

Diversity of Crops and Land Use Pattern in Barisal Region

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ABSTRACT

Development workers, researchers and extensionists always need a comprehensive understanding and a reliable database on existing cropping patterns, cropping intensity and crop diversity of a particular area for the planning of future research and development. With this view, a survey-work was implemented over all the upazilas of Barisal region during 2016. A pre-tested semi-structured questionnaire was used as tool to document the existing cropping patterns, cropping intensity and crop diversity of the area. In the current investigation, 103 cropping patterns were identified. The highest number of cropping patterns 40 was found in Burhanuddin upazila of Bhola district and the lowest eight was in Betagi and Taltali of Barguna. The most dominant cropping pattern single T. Aman occupied 13.40% of net cropped area (NCA) of the region with its distribution over 33 upazilas out of 42. The second largest area, 10.44% of NCA, was covered by Boro-Fallow-T. Aman, which was spread out over 32 upazilas. The lowest crop diversity index (CDI) was recorded 0.221 in Agailjhara of Barisal district followed by 0.598 in Bhandaria of Pirojpur. The highest value of CDI was observed 0.972 in Charfasson followed by 0.968 in Tazumuddin of Bhola. The range of cropping intensity values was observed 107-249%. The maximum value was for Bhola sadar and minimum for Agailjhara of Barisal. The overall CDI of Barisal region was calculated 0.968 and the grand mean for cropping intensity at regional level was 204%.

Key words: Land use, cropping intensity, cropping pattern, crop diversity and tidal wetland

INTRODUCTION

In Bangladesh a huge number of crops are produced under different cropping patterns with a variability from one region to another. Yearly sequences of crop production in a piece of land in a year is known as cropping pattern (Alam, 1994). Factors such as rainfall, climate, agricultural technology, soil type, insect and disease pressure, availability of irrigation facilities and other inputs, marketing and transport facilities, subsistence pressure and the growth of agro-industries etc changes the cropping pattern (Neena, 1998; Gadge, 2003; Rashid *et al.*, 2005).

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. In the past

Barisal region was known as granary of the state. This region mainly represents tidal wetland ecosystem of both saline and non-saline type. The crop production is restricted due to salinity in some areas during dry season. In the other areas it is affected by daily tide and monsoon tide. River bank erosion, exposure to cyclones and storm surges, risk of heavy late rainfall, torrential rain drip and remoteness of southern parts of the regions from urban markets are the limitation of this area (FAO, 1988). To increase the system productivity of the total environment it needs to bring diversity in enterprises for better utilization of limited resources. Diversified cropping pattern may be the strategic option for the farmers to coping strategy against the risks (Mandal and Bezbaruah, 2013). Typology of different cropping systems is the base for the managers

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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 mal adaption or inequity in the society over long term. An increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In this context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. On the basis of afore-said discussion, the present study was undertaken with the following specific objectives to:

- Understand the existing cropping patterns scenario in Barisal region
- Visualize the existing land use pattern at upazila and regional level
- Determine the crop diversity and cropping intensity at local and regional level.
- Generate bench mark information of crop diversity and land use pattern in Barisal region.

METHODOLOGY

Forty-two upazilas of Barisal, Bhola, Barguna, Patuakhali, Pirojpur and Jhalakati district under Barisal agricultural region were the locale of this study. Data were collected using double stage procedure. At initial stage, data were collected through pretested semi structured questionnaire from 42 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during September 2016 at upazila level. 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 for necessary correction and validation. Second stage of data collection was day-long data validation workshop at district level during 20 to 24 November 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 BRRRI Regional Station, Barisal, participated in the data validation workshop. The number participants of validation workshop ranged from 42 to 94 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).

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

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 Barisal region is 790,470 ha. Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in the region were banana, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 20 to 4,310 ha. The annual crops area accounted only 2.18% of the net cropped area (NCA) in the region. At a glance the region possesses 18.27% single cropped area (SCA), 54.86% double cropped area (DCA), 23.92% triple cropped area (TCA). The SCA had the major share of NCA in Agailjhara of Barisal, Taltali and sadar upazila of Barguna, Kalapara of Patuakhali and Nazirpur and Mathbaria upazilas of Pirojpur district followed by corresponding DCA. Most of the upazilas were dominated by DCA with exceptions in Bhola sadar and Barguna sadar upazila where triple cropped area is dominating (Table 1). The area which could not be defined under SCA, DCA, TCA or QCA was considered as others whose coverage is less than 1% of the NCA. This region mainly represents tidal wetland ecosystem of both saline and non-saline type. The crop production is restricted due to salinity in some area during dry season. In the other area it is affected by daily tide and monsoon tide. River bank erosion, exposure to cyclones and storm surges, risk of heavy late rainfall, torrential rain drip and remoteness of southern parts of the regions from urban markets are the limitation of this area (FAO, 1988). Because of these limiting factors land-use intensity is somewhat lower than that of other regions of the country with favourable environments. Increased use of surface water irrigation might improve the situation to some extent.

Cropping patterns of Barisal

In total 103 cropping patterns were recorded in Barisal region of which 10 cropping patterns with exclusive rice crop covers approximately 36% of the NCA. There were 14 cropping patterns with exclusive non-rice crop covering only around 2% of the NCA. Rest of the NCA

i.e. about 62% area is covered by 79 rice - non rice cropping patterns (Appendix 1).

