
09	Bajitpur	19300	360	5460	7290	1460	0	140	14710	170
10	Bhairab	12167	10	2000	3660	1240	0	150	7060	189
11	Hossainpur	11920	140	570	3190	4960	50	130	9040	249
12	Itna	38100	0	30450	290	20	0	140	30900	101
13	Karimganj	20052	310	2800	6810	4390	0	100	14410	209
14	Kishoreganj sadar	19372	20	830	7965	4420	0	185	13420	227
15	Katiadi	21912	370	2160	10160	2780	300	100	15870	205
16	Kuliarchar	10401	110	2040	5430	1630	0	100	9310	194
17	Mithamoin	21799	0	16650	130	20	0	100	16900	101
18	Nikli	21400	10	15520	1550	0	0	130	17210	109
19	Pakundia	18052	120	700	6580	4565	0	155	12120	231
20	Tarail	15800	30	8280	4060	560	0	150	13080	140
21	Bhaluka	44405	1500	2760	16570	1590	0	180	22600	188
22	Dhubaura	25187	50	2950	11625	930	0	145	15700	187
23	Phulbaria	39888	2200	3590	16050	4720	100	140	26800	197
24	Phulpur	31500	40	470	20895	2575	0	160	24140	209
25	Gafargaon	40116	210	5800	19040	3700	0	160	28910	192
26	Gouripur	27676	40	2820	18820	800	0	160	22640	191
27	Haluaghat	35607	90	8300	16020	2440	0	140	26990	178
28	Iswarganj	28619	110	3600	17000	2600	0	150	23460	195
29	Muktagachha	31290	1050	1200	18850	1630	0	120	22850	197
30	Mymensingh sadar	38845	230	880	16880	7790	0	150	25930	226
31	Nandail	32638	290	1300	19510	2580	0	110	23790	204
32	Trisal	33601	250	1060	16960	7480	0	100	25850	224
33	Atpara	19300	30	4020	9250	390	0	140	13830	173
34	Barhatta	22200	20	1420	13280	980	0	120	15820	197
35	Durgapur	27800	10	10340	7560	385	0	115	18410	146
36	Kalmakanda	37523	40	22450	5430	400	0	120	28440	122
37	Kendua	30527	80	4560	17500	1330	0	110	23580	186
38	Khaliajuri	29746	10	18670	270	40	0	120	19110	102
39	Madan	22587	10	9460	8330	350	0	160	18310	150
40	Mohanganj	24800	30	8845	6835	210	0	160	16080	146
41	Netrokona sadar	33297	50	3640	18090	950	0	120	22850	188
42	Purbadhala	31442	30	2155	20000	970	0	125	23280	195
43	Jhenaigati	20839	130	1260	13040	770	0	130	15330	196
44	Nakla	17479	180	0	11610	2850	0	140	14780	218
45	Nalitabari	32777	130	290	21190	2180	0	140	23930	207
46	Sherpur sadar	35781	300	1530	17400	8710	0	160	28100	225
47	Sreebardi	25156	20	1250	13900	3100	0	150	18420	210
	Mymensingh region		11430	244520	556280	131385	540	6425	950580	187

papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from zero to 2,200 ha and it accounted only 1.21 % of the net cropped area in the region. At a glance the region possesses 26% single cropped area (SCA), 59% double cropped area (DCA), 14% triple cropped area (TCA) and 0.06% quadruple cropped area. The SCA had the major share of NCA in Ashtagram, Itna, Mithamoin, Nikli and Tarail upazilas of Kishoreganj district; Durgapur, Kalmakanda, Khaliajuri, Madan and Mohanganj upazilas of Netrokona district followed by corresponding double cropped area (DCA). The rest of the upazilas were dominated by DCA (Table 1). Triple cropped area is exceptionally dominating in Madarganj upazila of Jamalpur district and Hossainpur upazila of Kishoreganj district. The quadruple cropped area was found only in Baksiganj and Melandaha upazila of Jamalpur district; Hossainpur and Katiadi upazila of Kishoreganj district and Phulbaria upazila of Mymensingh district. The area which could not be defined under SCA, DCA, TCA or QCA was considered as other whose coverage is less than 1% of the NCA.

Cropping patterns of Mymensingh

In total 129 cropping patterns were observed in Mymensingh region of which six cropping patterns with exclusive rice crop covers over 77% of the NCA. There were 40 cropping patterns with exclusive non-rice crop covering over 5% of the NCA. Rest of the NCA i.e. about 18% area is covered by 83 rice - non rice cropping patterns (Appendix 1).

Exclusive rice cropping

Crop-combination analysis is an important aspect of agricultural geography. It's practical in different ways. Firstly, it provides sufficient understanding of an individual crop. Secondly, it helps us in interpreting some aspects of social and economic environment of the region. It further indicates the problems and basis for agricultural planning. In Mymensingh region, rice is the most dominant crop and it accounts for the largest proportion of total cropped area (BBS, 2014). Exclusively rice-based cropping patterns occupied 77.40% land of the net cropped area (Table 2). The highest area coverage (49.61%) was observed by Boro−Fallow−T. Aman cropping pattern and common in all upazilas except Mithamoin in Kishoreganj district. Single Boro cropping pattern is available in 45 upazilas covered 23.00% land area which is next to Boro−Fallow−T. Aman cropping pattern. A wide variation was observed in all other exclusive rice-based cropping patterns in respect of area and existing upazilas as well. Boro–Aus−T. Aman occupied 2.29% land area exists in 22 upazilas followed by Fallow–Aus−T. Aman (1.27%) and single T. Aman (1.18%) in 9 upazilas (Table 2).

