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*Theme : Cropping Patterns of Bangladesh*



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## PREFACE

Bangladesh Rice Journal acts as an official focal point for the delivery of scientific findings related to rice research. It invites scientific write-up from the personnel involved in research and extension both at national and international level. In Bangladesh about 75% of the land is covered by rice, and rice is cultivated in different cropping patterns in a yearly sequence with temporal and spatial arrangement of other crops. Detailed information on country-wide cropping systems is a prime need for prioritization research and development activities to enhance agricultural growth of Bangladesh. To generate information of this vital issue the researchers of Rice Farming Systems Division of BRRI conducted a country-wide survey and verified the collected data through stakeholders consultation workshop arranged in 64 districts of Bangladesh. Huge information was generated on crops and cropping patterns at each and every upazila (Administrative unit) as well as on its national level.

A special issue of Bangladesh Rice Journal has been dedicated to compile this information with a thematic area 'cropping patterns of Bangladesh'. As usually all the manuscripts were peer reviewed and overviewed. This issue includes 15 articles. However, all the articles are interlinked. The first one presents overall scenario about crops and cropping systems in Bangladesh focussing on district-wise data. Each of the rest 14 articles describes the cropping systems of an individual agricultural region of the country with upazila-wise elaborate information.

It is expected that this special issue of Bangladesh Rice Journal will be an excellent source of references on crops and cropping patterns of Bangladesh and will meet up the deep-felt requirements of farmers, extension personnel, researchers and policy makers as well. One of the objectives of Sustainable Development Goal is to double the productivity of agricultural sector by 2030. We hope to achieve the target this piece of work would serve as a milestone in the history of agricultural research in Bangladesh.

**Dr Md Shahjahan Kabir**

Chief Editor, Bangladesh Rice J.

and

Director General, BRRI



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# Distribution of Crops and Cropping Patterns in Bangladesh

M Nasim<sup>1</sup>, S M Shahidullah<sup>1\*</sup>, A Saha<sup>1</sup>, M A Muttaleb<sup>1</sup>, T L Aditya<sup>2</sup>, M A Ali<sup>2</sup> and M S Kabir<sup>3</sup>

## ABSTRACT

Agricultural land use and distribution of cultivated crops expressed in cropping pattern (CP) constitute the base for increasing productivity. An in-depth study was conducted on the existing CPs of Bangladesh in each and every upazila (sub-districts) using semi structured questionnaire and data validation by the stakeholder consultation workshop conducted in each of 64 districts. Three hundred and sixteen CPs were identified throughout Bangladesh excluding the very minor ones. Topmost five CPs were only rice containing CPs, which covered 51% of the net cropped area. The most dominant CP was Boro-Fallow-T. Aman covering 27% of net cropped area. Results on major cropwise CPs, location-wise CPs, CP diversity and crop diversity etc are also presented herein.

**Key words:** Land use, cropping pattern, cropping intensity, crop diversity index

## INTRODUCTION

Bangladesh, an agriculture dominating country, belongs to the greatest delta (Ganga-Brahmaputra and Sundarbans) of the world criss-crossed by thousands of rivers and rivulets (Fig. 1). The land is enriched with fertile alluvial soil. The soil and environment is well suited for different kinds of crops all over the year. About 57% of its total land is arable (Anonymous, 2016a). The lion share of the total land has been brought under cultivation to satisfy the demand of teeming millions. Despite this achievement, a huge population has a limited access to enough land under their jurisdiction making agriculture a challenging option. On the other hand, the yearly transformation of a certain area (0.47%) of arable land from agriculture to non-agriculture use is a grave concern to agricultural community due to population pressure, urbanization and some non-agricultural purposes. Thus, getting more food from less land would be one of the most challenging concern for the country even having some improvement of the existing agricultural system. Despite the reduction of

dependency on absolute agriculture, 45% of the total labour forces of the country and 16% of GDP have to rely directly on agriculture (Anonymous, 2016a). Beside the crop coverage, the agricultural land is occupied by forest, mangrove forest, river, lake, *bil*, *haor*, aquaculture, tea and salt pan (Hasan *et al.*, 2013). Lots of crops are cultivated both of tropical and temperate origin in this country. Agricultural land use at a local level is expressed by the spatial and temporal distribution of crops often expressed as cropping pattern (CP). CP depends on the physiography, environment and socio-economic conditions of a particular area.

### Physiography, ecosystem and environment

Agriculture is predominantly influenced by the varying environmental and physiographic conditions of an area. Three broad physiographic groups are marked in Bangladesh and they belong to three distinct geographical ages as, tertiary hills, pleistocene terraces and recent floodplains (Fig. 2). These physiographic groups are represented by hill soils in south-eastern and north-eastern areas, accounting for about 12% of the land, terrace soils consist