Sole rice and non-rice cropping patterns at a glance

Table 2 lists 10 cropping patterns where rice was the only crop round the year. It comprises about 36% of the NCA in the region. Among them single rice, double rice and triple rice areas represented around 18%, 17% and 1%, respectively. It reflects the unparallel dominance of rice in the cropping systems in Barisal region. In case of individual pattern single T. Aman has the highest coverage (13.40%) and was recorded in 33 upazilas out of 42. The second dominant pattern Boro-Fallow-T. Aman area occupied 10.21% of NCA, which was reported in 32 upazilas. Fallow-Aus-T. Aman and the single Boro covered 5.44% and 4.44% area with its existence in only 26 and 14 upazilas respectively.

In the current investigation, 14 cropping patterns were identified where only non-rice crops are grown. Among these 14 patterns first nine have been arranged in descending order in Table 3. The rest five patterns with negligible area coverage (Table 7) were arranged with other patterns of different categories. Aggregate of the 14 patterns have had only 2.24% of NCA. In critical comparison it is clear that exclusive rice area is about 16 folds of exclusive non-rice area. Among these 14 patterns, three patterns comprise year-round vegetables distributed over majority of the upazilas. Year-round vegetable production system has occupied about nine-tenths of the non-rice cropping area and mainly practised on or alongside the homestead area.

Pulse crops under cropping systems

Twenty-seven cropping patterns with different pulse crops were found across the region (Table 4). Among them grasspea is covering the largest area whereas blackgram is cultivated in the smallest area. Four main cropping patterns of grasspea jointly cover approximately 17% of NCA. Mungbean holds the second position in pulse crop cultivation in Barisal region. There are two main cropping patterns for

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Agailjhara	15552	180	10100	450	145	0	155	11030	107
02 Babuganj	15247	210	600	8620	2410	0	170	12010	214
03 Bakerganj	40050	700	6150	11420	11100	0	130	29500	214
04 Banaripara	13486	445	2950	2950	1110	0	145	7600	169
05 Barisal sadar	26172	175	4020	14000	915	0	170	19280	183
06 Gournadi	14938	1175	200	7000	2475	0	130	10980	210
07 Hizla	33859	230	750	11300	1040	0	160	13480	200
08 Mehendiganj	41896	500	0	18640	3700	0	160	23000	214
09 Muladi	23050	800	1050	10025	2970	0	155	15000	208
10 Wazirpur	24932	680	7500	7950	310	0	140	16580	152
11 Bhola sadar	41316	230	1300	9870	14050	0	180	25630	249
12 Burhanuddin	28400	230	70	13120	6880	0	130	20430	232
13 Charfasson	144004	4310	5500	41100	26180	0	210	77300	221
14 Daulatkhan	29310	110	1200	6990	5990	0	120	14410	233
15 Lalmohan	39600	130	0	16915	8300	0	135	25480	232
16 Monpura	35300	95	1040	9250	1715	0	130	12230	205
17 Tazumuddin	51931	100	20	7755	2880	0	145	10900	226
18 Amtali	47758	60	1500	12620	9130	0	150	23460	232
19 Bamna	9227	85	1300	2660	2870	0	115	7030	221
20 Betagi	16800	190	600	5700	5750	0	150	12390	241
21 Barguna	38853	175	6100	3370	15220	0	105	24970	236
22 Patharghata	38730	60	1500	12650	3200	0	150	17560	209
23 Taltali	24242	60	8260	4180	1600	0	160	14260	152
24 Jhalakati	21293	1250	2600	8650	2400	0	170	15070	190
25 Kathalia	15747	800	1400	5580	2825	0	145	10750	206
26 Nalchity	21077	600	2040	10600	1040	0	120	14400	189
27 Rajapur	16433	180	4600	5120	1605	0	175	11680	172
28 Bauphal	48185	190	1550	29400	5670	0	180	36990	211
29 Dashmina	30074	220	500	16030	1820	0	150	18720	206
30 Dumki	9513	45	600	5050	1190	0	145	7030	208
31 Galachipa	52614	390	1000	24500	7625	0	175	33690	219
32 Kalapara	49210	20	21300	17725	1200	0	175	40420	150
33 Mirzaganj	17552	120	2400	1640	7310	0	100	11570	242
34 Patuakhali	36014	260	2400	20280	4970	0	150	28060	208
35 Rangabali	48000	100	6200	14625	14250	0	125	35300	223
36 Bhandaria	16356	540	5000	3430	720	0	150	9840	150
37 Kawkhali	7867	150	2100	2260	410	0	130	5050	163
38 Mathbaria	35325	240	9600	9210	1690	0	100	20840	161
39 Nazirpur	24849	300	8355	7735	310	0	100	16800	150
40 Nesarabad	18343	220	4050	5990	615	0	145	11020	166
41 Pirojpur	16387	550	3600	5020	2910	0	120	12200	190
42 Zianagar	9255	130	3400	2280	600	0	120	6530	154
Barisal region		17235	144405	433660	189100	0	6070	790470	204