Exclusive non-rice crops

In the current investigation, 40 cropping patterns were identified that was free from rice. Among them first 30 have been arranged in descending order in Table 3. The rest 10 patterns with negligible area coverage in Table 7 are arranged with other patterns of different categories. The agroclimatic conditions of Mymensingh region are suitable for growing rice year-round and rice takes up three-fourths of cropped areas. Though rice has a wide adaptation to different environmental situation, there are 40 exclusively non-rice cropping patterns occupying 49,935 ha land area which covers 5.25% of net cropped area in this region (Table 3). Among them the highest area (0.89%) was occupied by Vagetab−Vegetable−Vegetable cropping pattern existed in 23 out of 47 upazilas. Vegetables cultivated both in Rabi and Kharif-I seasons covered 0.48% of net cropped area found in 14 upazilas. The cropping patterns, Maize−Jute−Fallow (0.41%), Vegetable−Fallow−Fallow (0.39%) and Wheat−Jute−Fallow (0.30%) existed in six, nine and seven upazilas, respectively (Table 3). Now-a-days significant increase in the production of non-rice crops is ensuring biodiversity and nutritional balance through reducing the negative impacts of rice monoculture.

Aggregate of the 40 patterns have had 5.25% of NCA. In critical comparison it is clear that exclusive rice area is about 15 folds of

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

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
1	Boro−Fallow− T. Aman	471550	49.61	46
2	Boro−Fallow−Fallow	218650	23.00	45
3	Boro−Aus− T. Aman	21750	2.29	22
4	Fallow−Aus− T. Aman	12110	1.27	9
5	Fallow−Fallow− T. Aman	11180	1.18	9
6	Boro−Aus−Fallow	500	0.05	3
	Total	735740	77.40	---

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

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetable−Vegetable−Vegetable	8500	0.89	23
02	Vegetable−Vegetable−Fallow	4550	0.48	14
03	Maize−Jute−Fallow	3890	0.41	6
04	Vegetable−Fallow−Fallow	3630	0.38	9
05	Wheat−Jute−Fallow	2820	0.30	7
06	Sweet potato−Fallow−Fallow	2700	0.28	25
07	Chilli−Jute−Fallow	2670	0.28	9
08	Fallow−Fallow−Blackgram	2400	0.25	15
09	Vegetable−Jute−Fallow	2170	0.23	8
10	Chilli−Fallow−Fallow	2000	0.21	11
11	Groundnut−Fallow−Fallow	1875	0.20	18
12	Onion−Jute−Fallow	1720	0.18	5
13	Chilli−Vegetable−Fallow	1225	0.13	15
14	Mustard−Jute−Fallow	1210	0.13	4
15	Maize−Fallow−Fallow	1160	0.12	8
16	Onion−Vegetable−Vegetable	885	0.09	18
17	Potato−Jute−Fallow	810	0.09	5
18	Grasspea−Jute−Fallow	660	0.07	5
19	Garlic−Vegetable−Vegetable	640	0.07	15
20	Mustard−Fallow−Fallow	540	0.06	2
21	Blackgram−Jute−Fallow	500	0.05	4
22	Garlic−Jute−Fallow	480	0.05	4
23	Lentil−Jute−Fallow	470	0.05	6
24	Wheat−Vegetable−Vegetable	460	0.05	2
25	Potato−Chilli−Fallow	330	0.03	3
26	Sweet potato−Jute−Fallow	300	0.03	3
27	Wheat−Jute−Blackgram	250	0.03	1
28	Coriander−Fallow−Fallow	205	0.02	10
29	Vegetable−Fallow−Blackgram	180	0.02	3
30	Coriander−Jute−Fallow	170	0.02	2
31-40	Other 10 patterns (in Table 7)	535	0.06	-
	Total	49935	5.25	

exclusive non-rice area. The rapid increase in human population creates additional pressure on natural resources at above optimal levels of their inherent potential, which resulted the loss of biodiversity, serious soil erosion leading to depletion of plant nutrient, gradual degradation and decline in productivity and carrying capacity, etc. Even though appropriate cropping patterns may facilitate maximum possible land utilization as well as efficient use of other scarce resources in a sustainable manner. Diversified cropping pattern may be an option for the farmers as a coping strategy against risks (Mandal and Bezbaruah, 2013).

Oil-seed crops

Seventeen cropping patterns in combination of oil-seed crops occupy 41,810 ha land area which covers 4.40% of net cropped area (Table 4). Among the different oil crops, mustard takes up a great portion. The highest area coverage (2.34%) was recorded by Mustard−Boro−T. Aman cropping pattern which existed in 29 out of 47 upazilas. The second one Mustard−Boro−Fallow cropping pattern covered 1.27% land area existed in 18 upazilas. Though all these patterns occupied a poor portion of net cropped area, this could be the beginning, and the full potential of diversification has yet to be fully achieved to increase emphasis on the expansion of oil-seed crops in the Rabi season.

Vegetable and spices crops

Sixty-five cropping patterns have been arranged in descending order according to area coverage in Table 5. Potato, sweet potato, vegetable of Rabi, Kharif-I and Kharif-II; spices viz chilli, onion, garlic and coriander are included in this list. A row is included at the end of the Table 5 representing an aggregate of 15 patterns of vegetable and spices which is elaborately presented in the Table 7 with other patterns of different categories. The most contributing cropping pattern is Vegetable−Vegetable−T. Aman covering 0.94% of NCA which distributed over 13 upazilas.