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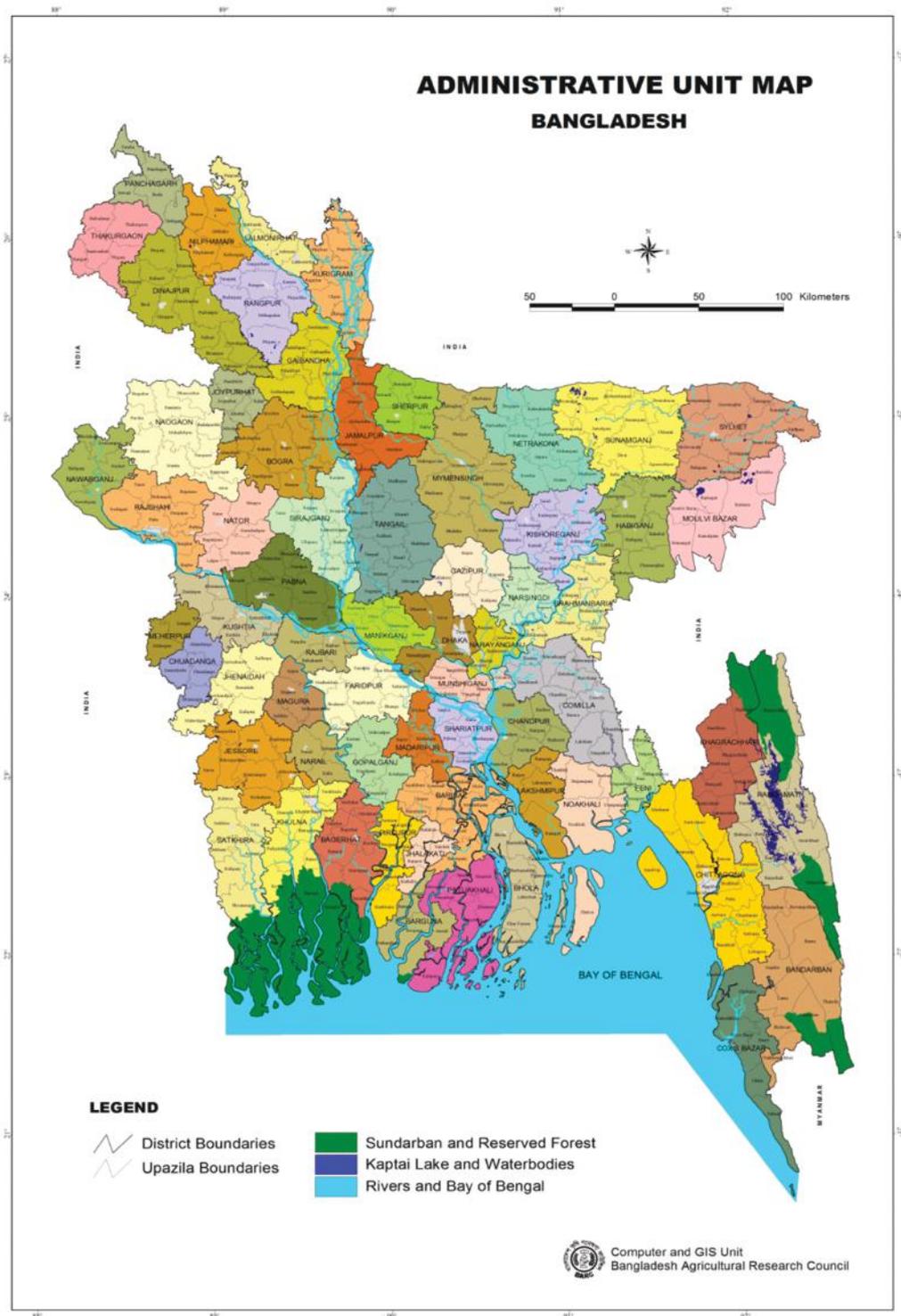


Fig. 1. Upazila-wise map of Bangladesh (<http://maps.barcapps.gov.bd/index.php?t=administrative>).

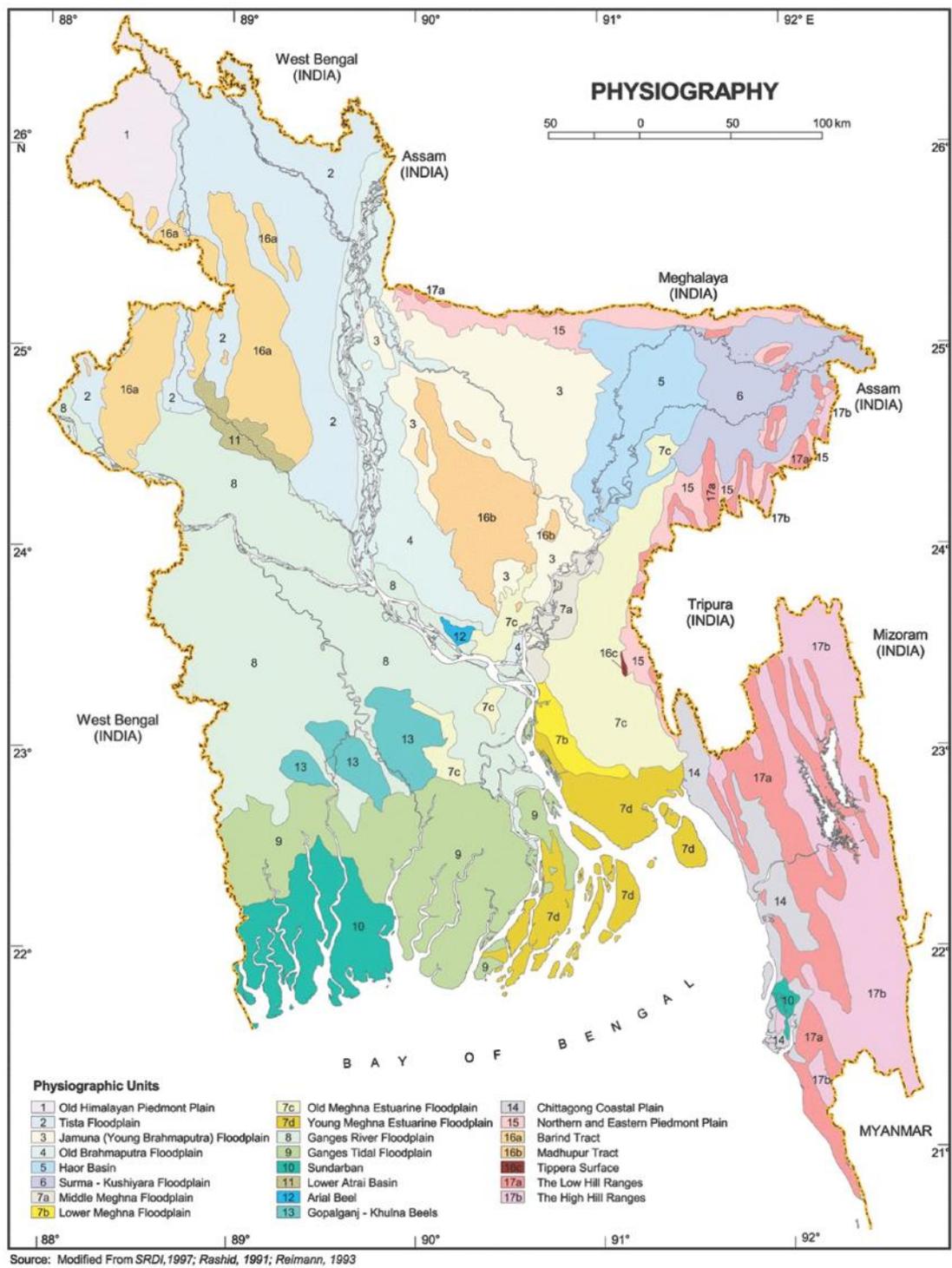


Fig. 2. Soil physiography and general soil type map of Bangladesh (<http://en.banglapedia.org/index.php?title=Physiography>).