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Fallow-Fallow- T. Aman	105950	13.40	33
02 Boro-Fallow- T. Aman	80710	10.21	32
03 Fallow-Aus- T. Aman	43000	5.44	26
04 Boro-Fallow-Fallow	35100	4.44	14
05 Boro-Aus- T. Aman	10230	1.29	6
06 Fallow-B.Aus+B.Aman	2570	0.33	3
07 Fallow-B.Aman	1950	0.25	4
08 Boro-B.Aman	1870	0.24	5
09 Boro-Aus-Fallow	1190	0.15	2
10 Fallow-Aus-Fallow	330	0.04	1
Total	282900	35.79	

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	8555	1.08	21
02 Vegetab-Vegetab-Fallow	7450	0.94	16
03 Grasspea-Jute-Fallow	400	0.05	1
04 Coriander-Vegetab-Fallow	350	0.04	3
05 Coriander-Fallow-Fallow	280	0.35	6
06 Chilli-Vegetab-Fallow	230	0.03	2
07 Vegetab-Jute-Fallow	170	0.02	2
08 S.Potato-Fallow-Fallow	60	0.01	1
09 Vegetab-Fallow-Fallow	60	0.01	2
10-14 Other five patterns (in Table 7)	160	0.02	-
Total	17715	2.24	

Table 4. Area for pulse crops under different cropping systems in Barisal region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mungbean-Fallow- T. Aman	83770	10.60	35
02 Grasspea-Fallow- T. Aman	66030	8.35	33
03 Grasspea-Aus- T. Aman	63140	7.99	39
04 Mungbean-Aus- T. Aman	45640	5.77	28
05 Felon-Fallow- T. Aman	16275	2.06	15
06 Felon-Aus- T. Aman	4200	0.53	5
07 Lentil-Fallow- T. Aman	3950	0.50	25
08 Chickpea-Fallow-T. Aman	2445	0.31	19
09 Grasspea-Jute- T. Aman	2250	0.28	5
10 Lentil-Jute- T. Aman	1260	0.16	6
11 Lentil-Aus- T. Aman	1090	0.14	12
12 Grasspea-Jute-Fallow	400	0.05	1
13 Chickpea-Aus-T. Aman	340	0.04	4
14 Blackgram-Jute- T. Aman	220	0.03	1
15-27 Other 13 patterns (in Table 7)	735	0.09	-
Total pulse crops	291745	36.90	

mungbean viz Mungbean-Fallow-T. Aman and Mungbean-Aus- T. Aman. These two patterns in-together occupy over 16% of NCA. In the documentation of pulse cropping systems adoption of grasspea was dominant across the region hence proved its widest adaptability. One pattern is available in 39 upazilas and the other exists in 33 upazilas. Finally the aggregate area of the pulse cropping system stands for about 37% of the NCA in Barisal region. In the tidal wetland ecosystem surface water for irrigation is not sufficient or limited access. Groundwater from shallow tubewell is mostly saline in nature. Deep tubewell is not available in the area. For all the said factors Boro can not be cultivated normally. Moreover, most of the T. Aman cultivars are local type and of photoperiod sensitive in nature which cause the late harvest of the crop. In that case most of the Rabi crops can not suit for plantation. Among the rabi crops stress-tolerant grasspea can easily be grown as relay system. The mungbean is a short duration mild drought and salt-tolerant crop with photo-insensitive in nature. With all these advantages grasspea and mungbean are extensively cultivated in the area (FAO, 1988).

Oil-seed crops under cropping systems

Groundnut is the most important one among the oil-seed crops in Barisal region. There are 21 cropping patterns for oil-seed crops among which only two patterns had been led by groundnut, however it is spread over 26 upazilas in the region (Table 5). The total share of oil-seed cropping patterns is about 6% of NCA whereas groundnut alone occupies 2.55%. Mustard covers over 1%. However, the highest number of the oil-seed cropping patterns are led by mustard and it is distributed in 23 out of 42 upazilas in the region.

Vegetables and spices crops

There are 39 cropping patterns arranged in descending order according to area coverage (Table 6). Potato and other vegetables of Rabi, Kharif-I and Kharif-II; spices viz chilli, onion, garlic, coriander are included in this list. The most dominant cropping pattern is Chilli-Fallow- T. Aman covering 3.50% of NCA which is distributed over 36 upazilas. The second one is Vegetables-Fallow- T. Aman covering 1.98% of NCA and it is recorded in 32 upazilas out of 42. The aggregated area allotted for vegetables and spices crops was 94,285 hectares that is equivalent to 11.93% of NCA in the region. The main spices crop is chilli which was grown in

Table 5. Area for oil-seed crops under different cropping systems in Barisal region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Groundnut-Fallow- T. Aman	14665	1.86	26
02 Sesame-Fallow- T. Aman	6560	0.83	14
03 Groundnut- Aus- T. Aman	5485	0.69	8
04 Soybean-Fallow- T. Aman	4600	0.58	3
05 Mustard-Boro- T. Aman	2640	0.33	4
06 Mustard-Aus- T. Aman	2510	0.32	10
07 Mustard-Fallow- T. Aman	2155	0.27	23
08 Sunflower-Fallow- T. Aman	1610	0.20	12
09 Soybean-B.Aman	800	0.10	2
10 Sesame-Aus- T. Aman	720	0.09	4
11 Mustard-Jute- T. Aman	610	0.08	4
12 Mustard-Sesame- T. Aman	560	0.07	2
13 Soybean-Jute- T. Aman	530	0.07	3
14 Fallow-Sesame- T. Aman	490	0.06	4
15 Soybean-Aus- T. Aman	470	0.06	2
16 Potato-Sesame- T. Aman	380	0.05	5
17-21 Other five patterns (in Table 7)	405	0.05	-
Total oil-seed crops	45190	5.72	

