

Cropping Systems and their Diversity in Khulna Region

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ABSTRACT

This study includes the existing cropping pattern, cropping intensity and crop diversity of Khulna region. A pre-designed and pre-tested semi-structured questionnaire was used to collect the information and validated through organizing workshop. Single T. Aman cropping pattern was the most dominant cropping pattern in Khulna region existed in 17 out of 25 upazilas. Boro-Fallow-T. Aman cropping pattern ranked the second position distributed almost in all upazilas. Boro-Fish was the third cropping pattern in the region distributed to 17 upazilas with the major share in Chitalmari, Dumuria, Rupsha, Tala, Kalaroa, Mollahat, Terokhada, Bagerhat sadar, Fakirhat, Rampal and Phultala upazilas. Single Boro rice was recorded as the fourth cropping pattern covered 18 upazilas with the higher share in waterlogged area of Dumuria, Mollahat, Tala, Bagerhat sadar, Fakirhat and Rampal. The highest number of cropping patterns was recorded in Kalaroa (26) followed by Tala (24) and the lowest was reported in Mongla (5). The overall crop diversity index (CDI) for the region was 0.93. The highest CDI was in Tala (0.95) and the lowest in Dacope (0.42). The average cropping intensity (CI) of the Khulna region was 171% with the lowest in Mongla (101%) and the highest in Kalaroa (224%).

Key words: Cropping intensity, diversity index, land use, rice-fish, and soil salinity

INTRODUCTION

Large number of crops are grown under different cropping pattern in different parts of Bangladesh with a variability from a region to another. Greater Khulna consists of both saline and non-saline ecosystems. Agriculture of this region is mainly dominated by rice and fish (shrimp and others). Year round vegetable cultivation as a dyke cropping is also frequently observed in Rice-Fish system for both ecosystems.

A cropping pattern is defined as yearly sequences of crop production in a piece of land (Alam, 1994). It depends on physical, historical, social, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The cropping pattern and the changes therein depend on a large number of factors like climate, soil type, rainfall, pest pressure, availability of technologies; availability of irrigation facilities and other inputs, marketing

and transport facilities, subsistence pressure and the growth of agro-industries (Neema, 1998; Gadge, 2003; Rashid *et al.*, 2005).

The coastal 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 Master Plan for Agricultural Development in the Southern Region of Bangladesh focused on increasing agricultural productivity and improving water management and rejuvenating productivity of degraded lands (MoA and FAO, 2013). Agricultural land use in the coastal districts is very poor. The average cropping intensity of the country was 179% in 2007-08, whereas it is 128-147% in southern districts (BBS, 2014). The major part of this region is affected by different gradient of salinity. The low land use in the region is mainly due to salinity and peculiar hydrology, waterlogging in Kharif II and early Rabi season and lack of quality irrigation water

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(drought) in Rabi and Kharif I seasons, and tidal storm (Rahman and Ahsan, 2011). The south-western part, Khulna, Bagerhat and Satkhira districts are the worst hit by water and soil salinity (SRDI, 2010). The stress environment of the southern part 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 saline lands for increased production of crops. Moreover, cultivable land area is decreasing day by day in the country. In this context, there is no other alternative but to address less favourable and unfavourable environments for food security and to adapt to the climatic variability.

The increased total system productivity of an environment needs diversity in enterprises for better utilization of limited resources. A detail information on land situation and cropping systems is a pre-requisite for a fruitful development programme. The Directorate of Agricultural Extension maintains a statistics on individual crop at upazila level. However, there is limited information on cropping pattern and cropping intensity at upazila and regional level. Understanding the present scenario of cropping patterns of a particular area may guide policy makers, researchers and extension personnel for 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 specific objectives of the study were to:

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

METHODOLOGY

Twenty-five upazilas of Khulna, Satkhira and Bagerhat districts under Khulna 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 January 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 Directorate 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. The workshop dates were 29 March for Khulna; 31 March for Bagerhat; and 11 April 2016 for Satkhira. 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 BIRRI regional station, Satkhira participated in the data validation workshop. The number of participants of validation workshop ranged from 58 to 95 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFS scientists to finalize and validate the data and authenticated data were captured. Crop diversity index was calculated by using the following equation described by Kshirsagar *et al.* (1997).