of two uplifted blocks in the west and centre of the country called Barind and Madhupur Tracts, respectively accounting for about 8% of the land and floodplain soils distributed across the country accounting for about 80% of the land. Soil types within these physiographic groups are classified into 21 general types (Fig. 2). The cultivation practices and type of crops are exclusively dependent on these soil types (FAO, 1988). In addition to physiography and general soil types, water plays a vital role on crop production. As per FAO (1988), there are five classes of soil based on land level in relation to seasonal flooding. Water is generally scarce for cultivation in high and medium highlands. Contrarily medium lowland, lowland and very lowland are prone to flood of varying degrees during monsoon (Fig. 3). Beside these, there are special types of flood-prone areas mostly confined to the northeastern corner of the country called *haor*, a saucer-shaped vast depressed area contains *bil* in it and is inundated by water during monsoon and is dried up in winter (Fig. 4). Tidal wetland, another type of land at the southern part of the country greatly influences the crop production practices of the area. These areas are flood free zones, however are experienced of high and low tide every six hours. The tidal wetland is of two types, saline and non-saline. The saline water obviously restricts crop production severely. There are lot of *charlands* along the rivers and the coastal belt. Most of the areas having favourable environments for growing crops (Fig. 4). However, a significant area with adverse growing conditions are not unlikely depending growing season when the crop is in progress in the field.

Subtropical monsoon climate prevails in Bangladesh, which is characterized by wide seasonal variation and uneven distribution of temperature and rainfall. Monsoon wind flow plays a vital role in crop production. During warmer season, the wind brings moisture with it to rain in the rainy season. Along with the progress of the rainy season, the major rivers flow with water from the Himalya up to the brim causing flood across the country. In winter,

temperature comes down and monsoon wind ceases. As a result, cold wind flows from the north towards the bay. The cold wind mainly comes from the Himalaya, which further lowers the temperature. The winter is designated as the dry parts of the year when temperature might go down as low as 4-5° C. In contrast, the temperature may goes up beyond 40° C in the summer in some places in Bangladesh. The extreme climatic events are not uncommon. The intensity of these events vary with season or geographical location of the country.

In respect to the suitability of growing crops, FAO (1988) classified the whole land into 30 Agroecological regions (AEZ) and 88 subregions (Fig. 5). In this system, information on the environment, which is relevant for land use, was used for the assessment of agricultural potential. By adding and superimposing these information, those regions and subregions were classified. The following information was taken into account: 1. Physiography (Land forms and soil parent material), 2. Depth and duration of seasonal flooding, 3. Length of rainfed Kharif and Rabi growing periods, 4. Length of pre-Kharif period of unreliable rainfall, 5. Length of the cool winter period and 6. Frequency of occurrence of extremely high (>40 °C) summer temperature.

### **Agricultural land use**

As described above, the country experiences a lot of environmental variations, so is the case for land use patterns. The land use in croplands involves: Single crop, double crop, triple crop, quadruple crop, current fallow etc The agricultural land use is highly dynamic in Bangladesh.

Among the cultivated crops, rice occupies about 75% of total cropped areas (Anonymous, 2016a). So all the other crops together, occupy the rest of the cropped area. Rice has the wide adaptation ability under different agroecological niches of Bangladesh. It can be cultivated from the slope of the hill to a very deep flooded areas where water depth rises around 3 m. It can be cultivated throughout the year with an adjustment of not experience of