Table 6. Vegetables and spices crops under different cropping patterns in Barisal region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Freq. (no. of upazila)
01 Chilli-Fallow- T. Aman	27700	3.50	36
02 Vegetab-Fallow- T. Aman	15640	1.98	32
03 Vegetab-Vegetab- T. Aman	9040	1.14	21
04 Vegetab-Vegetab-Vegetab	8555	1.08	21
05 Vegetab-Vegetab-Fallow	7450	0.94	16
06 Chilli-Aus- T. Aman	7040	0.89	13
07 Potato-Fallow- T. Aman	4620	0.58	25
08 Potato-Aus- T. Aman	4400	0.56	10
09 Vegetab-Aus- T. Aman	3810	0.48	13
10 Potato-Vegetab- T. Aman	750	0.09	7
11 Coriander-Fallow- T. Aman	615	0.08	15
12 Potato-Boro- T. Aman	520	0.07	3
13 Onion-Aus- T. Aman	455	0.06	8
14 Garlic-Aus- T. Aman	445	0.06	8
15 Garlic-Fallow- T. Aman	430	0.05	13
16 Potato-Sesame- T. Aman	380	0.05	5
17 Coriander-Vegetab-Fallow	350	0.04	3
18 Coriander-Fallow-Fallow	280	0.04	6
19 Onion-Fallow- T. Aman	270	0.03	14
20 Fallow-Vegetab- T. Aman	260	0.03	2
21 Chilli-Vegetab-Fallow	230	0.03	2
22-39 Other 18 patterns (in Table 7)	1045	0.13	-
Total for vegetables and spices crops	94285	11.93	

an area of 35,000 ha (4.43% of NCA). Probably two congenial 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 which were extremely location-specific, however, with a large area coverage. These are Soybean-Fallow- T. Aman (Table 5); Fallow-B. Aus+B. Aman and Boro-Aus-Fallow (Table 2). Area coverage of Soybean-Fallow- T. Aman was 4,600 hectares that distributed in Hizla (2,700 ha), Mehendiganj (500 ha) of Barisal district and in Tazumuddin (1,400 ha) in Bhola district. Fallow-B. Aus+B. Aman is limited to three upazilas viz Nesarabad (2,300 ha), Nazirpur (250 ha) and Kawkhali (20 ha) of Pirojpur district. Boro-Aus-Fallow is available in Nazirpur (1,100 ha) of Pirojpur and Agailjhara (90 ha) of Barisal district.

Rare cropping patterns

In the present investigation, 34 cropping patterns have been identified as rare with a negligible area coverage with seldom existence (Table 7). These are location specific system and are limited in one to four upazilas of the region. Total area coverage of these 34 patterns is only 0.28% of NCA. Among these the highest area was occupied by Mustard-Mungbean-T. Aman (185 ha) and it is recorded in three upazilas viz Babuganj of Barisal, Burhanuddin of Bhola and Dashmina upazila of Patuakhali district. The smallest area was recorded for Lentil-Mungbean-T. Aman whose coverage was five hectares only (Table 7).

Most dominant cropping pattern

Single T. Aman was the most dominant cropping pattern in Barisal region. It covers 13.70% of NCA in the region and is available in 33 upazilas out of 42 (Table 8). The highest area under this cropping was recorded 21,300 hectares in Kalapara upazila of Patuakhali

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

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Mustard-Mung T. Aman	185	0.02	3	Babuganj+Borhan.+Dashmina
02	Vegetab-Jute-Fallow	170	0.02	2	Banaripara+Ujirpur
03	Boro-Jute-Fallow	160	0.02	1	Agailjhara
04	Grasspea-B.Aus+B.Aman	150	0.02	1	Nesarabad
05	Maize-Aus- T. Aman	130	0.02	4	Bhola+Boran+Kalapara+Zianagar
06	Potato-Jute- T. Aman	110	0.01	1	Babuganj
07	Boro-Vegetab(Float/Norm)	100	0.01	1	Ujirpur
08	Lentil-Sesame- T. Aman	100	0.01	1	Jhalkathi
09	Onion-Jute- T. Aman	85	0.01	2	Muladi
10	Coriander-Sesame- T. Aman	80	0.01	1	Bhola
11	Millet(<i>kaon</i>)-F- T. Aman	80	0.01	2	Hijla
12	Coriander-Jute- T. Aman	70	0.01	2	Gournadi+Muladi
13	S.Potato-Fallow-Fallow	60	0.01	1	Taltoli
14	S.Potato-Jute- T. Aman	60	0.01	2	Babuganj+Gournadi
15	Vegetab-Fallow-Fallow	60	0.01	2	Monpura+Tajumuddin
16	Blackgram-Aus- T. Aman	55	0.01	3	Gournadi+Muladi+Kalapara
17	Garlic-Jute- T. Aman	50	0.01	1	Muladi
18	Garlic-Vegetab-Vegetab	50	0.01	3	Borhan+Najirpur+Nesarabad
19	Grasspea-Mung- T. Aman	50	0.01	1	Dumki
20	Lentil-Vegetab- T. Aman	50	0.01	1	Jhalkathi
21	Onion-Vegetab-Vegetab	50	0.01	3	Borhan+Najirpur+Nesarabad
22	Lentil-Vegetab-Vegetab	40	0.01	1	Bhola
23	Grasspea-Sesame- T. Aman	30	0.00	1	Gournadi
24	Potato-Maize- T. Aman	30	0.00	1	Najirpur
25	Potato-Mungbean- T. Aman	30	0.00	1	Najirpur
26	Potato-S.gourd-Aus	30	0.00	1	Borhanuddin
27	Chilli-Vegetab- T. Aman	20	0.00	1	Borhanuddin
28	Mungbean-B.Aus+B.Aman	20	0.00	1	Nesarabad
29	Chilli-Jute- T. Aman	10	0.00	1	Gournadi
30	Mungbean-Jute- T. Aman	10	0.00	1	Gournadi
31	Mustard-Fallow-Fallow	10	0.00	1	Nesarabad
32	Pea-Fallow- T. Aman	10	0.00	2	Muladi+Kathatoli
33	Potato-Jute-Fallow	10	0.00	1	Gournadi
34	Lentil-Mungbean- T. Aman	5	0.00	1	Dumki
	Total	2160	0.28		