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

Where, CDI_i = Crop Diversity Index

a_{ij} = Area planted to the j^{th} crop in the i^{th} location

A_i = Total area planted under all crops

The index is zero for a land area growing only one crop approaches unity as the level of diversity increase. 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

Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in the region were sugarcane, banana and papaya. The annual crops area in different upazilas ranged nil to 870 ha. The annual crops area accounted only 1.75% of the net cropped area (NCA) in the region. The single cropped area (SCA) had the major share of NCA in Mongla, Morrelganj, Rampal and sadar upazila of Bagerhat district; Dacope and Koyra upazilas of Khulna district and Shyamnagar upazila of Satkhira district followed by corresponding double cropped area (DCA). The rest of the upazilas were dominated by DCA (Table 1). The proportion of triple cropped area (TCA) were higher than SCA in Debhata, Kalaroa and sadar upazilas of Satkhira district. The quadruple cropped area was only reported in Kalaroa upazila. The SCA, DCA, TCA in the region were 36.4%, 51.4% and 9.6% of the NCA. The area which could not be defined under SCA, DCA, TCA or QCA was considered as other. The average cropping intensity (CI) of the Khulna region was 171% with the lowest in Mongla (101%) and the highest in Kalaroa (224%).

Cropping patterns of Khulna

In total 92 cropping patterns were observed in Khulna region of which nine cropping patterns

with exclusive rice crop covers about 63% of the NCA. There were 16 cropping patterns with exclusive non-rice crop covering over 4% of the NCA. Rest of the NCA i.e. around 33% area is covered by 67 rice - non rice cropping patterns (Appendix 1).

Exclusive rice crops

In Khulna region, most of the area (about 63%) was covered by exclusively rice-based cropping pattern (Table 2). The highest area coverage (26.76%) was occupied by single T. Aman cropping pattern and was reported in 17 upazilas out of 25. Boro-Fallow- T. Aman cropping pattern covered 22.21% area which was next to single T. Aman cropping pattern but existed in the highest number of upazilas (24). Single Boro covered 7.69% area and was reported in 18 upazilas followed by Boro-Aus-Fallow (2.12%) in eight upazilas. Other cropping patterns were Boro-Aus-T. Aman, Fallow-B. Aman and, Fallow-B. Aus + T. Aman.

Exclusive non-rice crops

Year round vegetables cultivation were found in most of the upazilas with the total coverage of 3.33%. Vegetables cultivated both in Rabi and Kharif-I seasons found in 10 upazilas whereas vegetables grown in Rabi season only in three upazilas with very less area coverage (Table 3).

In the current investigation, 16 cropping patterns were identified without rice. Among these 16 patterns; first eight have been arranged in descending order in Table 3. The rest eight patterns with negligible area coverage in Table 7 are arranged with other patterns of different categories. Aggregate of the 16 patterns have had 4.53% of NCA. In critical comparison it is clear that exclusive rice area is about 14 folds of exclusive non-rice area. In the major areas of Khulna region salinity is the main constraint against the diversification of crops and cropping patterns. 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

Table 1. Upazila-wise land utilization and cropping intensity of Khulna region, 2014-15.

Upazila	Area of upazila (ha)	Annual crop (ha)	SCA (ha)	DCA (ha)	TCA (ha)	QCA (ha)	Other (ha)	NCA (ha)	C.I. (%)
01 Bagerhat sadar	31356	750	6700	6330	2680	0	190	16650	171
02 Chitalmari	19206	20	1010	11340	990	0	160	13520	200
03 Fakirhat	15890	500	3100	4380	710	0	110	8800	167
04 Kachua	12351	430	1700	6040	810	0	150	9130	185
05 Mollahat	17682	870	4300	9540	1310	0	150	16170	176
06 Mongla	18242	0	2570	80	0	0	50	2700	103
07 Morrelganj	44580	800	19090	6420	1240	0	150	27700	132
08 Rampal	27644	0	6300	2840	200	0	60	9400	135
09 Sarankhola	15129	60	3800	4780	700	0	120	9460	166
10 Batiaghata	23622	20	5500	11740	500	0	110	17870	172
11 Dacope	28557	120	16100	2260	160	0	130	18770	114
12 Dighalia	8655	220	1200	4110	140	0	50	5720	177
13 Dumuria	45423	50	11200	15960	2160	0	130	29500	169
14 Phultala	7438	80	515	3955	220	0	110	4880	192
15 Koyra	26323	80	10680	4310	395	0	115	15580	133
16 Paikgachha	39302	160	3700	12420	710	0	120	17110	181
17 Rupsha	12025	210	2020	5640	200	0	90	8160	175
18 Terokhada	18769	140	4000	5100	120	0	130	9490	157
19 Assasuni	37660	0	4500	5960	920	0	120	11500	169
20 Debhata	17305	10	740	3870	2000	0	190	6810	219
21 Kalaroa	23150	230	1000	10890	5160	110	140	17530	224
22 Kaliganj	33178	560	5000	11070	1690	0	140	18460	179
23 Satkhira sadar	40758	110	1000	18930	6760	0	110	26910	221
24 Shyamnagar	199099	90	12000	4830	450	0	120	17490	133
25 Tala	33726	830	4010	13270	4390	0	230	22730	198
Khulna region	797070	6340	131735	186065	34615	110	3175	362040	171