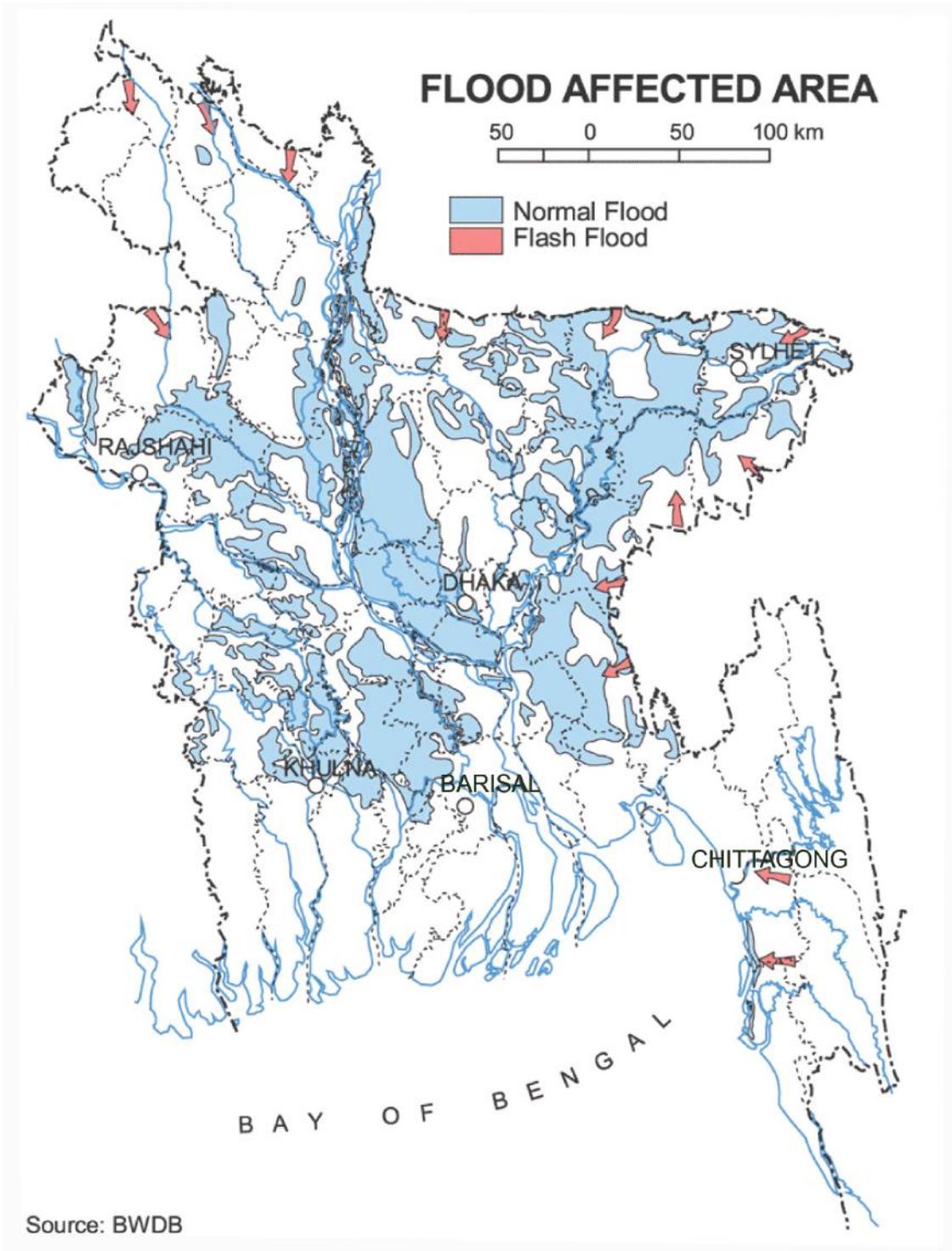


Fig. 3. Flood affected areas of Bangladesh (<http://lib.pmo.gov.bd/maps/images/bangladesh/Flood.gif>).

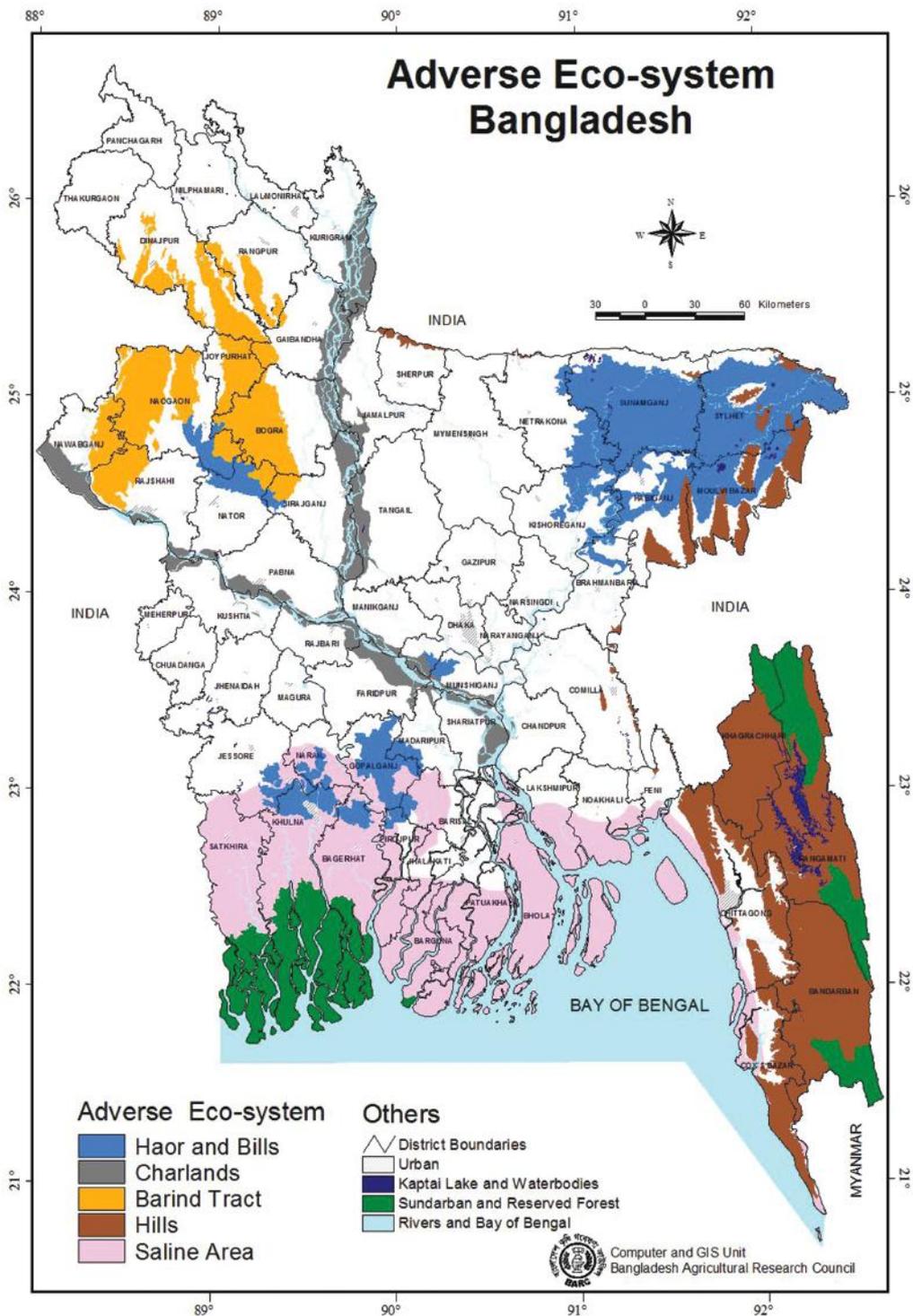


Fig. 4. Adverse ecosystem map of Bangladesh ([http://maps.barcapps.gov.bd/index.php?t=adverse\\_echo\\_system](http://maps.barcapps.gov.bd/index.php?t=adverse_echo_system)).