Year-round vegetable was the second dominant cropping pattern which possessed 8,500 ha; however, it is most widely available in 23 upazilas. Vegetable–Fallow−T. Aman is the third dominant pattern distributed among 16 upazilas. For availability of irrigation water in dry season, supply of modern varieties of various crops, skilled technology transfer system, knowledge on modern crop management practices, high market value of fresh vegetable, good communication and marketing facilities are enhancing the extensive production of various types of vegetables in Mymensingh region (FAO, 1988). Now-a-days vegetable dominating cropping patterns are gradually increasing to meet up the demand of home and abroad. Vegetable like colocasia, okra, amaranthus, brinjal, cucurbits, etc are grown in medium upland adjacent to rice fields

Table 4. Area for oil-seed crops in Mymensingh region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Mustard−Boro− T. Aman	22270	2.34	29
02	Mustard−Boro−Fallow	12090	1.27	18
03	Groundnut−Fallow−Fallow	1875	0.20	18
04	Mustard−Jute− T. Aman	1840	0.19	7
05	Mustard−Jute−Fallow	1210	0.13	4
06	Mustard−Aus− T. Aman	580	0.06	4
07	Mustard−Fallow−Fallow	540	0.06	2
08	Mustard−Boro−Aus− T. Aman	420	0.04	3
09	Mustard−Fallow− T. Aman	350	0.04	2
10	Groundnut−Jute− T. Aman	330	0.03	7
11-17	Other seven patterns (in Table 7)	305	0.02	-
	Total oil-seed crop	41810	4.40	

Table 5. Area for vegetable and spices crops in Mymensingh region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetable−Vegetable− T. Aman	8910	0.94	13
02	Vegetable−Vegetable−Vegetable	8500	0.89	23
03	Vegetable−Fallow− T. Aman	7460	0.78	16
04	Potato−Boro− T. Aman	6080	0.64	16
05	Vegetable−Boro− T. Aman	4730	0.50	13
06	Vegetable−Vegetable−Fallow	4550	0.48	14
07	Potato−Jute− T. Aman	4360	0.46	16
08	Vegetable−Fallow−Fallow	3630	0.38	9
09	Chilli−Boro−Jute	3600	0.38	3
10	Vegetable−Jute− T. Aman	3520	0.37	13
11	Boro−Vegetable− T. Aman	3420	0.36	3
12	Chilli−Aus−Fallow	2935	0.31	6
13	Sweet potato−Fallow−Fallow	2700	0.28	25
14	Chilli−Jute−Fallow	2670	0.28	9
15	Vegetable−Jute−Fallow	2170	0.23	8
16	Chilli−Fallow−Fallow	2000	0.21	11
17	Chilli−Fallow− T. Aman	1840	0.19	10
18	Potato−Boro−Fallow	1770	0.19	8
19	Onion−Jute−Fallow	1720	0.18	5
20	Vegetable−Aus− T. Aman	1350	0.14	7
21	Chilli−Vegetable−Fallow	1225	0.13	15
22	Potato−Aus− T. Aman	1210	0.13	8
23	Chilli−Jute− T. Aman	1150	0.12	4
24	Potato−Vegetable− T. Aman	1090	0.11	8
25	Potato−Fallow− T. Aman	1000	0.11	10
26	Fallow−Vegetable− T. Aman	980	0.10	2
27	Onion−Jute− T. Aman	940	0.10	11
28	Boro−Vegetable (Float/Norm)	900	0.09	5
29	Vegetable−Aus−Fallow	900	0.09	2
30	Onion−Vegetable−Vegetable	885	0.09	18
31	Potato−Jute−Fallow	810	0.09	5
32	Onion−Fallow− T. Aman	805	0.08	9
33	Vegetable−Boro−Fallow	690	0.07	2
34	Garlic−Vegetable−Vegetable	640	0.07	15
35	Garlic−Fallow− T. Aman	610	0.06	5
36	Chilli−Vegetable− T. Aman	515	0.05	5
37	Vegetable−Boro−Jute	500	0.05	1
38	Garlic−Jute−Fallow	480	0.05	4
39	Wheat−Vegetable−Vegetable	460	0.05	2
40	Potato−Aus−Fallow	400	0.04	1
41	Garlic−Jute− T. Aman	340	0.04	8
42	Potato−Boro−Jute	340	0.04	1
43	Potato−Chilli−Fallow	330	0.03	3
44	Sweet potato−Fallow− T. Aman	310	0.03	6
45	Sweet potato−Jute−Fallow	300	0.03	3
46	Chilli−Aus− T. Aman	250	0.03	1
47	Coriander−Fallow−Fallow	205	0.02	10
48	Vegetable−Fallow−Blackgram	180	0.02	3
49	Coriander−Fallow− T. Aman	170	0.02	5
50	Coriander−Jute−Fallow	170	0.02	2
51-65	Other 15 patterns (in Table 7)	535	0.06	-
	Total vegetable and spices crops	97235	10.23	

during rainy season and potato, sweet gourd, cole crops, leafy vegetable etc are grown during winter season in Tripura (Das *et al.*, 2015).

Fibre crops

Forty cropping patterns of jute crops occupy 72,230 ha land area which covers 7.60% land of net cropped area. The highest area coverage (1.91%) was occupied by Boro−Jute−T. Aman which existed in 15 upazilas out of 47 (Table 6). The second one Wheat−Jute−T. Aman cropping pattern covered 0.75% land area, however, existed in 27 upazilas. Fallow−Jute−T. Aman, Potato−Jute−T. Aman and Maize−Jute−Fallow were found in 12, 16 and 6 upzilas covered 0.58, 0.46 and 0.41% of net cropped area, respectively. Well-drained light-textured soil makes the friendly situation for early growth stages of jute. High temperature, high humidity, satisfactory rainfall is the pre-requisites for cultivation of the crop which are available in Mymensingh region. Clear sun-shine during the harvesting period is an extra facility for post-harvest management of fibre and stick. Generally sufficient water for jute retting is not available in the whole region, however, it is sporadically available. Now-a-days jute-stick also has a good market value with export potential. If modern technology for fibre separation could be made available the farmers will be encouraged for extensive jute cultivation in the region (FAO, 1988).

Table 6. Area for jute production in Mymensingh region, 2014-15.