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
1 Fallow-Fallow-T. Aman	96900	26.76	17
2 Boro-Fallow-T. Aman	80420	22.21	24
3 Boro-Fallow-Fallow	27850	7.69	18
4 Boro-Aus-Fallow	7670	2.12	8
5 Boro-Aus-T. Aman	3895	1.08	12
6 Fallow-B.Aman	3520	0.97	4
7 Boro-B.Aman	3500	0.97	4
8 Fallow-Aus-T. Aman	2220	0.61	6
9 Fallow-B.Aus+B.Aman	400	0.11	1
Total	226375	62.53	-

Table 3. Cropping pattern with exclusive non-rice in Khulna region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetables-Vegetables-Vegetables	12060	3.33	23
02 Vegetables-Vegetables-Fallow	2420	0.67	10
03 Vegetables-Fallow-Fallow	535	0.15	3
04 Chilli-Vegetab-Fallow	340	0.09	8
05 Potato-Jute-Fallow	250	0.07	1
06 Mustard-Jute-Fallow	200	0.06	1
07 W.Melon-Fallow-Fallow	200	0.06	1
08 Potato-Chilli-Fallow	100	0.03	1
09-16 Other eight patterns (in Table 7)	300	0.08	-
Total	16405	4.53	-

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). Typology of different cropping systems is the base for the managers of these systems to intensify production (Shriar, 2000).

Rice-Fish culture

Rice-Fish system occupied 16.41% of the NCA in the region. The waterlogged *ghers* create opportunity for practicing rice-fish in large area. Under the rice-fish system, the highest area was under Boro-Fish cropping pattern (8.67%) and was also extensive (17 upazilas) followed by Fish-T. Aman cropping pattern (5.63%) reported in eight upazilas (Table 4). Boro-Fallow-T. Aman + Fish and Fallow-Fallow-T. Aman + Fish were found in seven and two upazilas covered 1.49 and 0.61% of NCA, respectively. There is a general practice of seasonal and year round cultivation of vegetables on the bank of the field. Proper attention on this enterprise might uplift the total productivity of the system. Modern agricultural technology along

with increased marketing facilities can fulfill this need.

Pulse crops

Eighteen cropping patterns are holding different pulse crops (Table 5). Among them grasspea is covering the largest area. In contrast, chickpea is cultivated in the smallest area. Seven cropping patterns of grasspea jointly cover about three-fourths of the pulse crop area. Lentil holds the second position in pulse crop cultivation in Khulna region. There are seven cropping patterns for lentil also where Lentil-Jute-T. Aman is the most dominant. In the documentation of pulse cropping grasspea reported its widest spreading in the region. One pattern is available in 11 upazilas and the second one exists in six upazilas both are grasspea based. Finally the aggregate area of the pulse cropping system stands for 3.59% of the NCA in Khulna region.

Oil-seed crops

Sesame, mustard and sunflower are the oil-seed crops grown in the Khulna region. Among them, sesame is the most important one among the oil-seed crops in the region. There are 18 cropping patterns for oil-seeds of which eight

Table 4. Cropping patterns with rice and fish in Khulna region, 2014-15.