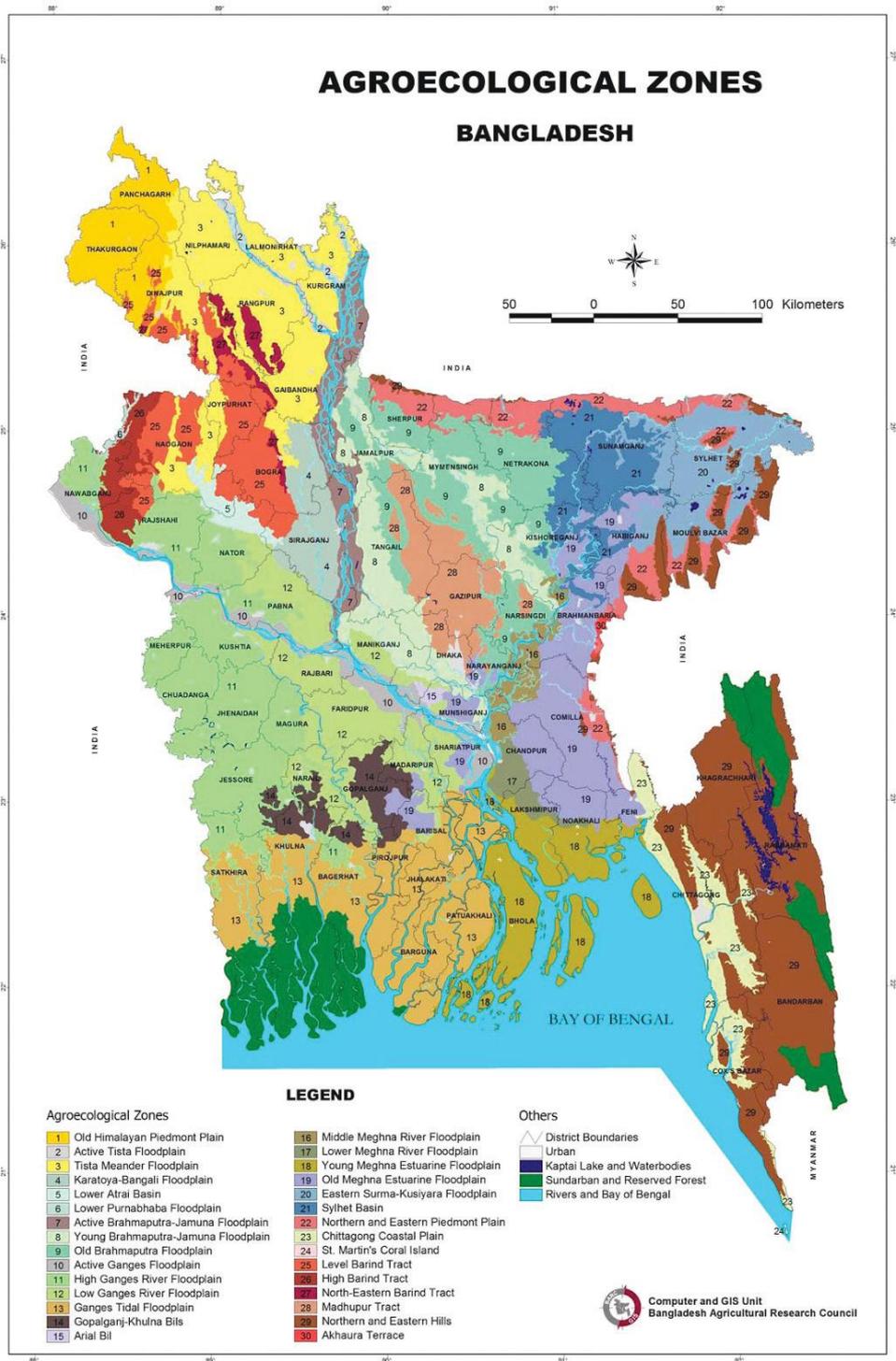


Fig. 5. Agroecological zone map of Bangladesh (<http://maps.barcapps.gov.bd/index.php?t=edaphic>).

extreme temperature during the reproductive phase. Rice is the best-adapted cereal crop in the lowland soil in the wet season. No other important crops have this ability to cope with the situation. When the vast areas of our country go under flood water for considerable time in the wet season, or when intermittent flash flood affects majority of our lowlands, or when tide water rises up and falls down twice a day, rice is the only crop option to be suited in those conditions. Thus rice enables us to bring these vast areas under cultivation in unfavourable conditions.

### **Rice growing environments**

The International Terminology for Rice Growing Environments (Khush, 1984) established a standard classification of rice ecosystems. In this system, primary classes are based on broad areas of sustained water depth. Secondary classes are based on subdivisions of water depths; the dynamics of the water regime, including the dependability of water supply; and on soil constraints in some cases. All classes of rice growing environments are widely present in Bangladesh. The primary classes are briefly defined below:

**Irrigated ecosystem.** The lands are irrigated with good water control and have adequate water supply throughout the growing season. Rainfall may supplement irrigation water. Rice is transplanted or direct seeded on puddle soil on levelled and bunded field. Lands represent harmonious nature of irrigated areas. Low lying areas, especially flood-prone areas are the most suitable areas. Most of the rice production comes from this ecosystem. In Bangladesh, they are scattered all over the country.

**Rainfed lowland.** Rainfed lowlands are usually in medium highland areas where rice cultivation depends on rainfall. After onset of rainfall, at some time, rain water accumulates on lands because of continuous and heavy rains. The soil is then puddled and rice is usually transplanted on levelled or slightly slopping bunded or dyked fields with variable depth and duration of flooding of rainfall. Soils alternate from flooded to nonflooded

conditions and thus short period of moisture stress or mild submergence may occur. The land is often submersed by flash flood. The water depth varies up to 100 cm and duration of flooding is usually not more than 10-12 days. Supplementary irrigation may be necessary. Both drought and flooding can occur within the same cropping season.

**Deep water.** The lowlying lands where flood water accumulates during rainy season and standing water depth vary from 50 cm to more than 3 m and flooding occurs only during part of the growing season is called deep water rice (DWR) ecosystem. Here rice is direct seeded on unbunded fields. Soil cycles from flooded to nonflooded conditions. Rice grows 50 to 60 days in rainfed field subject to drought or shallow flooding then is flooded to a depth of more than half a meter for a month or longer. The rice plant grows as flood water rises and rice is harvested after flood water recedes. Rice is often only the crop that can be grown in the flood-prone areas during flooding period. Catling *et al.* (1988) defined DWR as rice that is usually grown on land that is flooded to more than 50 cm depth for one month or more during the growing season. DWR at the early stage suffer from drought and with the onset of monsoon, it suffers from variable degrees of flooding that may last up to the reproductive stage. DWR ecosystem is different from tidal wetlands where water may rise more than 50 cm by tidal action but only for a short period in each day and from shallow flash-flood areas where rice may be submerged 50 cm or more but for up to 10-12 days.

**Upland.** Naturally well-drained soil with bunds or unbunded fields without surface water accumulation is called upland. Water does not stagnant even after heavy rains. Lands are level to steeply sloping. Crops suffer from lack of moisture and inadequate nutrition. Rice is direct seeded. Upland rice fields are mostly cultivated using traditional methods (predominantly slash and burn) in scattered fields. Uplands may encounter severe problems

with hard-pans, low pH sub soil, rapid onset of drought and lack of soil moisture. In the uplands, soils remain aerobic throughout the season.