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Boro−Jute− T. Aman	18150	1.91	15
02	Wheat−Jute− T. Aman	7150	0.75	27
03	Fallow−Jute− T. Aman	5540	0.58	12
04	Potato−Jute− T. Aman	4360	0.46	16
05	Maize−Jute−Fallow	3890	0.41	6
06	Chilli−Boro−Jute	3600	0.38	3
07	Vegetable−Jute− T. Aman	3520	0.37	13
08	Wheat−Jute−Fallow	2820	0.30	7
09	Chilli−Jute−Fallow	2670	0.28	9
10	Boro−Jute−Fallow	2330	0.25	5
11	Maize−Jute− T. Aman	2220	0.23	4
12	Vegetable−Jute−Fallow	2170	0.23	8
13	Mustard−Jute− T. Aman	1840	0.19	7
14	Onion−Jute−Fallow	1720	0.18	5
15	Mustard−Jute−Fallow	1210	0.13	4
16	Chilli−Jute− T. Aman	1150	0.12	4
17	Onion−Jute− T. Aman	940	0.10	11
18	Potato−Jute−Fallow	810	0.09	5
19	Lentil−Jute− T. Aman	745	0.08	9
20	Blackgram−Jute− T. Aman	670	0.07	6
21	Grasspea−Jute−Fallow	660	0.07	5
22	Blackgram−Jute−Fallow	500	0.05	4
23	Vegetable−Boro−Jute	500	0.05	1
24	Garlic−Jute−Fallow	480	0.05	4
25	Lentil−Jute−Fallow	470	0.05	6
26	Garlic−Jute− T. Aman	340	0.04	8
27	Potato−Boro−Jute	340	0.04	1
28	Groundnut−Jute− T. Aman	330	0.03	7
29	Sweet potato−Jute−Fallow	300	0.03	3
30	Wheat−Jute−Blackgram	250	0.03	1
31	Coriander−Jute−Fallow	170	0.02	2
32-40	Other nine patterns (in Table 7)	385	0.04	-
	Total area for jute	72230	7.60	

Sporadic and distinct cropping patterns

There were some cropping patterns which were extremely location-specific covering a large area. The Maize−Jute−Fallow is grown in 2,000 ha and 350 ha in Dewanganj and Islampur upazilas, respectively under Jamalpur district. Chilli−Boro−Jute is cultivated in 2,650 ha in Madarganj of Jamalpur and 500 ha in Bhairab of Kishoreganj district. Boro−Vegetable− T. Aman is limited to two upazilas viz Trisal (1,600 ha) and sadar upazila (1,700 ha) of Mymensingh district.

Rare cropping patterns

Forty cropping patterns with minor area coverage and narrow existence occupy 1,845 ha land area which covers 0.19% of net cropped area of this region. The area coverage of these patterns ranged from trace to 0.02% of net cropped area each existed in one to four upazilas. Among these patterns, three were single cropped, 16 were double cropped and 21 were triple cropped cropping patterns covering negligible area (Table 7).

Most dominant cropping pattern

In Mymensingh region, the most dominant cropping pattern was Boro−Fallow− T. Aman covering 49.6% of NCA and was available in 46 upazilas out of 47 (Table 8). The highest area under this cropping pattern was recorded 25,200 ha in Jamalpur sadar upazila which represents 5.34% of the total Boro−Fallow− T. Aman area of the region. Purbadhala upazila of Netrokona district has owned the highest area in consideration of indivdual upazila and occupied 86% of its NCA for this pattern alone. The least area coverage was reported in Khaliajuri, Nikli and Itna upazila. In the country-wide compilation of data it was observed that Boro−Fallow−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

Boro−Fallow−Fallow cropping pattern ranked the second position in Mymensingh region occupying 23.0% of NCA distributed in 45 upazilas (Table 9). However, their magnitude of contribution to the region was different, ranging 0.26 (Jamalpur sadar) to 95.24% (Khaliajuri) of the NCA. The major share of this pattern was from Itna, Astogram, Khaliajuri, Kalmakanda, Mithamoin, Nikli and Durgapur upazilas. Itna upazila of Kishoreganj district hold the higest area (27,500 ha) under this single Boro cropping pattern. Itna and Astogram upazilas together contributed remarkable share (23.19%) of single Boro cropping area in the region. This pattern was frequent and concurrently experienced by early flash flood in April and cold injury at reproductive stage. Diversified cropping pattern may be an option for the farmer as a coping strategy in flood prone areas (Mandal and Bezbaruah, 2013), but scope of diversification is limited due to environmental and climatic condition (FAO, 1988). In the country-wide compilation of data it was observed that the single Boro was the second dominant cropping pattern in Bangladesh covering 1.14 million ha (13% of NCA in the country) with its distribution in 342 upazilas of 59 districts (Nasim *et al*., 2017).

Third dominant cropping pattern

Mustard−Boro−T. Aman cropping pattern grips the third largest area coverage 22,270 ha distributed in 29 out of 47 upazilas in Mymensingh region. This area was an equivalent to 2.34% of NCA in the region. Jamalpur sadar has an area of 3,300 ha which stands for 14.82% of the total area under this pattern in the region (Table 10). Sarishabari ranks in second position for this pattern; however, this upazila has allotted the largest share (13.01%) of its NCA. In the country-wide compilation of data it was observed that Mustard−Boro− T. Aman was the 6th dominant cropping pattern in Bangladesh covering 1.85 lac ha (2.16% of NCA in the country) with its distribution in 203 upazilas of 51 districts (Nasim *et al*., 2017).