Rice-Fish	Area (ha)	% of NCA	Frequency (no. of upazila)
1 Boro-Fish	31400	8.67	17
2 Fish-T. Aman	20400	5.63	8
3 Boro-Fallow-T. Aman+Fish	5410	1.49	7
4 Fallow-Fallow-T. Aman+Fish	2200	0.61	2
Total rice-fish	59410	16.41	-

Table 5. Area coverage of pulse crops under different cropping systems in Khulna region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Grasspea-Fallow-T. Aman	8390	2.32	11
02 Lentil-Jute-T. Aman	1390	0.38	5
03 Mungbean-Fallow-T. Aman	1280	0.35	8
04 Grasspea-Jute-T. Aman	780	0.22	6
05 Grasspea-Aus-T. Aman	350	0.10	1
06 Lentil-Fallow-T. Aman	280	0.08	6
07 Grasspea-Mungbean-T. Aman	170	0.05	2
08 Boro-Fallow-Blackgram	100	0.03	1
09 Lentil-Sesame-T. Aman	50	0.01	1
10-18 Other nine patterns (in Table 7)	200	0.06	-
Total pulse crops	12990	3.59	-

patterns had been led by sesame alone (Table 6 and Table 7). The total share of oil-seed cropping patterns is 5.21% of NCA whereas sesame absolutely occupies about 3%. The second prevailing mustard covers over 2%. However, the dominance of oil-seed crops and its spreading over the region are not running in the same direction. Sunflower, with its third largest coverage, had been widely spread out over 11 upazilas.

Sporadic and distinct cropping patterns

There are some cropping patterns which are extremely location-specific, however, with a large area coverage. These are F-Jute-T. Aman, Boro-Jute-F (Appendix 1) and F-F-T. Aman+Fish (Table 4). The F-Jute-T. Aman is grown on 1,100 ha only in Kalaroa of Satkhira district. Boro-Jute-F is cultivated in Dumuria upazila (1,500 ha) of Khulna district and in Tala upazila (1,300 ha) of Satkhira district. Fallow-Fallow-T. Aman+Fish is practiced in Mongla (300 ha) of Bagerhat and in Dumuria (1,900 ha).

Rare cropping patterns

In the present investigation, 30 cropping patterns have been identified as rare cropping patterns with a negligible area coverage with seldom existence (Table 7). These are location specific system and are limited in one to four upazilas of the region. Total area coverage of the 30 patterns is far less than 1% of NCA. Among them the highest area was covered by Boro-

Fallow-Blackgram, Potato-Chilli-Fallow and Wheat-Fallow-T. Aman (100 ha for each). The smallest area was recorded for 10 cropping patterns whose coverage was 10 hectares for each (Table 7).

Most dominant cropping pattern

Single T. Aman cropping pattern was the most dominant cropping with 96,900 ha coverage in Khulna region in 17 upazilas, namely, Morrelganj, Dacope, Shyamnagar, Koyra, Batiaghata, Kaliganj, Dumuria, Rampal, Assasuni, Bagerhat sadar, Sarankhola, Paikgachha, Mongla, Rupsha, Kachua, Fakirhat and Debhata. The contribution of these upazilas in the existence of the cropping pattern ranged 0.10 to 19.30% in the region. The higher area coverage under this cropping pattern were in Morrelganj, Dacope, Shyamnagar, Koyra, Batiaghata, Kaliganj and Dumuria. On the other hand, the least area coverage was reported in Debhata, Fakirhat and Kachua (Table 8). 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). 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).

Table 6. Area coverage of oil-seed crops under different cropping systems in Khulna region, 2014-15.

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Fallow-Sesame-T. Aman	10170	2.81	8
02 Mustard-Jute-T. Aman	3210	0.89	4
03 Mustard-Boro-T. Aman	2470	0.68	4
04 Mustard-Fallow-T. Aman	940	0.26	9
05 Sunflower-Fallow-T. Aman	490	0.14	11
06 Mustard-Aus-T. Aman	450	0.12	1
07 Mustard-Sesame-T. Aman	310	0.09	1
08 Mustard-Aus-Fallow	200	0.06	1
09 Mustard-Jute-Fallow	200	0.06	1
10 Mustard-Boro-Jute-T. Aman	110	0.03	1
11 Potato-Sesame-T. Aman	70	0.02	1
12-18 Other seven patterns (in Table 7)	245	0.07	
Total oil-seed crops	18865	5.21	-