district. This area is 53.12% of the NCA in that Kalapara upazila. In another consideration it occupies 20.10% of total Fallow-Fallow-T. Aman area of the region. Taltali upazila of Barguna district has allocated its highest area for the single T. Aman pattern and it is 57.50% of its NCA. However, in respect of total region, this upazila had hold the 3rd position in the area coverage for this pattern. Soil salinity is a constraint for the cultivation of Boro rice and Rabi crops in Kalapara, Mathbaria, Taltali and

other saline-prone area. A large area of this pattern is distributed on the *charland* 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 third dominant cropping pattern in Bangladesh

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

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Kalapara	21300	53.12	20.10
02 Mathbaria	9200	44.35	8.68
03 Taltali	8200	57.50	7.74
04 Rangabali	6200	18.18	5.85
05 Barguna	6100	24.42	5.76
06 Bakerganj	6000	20.34	5.66
07 Charfasson	5000	6.58	4.72
08 Bhandaria	5000	50.81	4.72
09 Rajapur	4600	39.36	4.34
10 Zianagar	3400	52.00	3.21
11 Barisal sadar	3300	17.09	3.11
12 Pirojpur	3000	24.54	2.83
13 Mirzaganj	2400	20.73	2.27
14 Patuakhali sadar	2400	20.73	2.27
15 Kawkhali	2100	41.53	1.98
16 Nesarabad	1800	17.03	1.70
17 Jhalakati	1700	11.28	1.60
18 Amtali	1500	6.39	1.42
19 Patharghata	1500	8.54	1.42
20 Kathalia	1400	13.02	1.32
21 Bamna	1300	18.48	1.23
22 Daulatkhan	1200	8.95	1.13
23 Bauphal	1200	3.24	1.13
24 Monpura	1000	8.16	0.94
25 Galachpipa	1000	3.04	0.94
26 Muladi	700	4.66	0.66
27 Hizla	630	4.75	0.59
28 Betagi	600	4.84	0.57
29 Dumki	600	8.49	0.57
30 Banaripara	500	6.61	0.47
31 Nalchity	500	3.49	0.47
32 Dashmina	500	2.67	0.47
33 Nazirpur	120	0.76	0.11
Barisal region	105950	13.70	100.00

covering 5.09 lac ha (6% of NCA in the country) with its distribution in 162 upazilas of 32 districts (Nasim *et al.*, 2017).

Second dominant cropping pattern

The second dominant cropping pattern in Barisal region is Mungbean-Fallow- T. Aman. It belongs to 10.60% of NCA of the region and spread in 35 upazilas (Table 9). Bauphal upazila of Patuakhali district holds the highest area (15,000 ha) under this cropping followed by Dashmina upazila (10,300 ha) of the same district. These two upazilas jointly contribute

30.21% share of Mungbean-Fallow- T. Aman cropping area in the region. Monpura upazila of Bhola district stands in the fifth position, however, this upazila has allocated maximum share (60%) of its NCA.

Third dominant cropping pattern

Boro-Fallow- T. Aman cropping pattern holds the third largest area coverage 80,710 ha in Barisal region. This area is an equivalent to 10.21% of NCA in the region. However, this pattern is widely distributed over 32 upazilas of Barisal region. Among these upazilas