Fourth dominant cropping pattern

Boro−Aus−T. Aman cropping pattern was recorded as the fourth dominant cropping pattern occupied 21,750 ha distributed to 22 out of 47

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

	Cropping pattern	Area (ha)	% of NCA	Freq.	Upazila
01	Maize−Aus− T. Aman	150	0.02	3	Katiadi+Pakundia+Gafargaon
02	Garlic−Fallow−Fallow	110	0.01	4	Nikli+Itna+Mithamoin+Durgapur
03	Grasspea−Aus− T. Aman	110	0.01	3	Kishoreganj+Gafargaon+Nandail
04	Wheat−Fallow−Fallow	110	0.01	2	Astogram+Mithamoin
05	Mungbean−Jute−Fallow	100	1.91	2	Katiadi+Pakundia
06	Wheat−Aus−Blackgram	100	0.75	1	Madarganj
07	Groundnut−Sesame−Fallow	90	0.58	2	Bhairab+Pakundia
08	Pea−Aus−Vegetable	90	0.46	1	Gafargaon
09	Potato−Boro−Jute− T. Aman	70	0.41	2	Baksiganj+Melandaha
10	Sesame−Fallow− T. Aman	55	0.38	3	Jamalpur sadar +Tarail+Dhubaura
11	Grasspea−Boro−Fallow	50	0.37	1	Dewanganj
12	Maize−Vegetable− T. Aman	50	0.30	1	Nakla
13	Mungbean−Fallow− T.Aman	50	0.28	2	Jamalpur sadar +Tarail
14	Mungbean−Jute− T. Aman	50	0.25	3	Baksiganj+Phulpur+Mym. sadar
15	Sweet Potato−Jute− T. Aman	50	0.23	1	Muktagachha
16	W.Melon−Aus− T. Aman	50	0.23	1	Kalmakanda
17	Boro−Sesbania− T. Aman	40	0.19	1	Madarganj
18	Grasspea−Fallow− T. Aman	40	0.18	1	Jamalpur sadar
19	Grasspea−Jute− T. Aman	40	0.13	3	Baksiganj+Karimganj+Mym. sadar
20	Groundnut− Aus− T. Aman	40	0.12	1	Kuliarchar
21	Sesame−Aus−Fallow	40	0.10	1	Islampur
22	Lentil−Fallow− T. Aman	35	0.09	4	Bhairab+Bhaluka+Dhubaura+Durgapur
23	Maize−Mungbean−Vegetable	30	0.08	1	Pakundia
24	Millet(cheena)−F−F	30	0.07	1	Melandaha
25	Millet(Kaon)+Sesame−F	30	0.07	1	Madarganj
26	Potato−Boro−Aus− T. Aman	30	0.05	1	Hossainpur
27	Sesame−Jute− T. Aman	30	0.05	1	Baksiganj
28	Must−Boro−Jute− T. Aman	20	0.05	1	Baksiganj
29	Onion−Aus− T. Aman	20	0.05	1	Hossainpur
30	Onion−Maize− T. Aman	20	0.04	1	Pakundia
31	Chickpea−Fallow−T. Aman	15	0.04	2	Dhubaura+Phulbaria
32	Coriander−Jute− T. Aman	15	0.03	2	Melandaha+Phulpur
33	Coriander−Vegetable−Fallow	15	0.03	2	Tarail+Phulpur
34	Pea−Fallow− T. Aman	15	0.03	2	Dhubaura+Mym. sadar
35	Chickpea−Jute−T. Aman	10	0.02	1	Mymensingh sadar
36	Garlic−Aus−Fallow	10	0.01	1	Bhaluka
37	Lentil−Vegetable−Vegetable	10	0.01	1	Melandaha
38	Mungbean−Aus− T. Aman	10	0.01	1	Gafargaon
39	Pea−Vegetable−Fallow	10	0.01	1	Gouripur
40	Onion−Aus−Fallow	5	0.00	1	Durgapur
	Total area	1845	0.19		

Table 8. Distribution of the most dominant Boro−Fallow−T. Aman cropping patterns in Mymensingh region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Jamalpur sadar	25200	65.81	5.34
02	Phulpur	20000	82.85	4.24
03	Purbadhala	20000	85.88	4.24
04	Nalitabari	19500	81.47	4.14
05	Nandail	18900	79.45	4.01
06	Netrokona sadar	17800	77.90	3.77
07	Gouripur	17500	77.28	3.71
08	Kendua	17100	72.52	3.63
09	Muktagachha	16500	72.20	3.5
10	Bhaluka	16400	72.55	3.48
11	Ishwarganj	16400	69.91	3.48
12	Trisal	16200	62.67	3.44
13	Mymensingh sadar	16100	62.07	3.41
14	Sherpur sadar	16000	56.94	3.39
15	Phulbaria	14000	52.24	2.97
16	Gafargaon	14000	48.43	2.97
17	Sreebardi	13100	71.11	2.78
18	Barhatta	13000	82.15	2.76
19	Haluaghat	12500	46.31	2.65
20	Melandaha	11500	53.69	2.44
21	Jhenaigati	11400	74.34	2.42
22	Dhubaura	10150	64.65	2.15
23	Islampur	10000	38.76	2.12
24	Sarishabari	9200	42.74	1.95
25	Nakla	9000	60.89	1.91
26	Katiadi	8500	53.56	1.8
27	Atpara	8000	57.85	1.7
28	Durgapur	7200	39.11	1.53
29	Madarganj	7100	35.78	1.51
30	Dewanganj	6200	33.79	1.31
31	Baksiganj	6100	39.13	1.29
32	Madan	6100	33.32	1.29
33	Karimganj	5700	39.56	1.21
34	Bajitpur	5600	38.05	1.19
35	Mohanganj	5500	34.2	1.17
36	Pakundia	5400	44.55	1.15
37	Kuliarchar	4550	48.84	0.96
38	Kishoreganj sadar	3800	28.32	0.81
39	Kalmakanda	3500	12.30	0.74
40	Tarail	3100	23.70	0.66
41	Hossainpur	1800	19.91	0.38
42	Bhairab	1100	15.58	0.23
43	Astogram	400	1.55	0.08
44	Itna	250	0.81	0.05
45	Nikli	100	0.58	0.02
46	Khaliajuri	100	0.52	0.02
	Mymensingh region	471550	49.60	100.00