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

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Boro-Fallow-Blackgram	100	0.03	1	Tala
02	Potato-Chilli-Fallow	100	0.03	1	Satkhira sadar
03	Wheat-Fallow-T. Aman	100	0.03	4	Mollahat+Rupsha+Assasuni+Tala
04	Coriander-Fallow-Fallow	80	0.02	4	Chitalmari+Morrelg.+Debhata+Tala
05	Potato-Sesame-T. Aman	70	0.02	1	Tala
06	Chilli-Fallow-Fallow	50	0.01	2	Mongla+Koyra
07	Groundnut-Fallow-T. Aman	50	0.01	1	Dighalia
08	Lentil-Sesame-T. Aman	50	0.01	1	Chitalmari
09	Onion-Vegtab-Vegtab	50	0.01	2	Bagerhat sadar+Assasuni
10	Wheat-Mungbean-T. Aman	40	0.01	2	Phultala+Tala
11	Wheat-Vegtab-Vegtab	40	0.01	1	Koyra
12	Boro-Sesbania-T. Aman	30	0.01	2	Dighalia+Terokhada
13	Grasspea-Jute-Fallow	30	0.01	1	Kalaroa
14	Lentil-Vegtab-T. Aman	30	0.01	1	Tala
15	Mungbean-Jute-T. Aman	30	0.01	1	Debhata
16	Onion-Sesame-T. Aman	30	0.01	1	Tala
17	Potato-Mungbean-T. Aman	30	0.01	2	Assasuni+Kalaroa
18	Sunflower-Jute-Fallow	30	0.01	1	Citalmari
19	Wheat-Sesame-T. Aman	30	0.01	1	Tala
20	Sesame-Fallow-T. Aman	25	0.01	2	Dacope+Phultala
21	Boro-Jute-T. Aman	10	0.00	1	Bagerhat sadar
22	Chickpea-Jute-T. Aman	10	0.00	1	Kalaroa
23	Coriander-Fallow-T. Aman	10	0.00	1	Fakirhat
24	Coriander-Jute-T. Aman	10	0.00	1	Kalaroa
25	Coriander-Vegtab-Fallow	10	0.00	1	Kalaroa
26	Grasspea-B.Aman	10	0.00	1	Dighalia
27	Lentil-Aus-T. Aman	10	0.00	1	Kachua
28	Lentil-B.Aman	10	0.00	1	Dighalia
29	W.Melon-Aus-T. Aman	10	0.00	1	Bagerhat sadar
30	Wheat-Jute-Fallow	10	0.00	1	Dumuria
	Total	1095	0.30		

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

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Morrelganj	18700	67.50	19.30
02	Dacope	16100	85.78	16.62
03	Shyamnagar	12000	68.61	12.38
04	Koyra	10500	67.36	10.84
05	Batiaghata	5500	30.78	5.68
06	Kaliganj	5000	27.09	5.16
07	Dumuria	4900	16.61	5.06
08	Rampal	4400	46.81	4.54
09	Assasuni	4100	35.65	4.23
10	Bagerhat sadar	3800	22.82	3.92
11	Sarankhola	3800	40.17	3.92
12	Paikgachha	3000	17.53	3.10
13	Mongla	2000	74.07	2.06
14	Rupsha	2000	24.51	2.06
15	Kachua	700	7.67	0.72
16	Fakirhat	300	3.41	0.31
17	Debhata	100	1.47	0.10
	Khulna region	96900	27.24	100.00

Second dominant cropping pattern

Boro-Fallow-T. Aman cropping pattern ranked the second position in the region distributed to 24 upazilas out of 25. However, their magnitude of contribution to the region was different, ranging 0.02 (Dacope) to 18.65% (Satkhira sadar) of the total area for the pattern in the region. The major share was from Satkhira sadar, Dumuria, Kalaroa, Assasuni, Kaliganj, Bagerhat sadar, Tala and Chitalmari upazilas (Table 9). 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).