**Tidal wetland.** Tidal wetlands are near the sea coasts and inland estuaries that are directly or indirectly influenced by tides. They are heterogeneous environments. Freshwater tidal wetlands in Bangladesh occur near inland estuaries some distance from the coast. There is little or no intrusion of saline water. The usual feature of these areas is the occurrence of daily tidal flooding between 30 to 60 cm depth, with some extremes up to 80 cm from June to September then falling sharply to 20 cm in late September. The field condition in the high tide is unsuitable for any crop but rice. The water levels in coastal rice fields fluctuate. Transplanted rice is grown in this environment and they suffer from daily high and low tidal pressure and also high depth of standing water. Tall rice seedlings with quick growing nature are transplanted to withstand submergence and tidal pressure as tides rise and fall. Saline water tidal wetland occurs near sea coast and mouth of estuaries and sea water intrusion takes place. The soil may have severe problems of salinity and other toxicity. The soil comes in contact with sea water by tidal flooding, direct inundation of sea water and by saline underground water. However, in the rainy season rain water dilutes salts of the top soil and washes away and leaches the salts and at that time intrusion of saline water is also checked by fresh water in the upstream river. So, rice production is possible at that time. The problem of salinity increases in the dry season.

In Bangladesh rice is grown in all these ecosystems. Our rice seasons generally fit into the primary classes of rice ecosystems. Boro represents irrigated ecosystem, T. Aman represents rainfed lowland and tidal wetland, Aus represents upland and B. Aman represents deep water rice ecosystem. However, with the modern rice varieties, the association between rice ecotypes and ecosystems is fading (Miah *et al.*, 2004).

### **Non-rice crops growing environment**

Wheat is cultivated in Rabi season and it needs prolonged winter. It is best suited in well drained sandy loam soil, however, it is cultivated in range of sandy loam to clay loam soils. It is also suited to medium highland to medium lowland. Wheat is best suited in cold winter prone areas of northern districts. Wheat covers 5.23%, of the net cropped areas (NCA) (Anonymous, 2016b). Maize is cultivated in two seasons, Rabi and Kharif-I. It is suited best in loamy soils. It is found to be the best in the northern districts. It is also suited in *charlands* throughout the country. However, in most of the potato growing areas maize is followed after potato in Kharif-I season. Maize covers 3.9% of the NCA (Anonymous, 2016b).

Many of the varieties of pulses and oil seeds are well suited to our ecosystems. However, pulse and oil seed crops cover only 4.9% and 5.02%, respectively of the NCA (Anonymous, 2016b). Among the pulses, the major crops are grasspea, lentil, chickpea, blackgram and mungbean and the minor ones are pigeonpea, fieldpea, fava bean and cowpea. Grasspea, lentil, chickpea, fieldpea, cowpea and fava beans are grown during Rabi season. Blackgram is grown just after the peak of monsoon. Mungbean is grown in winter and in the late winter or in Kharif-I seasons as well. Among the oil seed crops, rapeseed and mustard, sesame and groundnut are the major crops while niger, safflower, sunflower and soybean are minor ones. Rapeseed and mustard, niger and linseed are grown in the Rabi season while groundnut, sunflower and soybean in both Rabi and Kharif-II seasons. Sesame is grown both in Kharif-I and Kharif-II seasons.

Pulses are not evenly distributed in the country. Their cultivation is mainly concentrated within the gangetic floodplain in the northern districts and in some areas of southern districts. Soils of this area are calcareous from top to certain depth, loamy in the ridges and clay in the basin. pH ranges from 6.5-8. Availability of phosphorus, calcium, molybdenum and boron is relatively high, which are important for grain legumes. Lentil, blackgram and mungbean

are grown on high and medium high lands, moderately well to poorly drained light textured soils while chickpea and grasspea are grown on medium-high to low lands, poorly drained heavy textured soils. Grasspea is grown almost all over the country in medium low and lowlands. Mungbean is grown in loam soil. It can also perform well in clay soil if it is well drained.

Rapeseed and mustard is best grown in loamy soils. It can also be cultivated in clay loam and silt loam soils. Groundnut is cultivated in sandy loam and sandy soil of *charland* on the river bank or in the basin. High land with sandy loam soil is suitable for sesame.

Jute is cultivated in loamy soils in medium highland to medium lowland. It requires natural water source near the field for its retting. Jute cultivation is scattered throughout the country, however, is concentrated in greater Faridpur and northern districts. It occupies about 8.05% of NCA (Anonymous, 2016b).

Sugarcane is cultivated in clay loam, loam and sandy loam soils. It is suited for medium highland and medium lowland. In some sandy loam soils where Boro cultivation is difficult, farmers often choose sugarcane in it. It grows well in the low Ganges river floodplain. Sugarcane covers about 1.25% of NCA (Anonymous, 2016b).

There are lots of vegetables cultivated in our country. Vegetable is cultivated in fertile and well-drained soil often near the cities and towns. Vegetables are grown round the year in three different seasons. Many temperate season's vegetable are well suited to our winter.

### **Cropping pattern**

There are many crop growing niches seen in Bangladesh to support an unique biodiversity of crops throughout the year. Types of crops cultivated in an area and round the year is very important to increase the total crop production and productivity in that area. Distribution of crops in an area round the year can be expressed by CP. The yearly sequence and spatial arrangement of crops or crops and seasonal fallow of a given area are known as

CP. CP is an important indicator of land use, environment and socio-economic aspects of farmers of a locality. It indicates the proportion of areas under different crops in a given time. It also indicates the cropping activities in an area. In CP, crops are grown in sequence on same piece of land in a year. Here succeeding crop is established after the preceding crop has been harvested. Thus in CP there is turn around time and may or may not have a fallow period in a season. CP is very important, it allows increase in intensity and hence total production in a year as well. Climate, environment, resources and socioeconomic conditions determine the CP in an area. Climate and environments play a vital role. Presence of water is an important factor to choose a crop. Economic consideration of a farmer like irrigation, inputs, value of crops and decision of farmer and communities and government policies are also crucial. Based on appropriate consideration of all these issues farmers make a decision and construct a CP with judicious sequence.