Table 9. Distribution of the 2nd dominant Boro−F−F cropping patterns in Mymensingh region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Itna	27500	89.00	12.58
02	Astogram	23200	89.91	10.61
03	Khaliajuri	18200	95.24	8.32
04	Kalmakanda	16400	57.66	7.50
05	Mithamoin	16000	94.67	7.32
06	Nikli	14500	84.28	6.63
07	Durgapur	10200	55.40	4.66
08	Madan	9200	50.25	4.21
09	Mohanganj	8700	54.10	3.98
10	Haluaghat	8200	30.38	3.75
11	Tarail	6200	47.40	2.84
12	Gafargaon	5800	20.06	2.65
13	Bajitpur	5200	35.33	2.38
14	Kendua	4500	19.08	2.06
15	Atpara	4000	28.92	1.83
16	Ishwarganj	3600	15.35	1.65
17	Netrokona sadar	3600	15.75	1.65
18	Phulbaria	3500	13.06	1.60
19	Gouripur	2800	12.36	1.28
20	Karimganj	2700	18.74	1.23
21	Purbadhala	2000	8.59	0.91
22	Dhubaura	1900	12.10	0.87
23	Madarganj	1850	9.32	0.85
24	Bhairab	1800	25.50	0.82
25	Katiadi	1800	11.34	0.82
26	Sarishabari	1500	6.97	0.69
27	Kuliarchar	1500	16.10	0.69
28	Sherpur sadar	1500	5.34	0.69
29	Barhatta	1400	8.85	0.64
30	Nandail	1300	5.46	0.59
31	Muktagachha	1200	5.25	0.55
32	Bhaluka	1100	4.87	0.50
33	Melandaha	830	3.87	0.38
34	Kishoreganj sadar	800	5.96	0.37
35	Baksiganj	750	4.81	0.34
36	Sreebardi	750	4.07	0.34
37	Hossainpur	500	5.53	0.23
38	Jhenaigati	500	3.26	0.23
39	Phulpur	400	1.66	0.18
40	Pakundia	300	2.47	0.14
41	Mymensingh sadar	260	1.00	0.12
42	Trisal	260	1.01	0.12
43	Nalitabari	200	0.84	0.09
44	Islampur	150	0.58	0.07
45	Jamalpur sadar	100	0.26	0.05
	Mymensingh region	218650	23.00	100.00

Table 10. Distribution of the 3rd dominant Mustard-Boro−T. Aman cropping patterns in Mymensingh region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Jamalpur sadar	3300	8.62	14.82
02	Sarishabari	2800	13.01	12.57
03	Sherpur sadar	1900	6.76	8.53
04	Madarganj	1800	9.07	8.08
05	Melandaha	1600	7.47	7.18
06	Nalitabari	1600	6.68	7.18
07	Dewanganj	1400	7.63	6.29
08	Karimganj	1200	8.33	5.39
09	Nakla	1000	6.77	4.49
10	Phulpur	700	2.90	3.14
11	Mymensingh sadar	700	2.70	3.14
12	Sreebardi	700	3.80	3.14
13	Baksiganj	600	3.85	2.69
14	Trisal	600	2.32	2.69
15	Muktagachha	400	1.75	1.80
16	Netrokona sadar	300	1.31	1.35
17	Gouripur	250	1.10	1.12
18	Madan	250	1.37	1.12
19	Jhenaigati	250	1.63	1.12
20	Barhatta	200	1.26	0.90
21	Kuliarchar	150	1.61	0.67
22	Phulbaria	150	0.56	0.67
23	Pakundia	100	0.82	0.45
24	Purbadhala	100	0.43	0.45
25	Dhubaura	80	0.51	0.36
26	Atpara	50	0.36	0.22
27	Nandail	40	0.17	0.18
28	Durgapur	40	0.22	0.18
29	Bhaluka	10	0.04	0.04
	Mymensingh region	22270	2.34	100.00

upazilas and representing 2.29% share of NCA in Mymensingh region (Table 11). The major share of this pattern was from Hossainpur, Kishoreganj sadar, Phulbaria, Pakundia and Katiadi upazilas. Hossainpur upazila of Kishoreganj district ranked in top position occupying 4,200 ha area which is 46.45% of upazila NCA. The least area coverage was reported in Nakla, Trisal, Mymensingh sadar, Dhubaura, Bhaluka, Kuliarchar and Madarganj upazilas for this pattern. Though continuous rice cropping was not suggested by the researchers and extension personnel, however, this type of land is not suitable for cultivation of non-rice crops.

Fifth dominant cropping pattern

Boro−Jute−T. Aman cropping pattern holds the fifth largest area coverage 18,150 ha distributed in 15 out of 47 upazilas in Mymensingh region (Table 12). However, their magnitude of contribution to the region was different, ranging 0.55 (Nakla) to 2.69% (Madarganj) of the NCA. In consideration of indivdual upazila, Madarganj upazila has allocated the highest area and it was 21.67% of its NCA for this pattern alone. Nakla, kuliarchar, Hossainpur and Bajitpur upazila had negligible area coverage for this pattern.