Third dominant cropping pattern

The third cropping pattern in the Khulna region was Boro-Fish which is distributed to 17 upazilas with different level of contribution (0.32 to 21.66%). The major share of the cropping pattern from Chitalmari, Dumuria, Rupsha,

Tala, Kalaroa, Mollahat, Terokhada, Bagerhat sadar, Fakirhat, Rampal and Phultala (Table 10). In non-saline or low saline *ghers* water stagnation in Kharif-II season restricted rice production creates opportunity for practicing Boro-Fish. Here year round vegetables are frequently grown as dyke crop. On the other hand, T. Aman-Fish is the dominant cropping pattern in saline *ghers*. Rice-fish is an exceptional enterprise in Khulna region. Some constraints like salinity and water-stagnation and some opportunities like availability of modern technologies for fish culture and its export facilities are the driving forces for the enterprise (FAO, 1988).

Fourth dominant cropping pattern

Boro-Fallow-Fallow, identified as fourth dominant cropping pattern, has occupied 27,850 hectares representing 7.83% share of NCA in Khulna region (Table 11). This pattern is distributed over 18 upazilas where Dumuria ranked in the top position. This upazila has

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

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Satkhira sadar	15000	55.73	18.65
02 Dumuria	7400	25.09	9.20
03 Kalaroa	6850	39.06	8.52
04 Assasuni	5600	48.70	6.96
05 Kaliganj	4600	24.92	5.72
06 Bagerhat sadar	4500	27.02	5.60
07 Tala	4500	19.80	5.60
08 Chitalmari	3800	28.11	4.73
09 Batiaghata	2950	16.51	3.67
10 Fakirhat	2900	32.95	3.61
11 Kachua	2800	30.67	3.48
12 Debhata	2800	41.09	3.48
13 Mollahat	2500	15.45	3.11
14 Koyra	2000	12.83	2.49
15 Rupsha	2000	24.51	2.49
16 Phultala	1900	38.92	2.36
17 Morrelganj	1800	6.50	2.24
18 Dighalia	1700	29.72	2.11
19 Shyamnagar	1600	9.15	1.99
20 Paikgachha	1500	8.76	1.87
21 Rampal	1200	12.77	1.49
22 Terokhada	400	4.21	0.50
23 Sarankhola	100	1.06	0.12
24 Dacope	20	0.11	0.02
Khulna region	80420	22.61	100.00

Table 10. Distribution of the 3rd dominant Boro-Fish cropping pattern in Khulna region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Chitalmari	6800	50.30	21.66
02 Dumuria	3900	13.22	12.42
03 Rupsha	3400	41.67	10.83
04 Tala	3000	13.20	9.55
05 Kalaroa	2600	14.82	8.28
06 Mollahat	1800	11.13	5.73
07 Terokhada	1700	17.90	5.41
08 Bagerhat sadar	1500	9.01	4.78
09 Phultala	1500	30.73	4.78
10 Rampal	1400	14.89	4.46
11 Fakirhat	1300	14.77	4.14
12 Dighalia	800	13.99	2.55
13 Batiaghata	500	2.80	1.59
14 Debhata	500	7.34	1.59
15 Kachua	400	4.38	1.27
16 Satkhira sadar	200	0.74	0.64
17 Assasuni	100	0.87	0.32
Khulna region	31400	8.83	100.00

4,400 ha area for single Boro which is only 14.92% of upazila NCA. Fakirhat upazila ranks in fifth position with 2,800 ha area for this pattern, however, this upazila has the biggest share (31.82%) of its NCA. This pattern is frequent and concurrently suffer from early flash in April and cold injury at the reproductive stage. 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).

Fifth dominant cropping pattern

Fifth dominant cropping pattern Fish-T. Aman had been covering 20,400 hectares representing 5.74% share of NCA in Khulna region (Table 12). This pattern is distributed in only eight upazilas where Paikgachha ranked in top position contributing 41.67% of the pattern area in the region. This upazila had 8,500 ha area for Fish-T. Aman pattern which is about one-half of upazila NCA. Kaliganj upazila had the 2nd largest area 3,500 ha for this cropping and this upazila had allotted also the 2nd biggest share (18.96%) of its NCA.