Table 9. Distribution of the 2nd dominant cropping pattern Mungbean–Fallow– T. Aman in Barisal region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Bauphal	15000	40.76	17.91
02 Dashmina	10300	55.68	12.30
03 Patuakhali sadar	10000	35.97	11.94
04 Patharghata	8500	48.57	10.15
05 Monpura	7300	60.08	8.71
06 Charfasson	6000	8.23	7.16
07 Galachipa	5100	15.32	6.09
08 Babuganj	3600	30.51	4.30
09 Amtali	2820	12.05	3.37
10 Barisal sadar	2450	12.83	2.92
11 Rangabali	2000	5.68	2.39
12 Dumki	1700	24.29	2.03
13 Tazumuddin	1100	10.19	1.31
14 Muladi	850	5.99	1.01
15 Bakerganj	800	2.78	0.95
16 Mehendiganj	700	3.11	0.84
17 Bhola sadar	600	2.36	0.72
18 Kalapara	600	1.49	0.72
19 Dualatkhan	500	3.50	0.60
20 Lalmohan	500	1.97	0.60
21 Taltali	500	3.52	0.60
22 Hizla	480	3.62	0.57
23 Wazirpur	400	2.52	0.48
24 Barguna sadar	400	1.61	0.48
25 Kathalia	300	3.02	0.36
26 Gournadi	220	2.24	0.26
27 Jhalakati	200	1.45	0.24
28 Nalchity	200	1.45	0.24
29 Mirzaganj	200	1.75	0.24
30 Rajapur	180	1.57	0.21
31 Nazirpur	120	0.73	0.14
32 Burhanuddin	50	0.25	0.06
33 Bhandaria	50	0.54	0.06
34 Kawkhali	30	0.61	0.04
35 Zianagar	20	0.31	0.02
Barisal region	83770	10.60	100.00

Lalmohan of Bhola has the biggest area of 9,200 ha for the pattern, which stands for 11.40% of the total area under this pattern in the region (Table 10). Gournadi upazila of Barisal district ranks in sixth position for Boro–Fallow–T. Aman, however, this upazila has allotted the biggest share (53.06%) of its NCA. Here it is clear that Barisal region is quite different than national level. 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).

Fourth dominant cropping pattern

Fourth dominant cropping pattern Grasspea–Fallow– T. Aman has occupied 65,960 hectares representing 8.34% share of NCA in Barisal region (Table 11). This pattern is widely distributed over 32 upazilas where Mathbaria of Pirojpur district ranked in top position. This

Table 10. Distribution of the 3rd dominant cropping pattern Boro-F- T. Aman in Barisal region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Lalmohan	9200	36.29	11.40
02 Charfasson	9000	12.35	11.15
03 Burhanuddin	8450	41.83	10.47
04 Mehendiganj	6000	26.67	7.43
05 Wazirpur	5800	36.48	7.19
06 Gournadi	5200	53.06	6.44
07 Daulatkhan	4500	31.47	5.58
08 Bhola sadar	3600	14.17	4.46
09 Barisal sadar	3500	18.32	4.34
10 Jhalakati	3000	21.74	3.72
11 Nazirpur	2800	16.97	3.47
12 Hizla	2600	19.62	3.22
13 Banaripara	2550	35.66	3.16
14 Muladi	2400	16.90	2.97
15 Nalchity	2200	15.94	2.73
16 Pirojpur sadar	2000	17.17	2.48
17 Bakerganj	1800	6.25	2.23
18 Babuganj	1200	10.17	1.49
19 Tazumuddin	900	8.33	1.12
20 Mathbaria	900	4.37	1.12
21 Nesarabad	800	7.41	0.99
22 Bauphal	500	1.36	0.62
23 Galachipa	400	1.20	0.50
24 Barguna	350	1.41	0.43
25 Dashmina	350	1.89	0.43
26 Kathalia	200	2.01	0.25
27 Kalapara	200	0.50	0.25
28 Rangabali	200	0.57	0.25
29 Rajapur	50	0.43	0.06
30 Dumki	20	0.29	0.02
31 Bhandaria	20	0.22	0.02
32 Zianagar	20	0.31	0.02
Barisal region	80710	10.21	100.00

upazila has 6,200 ha area for Grasspea-Fallow-T. Aman which is 29.89% of its NCA and it is the highest share among all the upazilas.

Fifth dominant cropping pattern

The fifth dominant cropping pattern Grasspea-Aus-T. Aman had been covering 63,140 hectares representing 7.99% share of NCA in Barisal region (Table 12). This pattern also is widely distributed over 32 upazilas where Barguna sadar ranked in top position. This upazila had 10,200 ha area for Grasspea-Aus-T. Aman pattern which represented 41.13% of upazila NCA. Mirzaganj upazila had the 3rd

largest area 5,000 ha for this cropping, however, this upazila had the biggest share (43.67%) of its NCA.

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 103 cropping patterns were identified in the whole area of Barisal region under this investigation. The highest number of cropping patterns was identified 40 in Burhanuddin upazila of Bhola district followed by 37 in Bhola sadar upazila;

and 32 in Hizla and Mehendiganj of Barisal district (Table 13). In contrast, the lowest number of cropping patterns was identified 8 in Betagi and Taltoli followed by 10 in Patharghata of Barguna district. The higher 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. The lowest diversity index for cropping pattern was recorded 0.152 in Agailjhara of Barisal followed by 0.598 in Taltali of Barguna. In a study Shahidullah *et al.* (2006) also found lowest values for all the diversity

and intensity parameters in salt affected area of greater Noakhali. The highest value of diversity index for cropping patterns was found 0.937 in Charfason upazila that was followed by 0.926 in Tazumuddin upazila of Bhola. The lowest CDI was reported 0.221 in Agailjhara followed by 0.598 in Bhandaria. The highest value of CDI was observed 0.972 in Charfason followed by 0.968 in Tazumuddin upazila. Diversified cropping pattern may enabled 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