CP or crop sequence is practically an annual strategy to optimize agronomic and economic yield in sustainable manner. CP itself is a dominant management practice in agriculture. This management not only help increase total production in a year but it influences many other management practices to be followed in it. It is so vital that many technologies, which are otherwise potential when is practiced individually, fail to show its potentiality when they have to be fitted in CP. CP controls many crop production and soil property issues. Crop diversity, input use, management, weed and disease infestation, soil physical properties like bulk density etc, cover crop, green manure, mulches, organic matter, C-N storage, erosion, water infiltration etc are influenced by CP. Thus CP provides us with a complete picture of agriculture in a locality.

The cropping patterns of Bangladesh are usually rice-based. However, these are diversified as well. The other crops in sequence are selected from the non-rice cereals, pulses, oil crops, vegetables and fibre crops. Thus rice-based cropping patterns not only provide us

the major source of dietary energy through rice but also supplements our essential diets.

Before 1970 i.e., before the green revolution era, many cropping patterns were evolved based on the characteristics of traditional varieties, age-old management practices, socioeconomic needs and the existing environments. There has been a lot of changes and re-adjustments since the green revolution era to date. Many new crop varieties and technologies adaptable to the changing environments are coming up. The input-intensive technologies turned many direct seeded rice areas into transplanted rice areas for better efficacy of the inputs and ease of management practices. Irrigation and other technologies turned many Rabi crop growing areas into Boro growing areas. Wheat, maize and potato areas also increased. As a result, many Rabi crops including pulses and oil seeds failed to accommodate in the systems and their areas decreased significantly. Boro areas increased dramatically. DWR and direct seeded Aus and Aman areas with local varieties decreased considerably.

### **Uniqueness, usefulness and policy relevance of the study in Bangladesh**

Distribution of crops i.e., agricultural land occupied by different crops is an important consideration which is usually expressed by CP. Study of CP has lots of merits. However, only some sporadic studies are found on this subject (Ali, 2014; Chowdhury *et al.*, 2008; Hossain *et al.*, 2016; Shahidullah *et al.*, 2006), they are mostly confined for a small locality. Rice Farming Systems Division of BRRI conducted an earlier study during the end of 1990, which was a bit similar to this study based on data collected from DAE on CP (Nur-E-Elahi *et al.*, 2001). The study was not very huge, narrow in presentation, however, district wise major CPs were identified. Contrarily, current study is huge. It presents information on CPs throughout the country in each and every upazila. List of CPs, their area coverage,

their relation with other land use parameters, groups of CPs according to major crops and related information is accumulated in this study. Stakeholders need information on crops, their spatial and temporal distribution, their environment and management in different areas of the country, which is very vital in decision making. No study can provide us with this information. This study is a means to solve the gap on this vital aspect of information. This study has many implications to the concerned stakeholders. Farmers will have ideas about his ecosystems and land use and avenue of improvement/intervention. Researchers will have avenues on crops and varieties and their areas of improvement, use of inputs tagged with existing environment and integration of component technologies to get potential yield of the CP. Policy makers and extension personnel will get ideas on material and capital input mobilization, technology transfer etc to explore the potential yield of the system. Thus, this study may be considered as vital and unique by its nature.

### **Justification and objective of the study**

CP brings appropriate crops and management in appropriate space and time. Improved formation of CP helps to approach the sustainable food security. The information related to CP is quite vital to the farmer, researcher and extension experts. Even the policy makers would have the idea to formulate the policy issues from the major CPs of the country. Unfortunately, we have a little updated knowledge about the CP of the whole country. It is not known how many CPs are there or what is the most dominant CP with its area coverage or related information all over the country. It is also not known how many CPs are there with a specific crop in it or CP without rice crops. The present study is an attempt to answer those questions, and aims to study agricultural land use and CP and create data base on it across the whole country with a view to exploring the potential of CPs in future from these information.

## METHODOLOGY

The study was conducted following two steps.

- Collection and analysis of secondary data and find out the mismatching of the data.
- Conducting stakeholder consultation workshop to review, verify and validate mismatch data discussing with the relevant sources and finalize data.

### **Collection and analysis of secondary data and finding mismatch**

Present study was carried out basically using secondary source of information from the Department of Agricultural Extension (DAE). DAE keeps records of crops in every nook and corner of the country. At the grass root level, in the blocks, Sub Assistant Agriculture Officer (SAAO) collects data from the field. They use Mauza map to identify NCA and the land use for non-agricultural purposes. In the cropped area, major crop growing field and their coverage is also identified. SAAO conducts survey following the possible ways to collect data. They collect the list of farmers and their lands from the manager of each Boro irrigation scheme. They also make list of farmers for the other major crops like T. Aman, Aus, wheat, jute etc and for minor crops as well. They collected data by interviewing farmers who cultivate different crops, use different varieties in respective hectareage. He also uses his own judgment by his own eye estimation. Finally observing the actual harvest area, judging by his own experience, the individual crop, their varieties and coverage are identified. By these ways they keep data of each and every crop and their coverage in his blocks. Combining block data, union, then upazila, then district data are compiled and kept in the record book of DAE. Thus in each upazila, season wise cultivated crops and their coverage are recorded.

DAE also keeps information on CP. Each crop is cultivated in a specific field in a single, double, triple or quadruple CP. Based on individual crops coverage, the area of a crop in a CP is distributed. Other crops of these CP

have to match in their respective coverage. Thus individual CP coverage data were developed.

Data we used in this study were collected from DAE. A semi-structured questionnaire was developed for data collection on crop, CP, their area coverage etc for the year of 2014. A small team of investigators visited the Deputy Director (DD), DAE office. They collected the secondary information of crops, their hectareage from each upazila from the district office. The questionnaires were then distributed to each upazila to collect information on CPs and their hectareage and other related issues. Upazila Agriculture Office filled up the questionnaires and sent back to the investigators. These data were analyzed to find out the mismatch of data, if any, among the data and any query regarding them.

### **Conducting stakeholder consultation workshop**

Two sets of data, one collected from DD Office on crop and their coverage in each upazila and the other collected through questionnaire on CP and their coverage from Upazila Agriculture Office were analyzed. After analysis of the data, usually there were some mismatches of data and were some information that needed further clarification. To purify and finalize this information stakeholder consultation workshops were conducted in 64 districts separately to work on upazila level data. A team of investigators (researchers) visited each district and organized a workshop. In the workshop, DD and district level all concerned officers of DAE and from upazila level UAO, AEO, UAA, SAPPO, SAAOs of respective upazila attended. In the workshop if there is a mismatch of data or any other query on data, researchers pointed out it for discussion. Then the data were finalized. The whole study was conducted from August 2015 to November 2016, throughout the country.