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 Kalaroa (26) followed by Tala (24), Dumuria (22), Kachua (21), Mollahat (20). These upazilas are in non-saline areas where Kalaroa is mainly high to medium high land ecosystem. The number of cropping patterns in Rampal, Rupsha, Koyra, Dacope, Tekokhada, Shyamnagar, were 8, 10, 11, 11, 12 and 13, respectively. In contrast, the lowest number of cropping patterns were reported in Mongla (5). Higher number of cropping pattern is generally related to higher diversity indices for cropping pattern. The upazilas having lower number of cropping pattern were related to either salinity or water-logging or both. The calculated diversity indices (CDI) for cropping pattern are presented in Table 13. The overall crop diversity index for the region was 0.93. The highest CDI was in Tala (0.95) followed by Mollahat and Kachua and Dumuria and the lowest CDI was in Dacope (0.42) which was close to Mongla (0.48%). The average cropping intensity (CI) of the Khulna region was 171%. The lowest CI was recorded in Mongla (101%) and the highest was in Kalaroa (224%). The cropping intensity of Satkhira sadar, Debhata and Chitalmari were

Table 11. Distribution of the 4th dominant Boro-Fallow-Fallow cropping pattern in Khulna region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Dumuria	4400	14.92	15.80
02 Mollahat	4200	25.96	15.08
03 Tala	4000	17.60	14.36
04 Bagerhat sadar	2900	17.41	10.41
05 Fakirhat	2800	31.82	10.05
06 Rampal	1900	20.21	6.82
07 Chitalmari	1000	7.40	3.59
08 Kalaroa	1000	5.70	3.59
09 Satkhira	1000	3.72	3.59
10 Kachua	800	8.76	2.87
11 Dighalia	700	12.24	2.51
12 Paikgachha	700	4.09	2.51
13 Terokhada	700	7.37	2.51
14 Debhata	600	8.80	2.15
15 Phultola	500	10.24	1.80
16 Assasuni	400	3.48	1.44
17 Koyra	150	0.96	0.54
18 Morrelganj	100	0.36	0.36
Khulna region	27850	7.83	100.00

Table 12. Distribution of the 5th dominant Fish-T. Aman cropping pattern in Khulna region, 2014-15.

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
1 Paikgachha	8500	49.66	41.67
2 Kaliganj	3500	18.96	17.16
3 Tala	2500	11.00	12.25
4 Koyra	2000	12.83	9.80
5 Shyamnagar	2000	11.44	9.80
6 Morrelganj	1500	5.41	7.35
7 Batiaghata	300	1.68	1.47
8 Debhata	100	1.47	0.49
Khulna region	20400	5.74	100.00

221, 219 and 200%, respectively. The lower CI was related to the higher salinity and water-logging in the respective upazila. Shahidullah *et al.* (2006) also found the lowest CI in the salinity affected upazilas of eastern coastal Region of Bangladesh. Diversified cropping pattern may enabled the farmers compulsion of extracting the maximum possible utilization of land in the flood free period (Mandal and Bezbaruah, 2013). Our findings agree with the results of Singh and Sidhu (2006) and Tschardtke *et al.*, 2005 and 2007).

CONCLUSION

The cropping intensity of the Khulna region was much lower than the national average. Single T. Aman, Boro-Fallow-T. Aman, Boro-Fish, Boro-Fallow-Fallow, Fish-T. Aman were the major cropping patterns in the region. The non-rice based cropping patterns were few with less area coverage leads to the challenge of food and nutritional security for Khulna region. Based on the findings of the study, the following recommendations were made.

Table 13. Crops and cropping pattern and their diversity index in Khulna region, 2014-15.

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Bagerhat sadar	16	13	0.81	0.89	171
02 Chitalmari	17	16	0.66	0.83	200
03 Fakirhat	17	15	0.76	0.87	167
04 Kachua	21	18	0.86	0.92	185
05 Mollahat	20	17	0.86	0.93	176
06 Mongla	05	05	0.43	0.48	103
07 Morrelganj	18	16	0.53	0.73	132
08 Rampal	08	08	0.70	0.81	135
09 Sarankhola	12	10	0.67	0.82	166
10 Batiaghata	16	15	0.74	0.86	172
11 Dacope	11	08	0.26	0.42	114
12 Dighalia	17	12	0.84	0.90	177
13 Dumuria	22	17	0.67	0.91	169
14 Phultala	14	12	0.73	0.86	192
15 Koyra	11	10	0.51	0.71	133
16 Paikgachha	12	09	0.70	0.83	181
17 Rupsha	10	09	0.71	0.83	175
18 Terokhada	12	10	0.81	0.85	157
19 Assasuni	18	12	0.63	0.79	169
20 Debhata	15	10	0.79	0.91	219
21 Kalaroa	26	19	0.81	0.92	224
22 Kaliganj	15	09	0.81	0.91	179
23 Satkhira sadar	21	15	0.67	0.86	221
24 Shyamnagar	13	11	0.51	0.71	133
25 Tala	24	17	0.88	0.95	198
Khulna region	92	27	0.86	0.93	171