Crop diversity and cropping intensity

Higher number of available crops under cultivation in an area dictates its higher diversity. Number of cropping patterns was also a gross indicator of crop diversity. A total of 129 cropping patterns were identified in the whole area of Mymensingh region under this

Table 11. Distribution of the 4th dominant Boro-Aus-T. Aman cropping patterns in Mymensingh region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Hossainpur	4200	46.45	19.31
02	Kishoreganj sadar	3800	28.32	17.47
03	Phulbaria	3300	12.31	15.17
04	Pakundia	2100	17.32	9.66
05	Katiadi	1700	10.71	7.82
06	Gafargaon	1300	4.50	5.98
07	Nandail	1200	5.04	5.52
08	Haluaghat	1000	3.71	4.60
09	Sreebardi	700	3.80	3.22
10	Muktagachha	600	2.63	2.76
11	Ishwarganj	400	1.71	1.84
12	Nalitabari	400	1.67	1.84
13	Karimganj	300	2.08	1.38
14	Bajitpur	200	1.36	0.92
15	Jhenaigati	200	1.30	0.92
16	Madarganj	50	0.25	0.23
17	Kuliarchar	50	0.54	0.23
18	Bhaluka	50	0.22	0.23
19	Dhubaura	50	0.32	0.23
20	Mymensingh	50	0.19	0.23
21	Trisal	50	0.19	0.23
22	Nakla	50	0.34	0.23
	Mymensingh region	21750	2.29	100.00

Table 12. Distribution of the 5th dominant Boro−Jute-T. Aman cropping patterns in Mymensingh region, 2014-15.

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Madarganj	4300	21.67	23.69
02	Melandaha	3000	14.01	16.53
03	Baksiganj	2300	14.75	12.67
04	Sarishabari	2300	10.68	12.67
05	Islampur	1300	5.04	7.16
06	Dewanganj	1200	6.54	6.61
07	Mymensingh sadar	1000	3.86	5.51
08	Trisal	950	3.68	5.23
09	Sherpur sadar	600	2.14	3.31
10	Sreebardi	550	2.99	3.03
11	Bhaluka	200	0.88	1.10
12	Bajitpur	150	1.02	0.83
13	Hossainpur	100	1.11	0.55
14	Kuliarchar	100	1.07	0.55
15	Nakla	100	0.68	0.55
	Mymensingh region	18150	1.91	100.00

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

	Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
1	Baksiganj	29	17	0.806	0.923	235
2	Dewanganj	17	13	0.847	0.933	222
3	Islampur	21	16	0.817	0.913	208
4	Jamalpur sadar	25	19	0.554	0.795	211
5	Madarganj	22	18	0.789	0.915	242
6	Melandaha	21	14	0.680	0.863	222
7	Sarishabari	25	18	0.779	0.899	216
8	Astogram	22	14	0.191	0.271	106
9	Bajitpur	16	13	0.722	0.848	170
10	Bhairab	14	12	0.837	0.920	189
11	Hossainpur	28	14	0.733	0.876	249
12	Itna	14	13	0.206	0.216	101
13	Karimganj	22	18	0.788	0.906	209
14	Kishoreganj sadar	18	17	0.814	0.911	227
15	Katiadi	22	19	0.686	0.849	205
16	Kuliarchar	25	14	0.728	0.859	194
17	Mithamoin	14	13	0.103	0.111	101
18	Nikli	15	13	0.287	0.391	109
19	Pakundia	30	17	0.763	0.902	231
20	Tarail	17	15	0.693	0.809	140
21	Bhaluka	17	14	0.463	0.693	188
22	Dhubaura	20	13	0.555	0.745	187
23	Phulbaria	21	16	0.692	0.840	197
24	Phulpur	29	17	0.311	0.679	209
25	Gafargaon	25	18	0.698	0.844	192
26	Gouripur	19	14	0.386	0.662	191
27	Haluaghat	16	12	0.682	0.825	178
28	Iswarganj	12	8	0.486	0.733	195
29	Muktagachha	14	12	0.471	0.725	197
30	Mymensingh sadar	25	21	0.594	0.835	226
31	Nandail	14	12	0.362	0.691	204
32	Trisal	19	15	0.587	0.830	224
33	Atpara	13	11	0.577	0.741	173
34	Barhatta	11	9	0.316	0.644	197
35	Durgapur	19	14	0.540	0.707	146
36	Kalmakanda	14	11	0.620	0.731	122
37	Kendua	15	14	0.437	0.682	186
38	Khaliajuri	16	15	0.093	0.114	102
39	Madan	12	10	0.633	0.781	150
40	Mohanganj	27	15	0.588	0.744	146
41	Netrokona sadar	11	10	0.368	0.645	188
42	Purbadhala	13	11	0.255	0.604	195
43	Jhenaigati	18	13	0.440	0.704	196
44	Nakla	20	12	0.611	0.831	218
45	Nalitabari	15	10	0.330	0.684	207
46	Sherpur sadar	15	10	0.654	0.859	225
47	Sreebardi	10	8	0.485	0.762	210
	Mymensingh region	129	37	0.699	0.840	187

investigation. The highest number of cropping patterns was identified 30 in Pakundia upazila and that was 29 in Baksiganj and Phulpur; 28 in Hossainpur and 27 in Mohanganj (Table 13). The lowest number of cropping patterns was identified 10 in Sreebardi followed by 11 in Barhatta and Netrokona sadar both. The higher number of cropping patterns is generally related to higher level crop diversity indices. The upazilas having lower number of cropping patterns were related to either water logging or discontinuous region occurring as a narrow strip of land at the foot of the northern and eastern hills or both. The lowest diversity index for cropping pattern was recorded 0.103 in Mithamoin followed by 0.191 in Astogram and 0.206 in Itna. The highest value of diversity index for cropping pattern was found 0.847 in Dewanganj upazila that was followed by 0.837 in Bhairab upazila. The calculated diversity indices (CDI) for cropping pattern are presented in Table 13. The lowest CDI was reported 0.111 in Mithamoin followed by 0.114 in Khaliajuri. The highest value of CDI was observed 0.933 in Dewanganj followed by 0.920 in Bhairab upazila. The range of cropping intensity values was recorded 101-249%. The maximum value was for Hossainpur upazila and minimum for Itna and Mithamoin upazilas of Kishoreganj district. As a whole the CDI of Mymensingh region was calculated 0.840 and the average cropping intensity at regional level was 187%. 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). Diversification of crops helps risk reduction as diversification allows a producer to balance low price in one or two crops with reasonable prices in other. (Blade and Slinkard, 2002). In India the farmers of Kerala diversified their cropping pattern to minimize crop failures and price fluctuations (Mahesh, 1999).