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

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Mathbaria	6200	29.89	9.39
02 Patuakhali sadar	5200	18.55	7.88
03 Kalapara	5100	12.72	7.72
04 Bauphal	4500	12.15	6.82
05 Mehendiganj	4200	18.22	6.36
06 Barisal sadar	4000	20.71	6.06
07 Muladi	3600	23.98	5.45
08 Taltali	3400	23.84	5.15
09 Patharghata	3100	17.65	4.69
10 Lalmohan	2900	11.38	4.39
11 Betagi	2800	22.60	4.24
12 Babuganj	2500	20.80	3.79
13 Hizla	2300	17.35	3.48
14 Amtali	2300	9.80	3.48
15 Galachpipa	2000	6.09	3.03
16 Dumki	1700	24.06	2.57
17 Bhandaria	1600	16.26	2.42
18 Tazumuddin	1500	13.66	2.27
19 Rajapur	1200	10.27	1.82
20 Katahalia	900	8.37	1.36
21 Nalchity	750	5.24	1.14
22 Nazirpur	700	4.46	1.06
23 Jhalakati	650	4.31	0.98
24 Dashmina	600	3.20	0.91
25 Daulatkhan	400	2.98	0.61
26 Bamna	400	5.69	0.61
27 Wazirpur	300	1.81	0.45
28 Monpura	300	2.45	0.45
29 Gournadi	260	2.68	0.39
30 Zianagar	250	3.82	0.38
31 Kawkhali	200	3.95	0.30
32 Burhanuddin	150	0.86	0.23
Barisal region	65960	8.34	100.00

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

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Barguna	10200	41.13	16.15
02 Bakerganj	9000	31.25	14.25
03 Mirzaganj	5000	43.67	7.92
04 Charfasson	3700	5.08	5.86
05 Betagi	3000	24.59	4.75
06 Rangabali	3000	8.52	4.75
07 Amtali	2600	11.11	4.12
08 Pirojpur	2600	22.32	4.12
09 Bhola sadar	2500	9.84	3.96
10 Kathalia	2000	20.10	3.17
11 Bauphal	1900	5.16	3.01
12 Muladi	1750	12.32	2.77
13 Taltali	1600	11.27	2.53
14 Lalmohan	1500	5.92	2.38
15 Bamna	1400	20.14	2.22
16 Patharghata	1400	8.00	2.22
17 Daulatkhan	1200	8.39	1.90
18 Mehendiganj	1000	4.44	1.58
19 Galachipa	1000	3.00	1.58
20 Patuakhali sadar	1000	3.60	1.58
21 Nalchity	700	5.07	1.11
22 Jhalakati	650	4.71	1.03
23 Dashmina	600	3.24	0.95
24 Burhanuddin	550	2.72	0.87
25 Dumki	500	7.14	0.79
26 Kawkhali	400	8.16	0.63
27 Zianagar	350	5.47	0.55
28 Hizla	300	2.26	0.48
29 Bhandaria	300	3.23	0.48
30 Mathbaria	300	1.46	0.48
31 Gournadi	200	2.04	0.32
32 Tazumuddin	200	1.85	0.32
33 Rajapur	200	1.74	0.32
34 Monpura	150	1.23	0.24
35 Babuganj	120	1.02	0.19
36 Wazirpur	110	0.69	0.17
37 Kalapara	100	0.25	0.16
38 Nazirpur	30	0.18	0.05
39 Nesarabad	30	0.28	0.05
Barisal region	63140	7.99	100.00

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

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Agailjhara	11	13	0.152	0.221	107
02 Babuganj	21	19	0.842	0.928	214
03 Bakerganj	19	15	0.836	0.916	214
04 Banaripara	20	17	0.767	0.859	169
05 Barisal sadar	22	14	0.865	0.927	183
06 Gournadi	22	16	0.706	0.845	210
07 Hizla	32	17	0.875	0.936	200
08 Mehendiganj	32	19	0.877	0.944	214
09 Muladi	28	16	0.889	0.943	208
10 Wazirpur	18	14	0.669	0.799	152
11 Bhola sadar	37	18	0.827	0.917	249
12 Burhanuddin	40	22	0.706	0.870	232
13 Charfasson	26	17	0.937	0.972	221
14 Daulatkhan	25	15	0.847	0.936	233
15 Lalmohan	24	17	0.833	0.934	232
16 Monpura	16	16	0.625	0.816	205
17 Tazumuddin	31	18	0.926	0.968	226
18 Amtali	15	13	0.887	0.950	232
19 Bamna	18	14	0.840	0.927	221
20 Betagi	08	05	0.821	0.917	241
21 Barguna	15	11	0.745	0.884	236
22 Patharghata	10	09	0.712	0.865	209
23 Taltali	08	08	0.598	0.786	152
24 Jhalakati	26	18	0.909	0.953	190
25 Kathalia	24	13	0.862	0.928	206
26 Nalchity	23	17	0.833	0.906	189
27 Rajapur	23	15	0.784	0.902	172
28 Bauphal	27	16	0.801	0.907	211
29 Dashmina	27	11	0.680	0.846	206
30 Dumki	24	13	0.858	0.931	208
31 Galachipa	28	17	0.918	0.965	219
32 Kalapara	31	19	0.662	0.821	150
33 Mirzaganj	20	16	0.736	0.878	242
34 Patuakhali	21	15	0.812	0.912	208
35 Rangabali	18	13	0.836	0.925	223
36 Bhandaria	21	09	0.490	0.598	150
37 Kawkhali	15	07	0.704	0.764	163
38 Mathbaria	21	17	0.707	0.768	161
39 Nazirpur	34	21	0.702	0.717	150
40 Nesarabad	21	13	0.852	0.915	166
41 Pirojpur	14	08	0.838	0.912	190
42 Zianagar	17	11	0.648	0.810	154
Barisal region	103	32	0.931	0.968	204