- Initiative to be taken to increase productivity of exclusive rice based cropping pattern along with recommended crop management packages.
- Short to medium duration high yielding potential Boro rice varieties suitable for Boro-Fish cropping pattern and water-logging tolerant non-lodging T. Aman varieties and suitable fish species with improved production practices to be extensively adopted for increasing system productivity.
- The cropping patterns with minor area coverage particularly Rice-Fish systems along with year round vegetable production on the dyke should be taken as priority technology for up-scaling in south west region.
- The upazilas having higher cropping pattern index might be studied in depth to extrapolate potential cropping patterns to other upazilas of similar environments.
- Research initiative should be taken to develop a mixing model of surface water and ground water with mild salinity for safe production of multiple crops.

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

Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Fallow-Fallow-T. Aman	96900	32	Vegetab-Jute-T. Aman	760
02	Boro-Fallow-T. Aman	80420	33	Vegetab-Aus-T. Aman	720
03	Boro-Fish	31400	34	Vegetab-Fallow-Fallow	535
04	Boro-Fallow-Fallow	27850	35	Garlic-Jute-T. Aman	530
05	Fish-T. Aman	20400	36	Fallow-Vegetab-T. Aman	500
06	Vegetab-Vegetab-Vegetab	12060	37	Sunflower-Fallow-T. Aman	490
07	Fallow-Sesame-T. Aman	10170	38	Potato-Fallow-T. Aman	460
08	Grasspea-Fallow-T. Aman	8390	39	Mustard-Aus-T. Aman	450
09	Boro-Aus-Fallow	7670	40	Chilli-Jute-T. Aman	410
10	Boro-Fallow-T. Aman+Fish	5410	41	Fallow-B.Aus+B.Aman	400
11	Boro-Aus-T. Aman	3895	42	Grasspea-Aus-T. Aman	350
12	Fallow-B.Aman	3520	43	S.Potato-Fallow-T. Aman	350
13	Boro-B.Aman	3500	44	Chilli-Vegetab-Fallow	340
14	Mustard-Jute-T. Aman	3210	45	Mustard-Sesame-T. Aman	310
15	Boro-Jute-Fallow	2800	46	Wheat-Aus-T. Aman	300
16	Mustard-Boro-T. Aman	2470	47	Lentil-Fallow-T. Aman	280
17	Vegetab-Vegetab-Fallow	2420	48	Maize-Fallow-T. Aman	260
18	Fallow-Aus-T. Aman	2220	49	Boro-Vegetab-T. Aman	250
19	Fallow-Fallow-T. Aman+Fish	2200	50	Potato-Aus-T. Aman	250
20	W.Melon-Fallow-T. Aman	2100	51	Potato-Jute-Fallow	250
21	Wheat-Jute-T. Aman	1510	52	Onion-Fallow-T. Aman	220
22	Lentil-Jute-T. Aman	1390	53	Chilli-Fallow-T. Aman	210
23	Potato-Vegetab-T. Aman	1310	54	Mustard-Aus-Fallow	200
24	Mungbean-Fallow-T. Aman	1280	55	Mustard-Jute-Fallow	200
25	Vegetab-Fallow-T. Aman	1200	56	W.Melon-Fallow-Fallow	200
26	Fallow-Jute-T. Aman	1100	57	Grasspea-Mungbean-T. Aman	170
27	Potato-Jute-T. Aman	1100	58	Vegetab-Aus-Fallow	150
28	Vegetab-Vegetab-T. Aman	960	59	Garlic-Fallow-T. Aman	130
29	Mustard-Fallow-T. Aman	940	60	Potato-S.gourd-Aus	130
30	Onion-Jute-T. Aman	820	61	Boro-Vegetab(Float/Norm)	120
31	Grasspea-Jute-T. Aman	780	62	Mustard-Boro-Jute-T. Aman	110
			63-92	Other 30 patterns (Table 7)	1095