CONCLUSION

The cropping intensity of the Mymensingh region was little bit lower than the national average. Boro−Fallow−T. Aman, Single Boro, Mustard−Boro−T. Aman, Boro−Aus− T. Aman, Boro−Jute−T. Aman were the dominant cropping patterns in the region. These scenarios throw a challenge to biodiversity, food and nutritional security for the people of the region. Based on the findings of the study, the following recommendations were made.

- Initiative to be taken to increase productivity of exclusive rice based cropping pattern along with recommended crop management packages.
- Some of the portion of double-rice area could be brought under Mustard-Boro-T. Aman and /or Boro-Jute-T. Aman cropping systems.
- In the single Boro area suitable vegetable might be grown on floating bed system in wet season.
- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.

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

	Cropping pattern	Area (ha)		Cropping pattern	Area (ha)
01	Boro−Fallow− T. Aman	471550	46	Maize−Aus−Fallow	1000
02	Boro−Fallow−Fallow	218650	47	Potato−Fallow− T. Aman	1000
03	Mustard−Boro− T. Aman	22270	48	Wheat−Aus−Fallow	1000
04	Boro−Aus− T. Aman	21750	49	Fallow−Vegetable− T. Aman	980
05	Boro−Jute− T. Aman	18150	50	Onion−Jute− T. Aman	940
06	Fallow−Aus− T. Aman	12110	51	Boro−Vegetable(Float/Norm)	900
07	Mustard−Boro−Fallow	12090	52	Vegetable−Aus−Fallow	900
08	Fallow−Fallow− T. Aman	11180	53	Onion−Vegtab−Vegetable	885
09	Vegetable−Vegetable− T. Aman	8910	54	Potato−Jute−Fallow	810
10	Vegetable−Vegetable−Vegetable	8500	55	Onion−Fallow− T. Aman	805
11	Vegetable−Fallow− T. Aman	7460	56	Lentil−Jute− T. Aman	745
12	Wheat−Jute− T. Aman	7150	57	Wheat−Aus− T. Aman	740
13	Potato−Boro− T. Aman	6080	58	Vegetable−Boro−Fallow	690
14	Fallow−Jute− T. Aman	5540	59	Blackgram−Aus− T. Aman	680
15	Vegetable−Boro− T. Aman	4730	60	Blackgram−Jute− T. Aman	670
16	Vegetable−Vegetable−Fallow	4550	61	Grasspea−Jute−Fallow	660
17	Potato−Jute− T. Aman	4360	62	Garlic−Vegetable−Vegetable	640
18	Maize−Jute−Fallow	3890	63	Garlic−Fallow− T. Aman	610
19	Vegetable−Fallow−Fallow	3630	64	Mustard−Aus− T. Aman	580
20	Chilli−Boro−Jute	3600	65	Mustard−Fallow−Fallow	540
21	Vegetable−Jute− T. Aman	3520	66	Chilli−Vegetable− T. Aman	515
22	Boro−Vegetable− T. Aman	3420	67	Blackgram−Jute−Fallow	500
23	Chilli−Aus−Fallow	2935	68	Boro−Aus−Fallow	500
24	Wheat−Jute−Fallow	2820	69	Vegetable−Boro−Jute	500
25	Sweet potato−Fallow−Fallow	2700	70	Garlic−Jute−Fallow	480
26	Chilli−Jute−Fallow	2670	71	Lentil−Jute−Fallow	470
27	Fallow−Fallow−Blackgram	2400	72	Wheat−Vegetable−Vegetable	460
28	Boro−Jute−Fallow	2330	73	Mustard−Boro−Aus− T. Aman	420
29	Maize−Jute− T. Aman	2220	74	Potato−Aus−Fallow	400
30	Vegetable−Jute−Fallow	2170	75	Maize−Fallow− T. Aman	355
31	Wheat−Fallow− T. Aman	2030	76	Mustard−Fallow− T. Aman	350
32	Chilli−Fallow−Fallow	2000	77	Garlic−Jute− T. Aman	340
33	Groundnut−Fallow−Fallow	1875	78	Potato−Boro−Jute	340
34	Boro−Fallow−Blackgram	1870	79	Groundnut−Jute− T. Aman	330
35	Chilli−Fallow− T. Aman	1840	80	Potato−Chilli−Fallow	330
36	Mustard−Jute− T. Aman	1840	81	Sweet potato−Fallow− T.Aman	310
37	Potato−Boro−Fallow	1770	82	Lentil−Aus− T. Aman	305
38	Onion−Jute−Fallow	1720	83	Sweet potato−Jute−Fallow	300
39	Vegetable−Aus− T. Aman	1350	84	Chilli−Aus− T. Aman	250
40	Chilli−Vegetable−Fallow	1225	85	Wheat−Jute−Blackgram	250
41	Mustard−Jute−Fallow	1210	86	Coriander−Fallow−Fallow	205
42	Potato−Aus− T. Aman	1210	87	Vegetable−Fallow−Blackgram	180
43	Maize−Fallow−Fallow	1160	88	Coriander−Fallow− T. Aman	170
44	Chilli−Jute− T. Aman	1150	89	Coriander−Jute−Fallow	170
45	Potato−Vegetable− T. Aman	1090	90-129	Other 40 patterns (Table 7)	1845