and sorghum had almost disappeared and there is reduced varietal diversification in rice and wheat. Crop diversification index of wheat-rice system has 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 (Tscharntke *et al.*, 2005, 2007). The range of cropping intensity values was recorded 107-249%. The maximum value was for Bhola sadar upazila of Barisal district and minimum for Agailjhrara upazila of Barisal

district. As a whole the CDI of Barisal region was calculated 0.968 and the average cropping intensity at regional level was 204%. 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).

CONCLUSION

The cropping intensity of the Barisal region was very close to the national average. Single T. Aman, single Boro, Mungbean-Fallow-T. Aman, Boro-Fallow-T. Aman were the dominant cropping patterns in the region. Exclusive rice area is about 16 folds of exclusive non-rice area. The non-rice based cropping patterns were found few, however, its abundance is bigger than that of Sylhet, Chittagong and Khulna region over all. 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. High yielding salt tolerant rice varieties along with recommended crop management packages to be adopted. Several upazilas have unique or exceptional cropping patterns with large area coverage. Those might be studied in-depth to extrapolate to similar environments. Effort should be given so that a portion of single T. Aman area could be shifted to Mungbean-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 Barisal region, 2014-15.

	Cropping pattern	Area (ha)		Cropping pattern	Area (ha)
01	Fallow-Fallow- T. Aman	105950	36	Mustard-Fallow- T. Aman	2155
02	Mungbean-Fallow- T. Aman	83770	37	Fallow-B.Aman	1950
03	Boro-Fallow- T. Aman	80710	38	Muskmelon-F- T. Aman	1935
04	Grasspea-Fallow- T. Aman	66030	39	Boro-B.Aman	1870
05	Grasspea-Aus- T. Aman	63140	40	Sunflower-F- T. Aman	1610
06	Mungbean-Aus- T. Aman	45640	41	Maize-Fallow- T. Aman	1270
07	Fallow-Aus- T. Aman	43000	42	Lentil-Jute- T. Aman	1260
08	Boro-Fallow-Fallow	35100	43	Boro-Aus-Fallow	1190
09	Chilli-Fallow-T.Aman	27700	44	Lentil-Aus- T. Aman	1090
10	W.Melon-Fallow- T. Aman	22230	45	Soybean-B.Aman	800
11	Felon-Fallow- T. Aman	16275	46	Potato-Vegetab- T. Aman	750
12	Vegetab-Fallow- T. Aman	15640	47	Sesame-Aus- T. Aman	720
13	Groundnut-F- T. Aman	14665	48	Coriander-F- T. Aman	615
14	S.Potato-Fallow- T. Aman	10250	49	Mustard-Jute- T. Aman	610
15	Boro-Aus- T. Aman	10230	50	Mustard-Sesame- T.Aman	560
16	W.Melon-Aus- T. Aman	10100	51	Soybean-Jute- T. Aman	530
17	Vegetab-Vegetab- T. Aman	9040	52	Potato-Boro- T. Aman	520
18	Vegetab-Vegetab-Vegetab	8555	53	Fallow-Sesame- T. Aman	490
19	Vegetab-Vegetab-Fallow	7450	54	Soybean-Aus- T. Aman	470
20	Chilli-Aus- T. Aman	7040	55	Onion-Aus- T. Aman	455
21	Sesame-Fallow- T. Aman	6560	56	Garlic-Aus- T. Aman	445
22	Groundnut- Aus- T. Aman	5485	57	Garlic-Fallow- T. Aman	430
23	Wheat-Fallow- T. Aman	4640	58	Grasspea-Jute-Fallow	400
24	Potato-Fallow- T. Aman	4620	59	Fallow-Jute- T. Aman	390
25	Soybean-Fallow- T. Aman	4600	60	Potato-Sesame- T. Aman	380
26	Potato-Aus- T. Aman	4400	61	Coriander-Vegetab-F	350
27	Felon-Aus- T. Aman	4200	62	Chickpea-Aus-T. Aman	340
28	Lentil-Fallow- T. Aman	3950	63	Fallow-Aus-Fallow	330
29	Vegetab-Aus- T. Aman	3810	64	Coriander-Fallow-Fallow	280
30	Mustard-Boro- T. Aman	2640	65	Onion-Fallow- T. Aman	270
31	Fallow-B.Aus+B.Aman	2570	66	Fallow-Vegetab- T. Aman	260
32	Mustard-Aus- T. Aman	2510	67	Chilli-Vegetab-Fallow	230
33	Chickpea-Fallow-T. Aman	2445	68	Blackgram-Jute- T. Aman	220
34	Wheat-Aus- T. Aman	2410	69	Wheat-Jute- T. Aman	220
35	Grasspea-Jute- T. Aman	2250	70-103	Other 34 patterns (Table 7)	2160