Thus the data used for final analysis were the overviewed data. The CP for the present study with its hectareage means the proportion of areas under different CPs in each upazila in 2014.

### Analysis of data

Collected data were analyzed using Micro Soft Excel programme. Tally, addition, average and descriptive statistics were used for presentation of data. Based on these data, tables were constructed and discussed accordingly.

### Limitation of the data

The data were collected from administrative area i.e., from each upazila of the country. So results were presented easily for upazila, district or region. However, among the upazilas there is transboundary ecosystem coverage where parts of the upazila are taken into account. Examples are *Barind* tract, *haor* areas, tidal wetlands etc. These areas extend transboundary of more than one upazilas. Exact ecosystem-wise result presentation is difficult in this study. Primary level data collection, ground truthing etc were not included in this study.

### Relevant terminology

**Land use.** The utilization of surface of a land on a specific space at a given time is called land use. When a land is utilized for agricultural purpose, it may be termed as agricultural land use.

**CP.** The sequence of crops or crops and fallow on a given area in a year. It includes the seasonal and annual crops, not the perennial crops. Seasonal crops can be sequenced by other seasonal crops or fallow. Annual crops may be replaced after its harvest. So, these are included in CP. Perennial crops, orchard crops, tree crops are not sequenced. So they are excluded from the CP. In case of mixed crops or inter crops, the area in which they are cultivated from it, the portion of area of a companion crop occupied is calculated using land equivalent ratio. CP is generally denoted by writing the crop's name one after another separated by dash sign. Serial of crops indicates the sequence, which is demarcated by dash sign. If in one season the land remained fallow, instead of crop name fallow was written. Writing CP generally started from Rabi or Boro season followed by Kharif-I or Aus then Kharif-II or Aman season. The examples are: Potato-Maize-T. Aman, Boro-Fallow-Fallow etc. If two crops are grown in one

season in a CP, e.g., two potato crops in Rabi season, a dash is used in between the crops e.g., Potato-Potato-Aus- T. Aman. Other than arable crops, e.g., orchard fruit crops, plantation tree, social forest, bamboo bushes, homestead crops, rooftop crops were not considered as crops of CP. Very minor CPs in terms of area coverage, was not included in our CP list. However, they were included in 'Other' category (Table 2) and were used in calculation of CP of respective upazila.

**Fallow.** In a temporal distribution of crops in a land in a year, if a season remains uncultivated it is considered as fallow. Fallow lands may be converted to cultivated land. Unfavourable weather like flood or socioeconomic conditions may cause a land to remain fallow.

**Current fallow (CF).** If a cultivable land remains fallow throughout the year, it is called CF. However, if a land remains fallow in one season, but cultivated in another season in a year, it is not CF. CF was not considered in NCA.

**Net cropped area (NCA):** A cultivable land may be either cultivated or remained fallow throughout the year. When a land is cultivated, one or two or three crops round the year may be cultivated in it. The summation of cultivated land area of a region is called NCA. Thus, it is the actual area under crop in a specific year. CF is not considered in it.

**Single cropped area/DCA/TCA/QCA:** If only one crop is cultivated in a year in an arable land, the area is called SCA. Using similar sense double, triple and quadruple crop areas are defined.

**Total cropped area.** It is the summation of area cultivated once as well as more than once in a particular year. When two crops in sequence are cultivated in a land in a year, the area is counted twice and so on for three and four crops. Thus it is the summation of SCA x 1, DCA x 2, TCA x 3 and QCA x 4.

**Cropping intensity (CI).** CI is the ratio of total cropped area and NCA in a particular region in a year. It practically indicates number of crops cultivated in a year in a specific land. It is expressed in percentage.

**Annual crops (AC).** Annual crops are the crops which are cultivated throughout the year, e.g., sugarcane, banana, papaya. These crops are considered in crops of CP, as in the next year cultivation of these crops may be replaced by other seasonal crops in sequence. As such they are included in NCA. Contrarily in Boro-Fallow-Fallow CP, Boro crop is not an annual crop but a seasonal crop.

**Fruit crops.** Permanent perennial fruit-bearing crops. They are not considered in CP as they have no sequence. However, annual fruit crops i.e., banana, papaya etc are differed from it and were considered in crops of CP as stated above. If arable field crop is cultivated with fruit trees as intercrop, land equivalent ration of the field crop was considered and this field crop was put into CP.

**Timber crops and bamboo bushes.** Timber producing permanent and perennial trees and bamboo bushes were not considered in CP as they have no temporal sequence.

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.

## RESULTS AND DISCUSSIN

Many striking results were revealed when data were analyzed by spread-sheet. Table 1 shows the district-wise common land use pattern of Bangladesh as represented by annual crop area, SCA, DCA, TCA, QCA, others, NCA and CI. DCA dominated in different districts

in comparison to SCA or TCA except in Narayanganj, Pirojpur, Sirajganj, Sunamganj, Tangail and Rangamati. These districts have more low-lying areas except Rangamati. Therefore, single Boro CP dominated in those districts. Whereas, in Rangamati, single season *jhum* cultivation is dominated. QCA was extremely low in most of the districts. It was the highest in Bogra followed by Naogoan and Jessore. As QCA was very low, it contributed less to CI i.e., number of crops in yearly sequence. However, the region which had more TCA, consequently had greater CI. TCA was the highest in Bogra district followed by Naogoan and Dinajpur districts. Bogra district had the highest CI followed by Kushtia, Laxmipur and Thakurgoan districts. Lowest CI was found in Sunamganj followed by Rangamati and Gopalganj. Sunamganj and Gopalganj are *haor* and low lying areas where scope of cultivation of crops is only possible in Rabi season and in Rangamati, a hilly region, only *jhum* crops are grown in one season. Annual crop (AC) area was the highest in Tangail followed by Natore and Rangamati. Thus these districts produced more banana, papaya, turmeric, ginger etc. Table 24 presents the information on ACs. NCA of the country was more than 8 million hectares. Population pressure, urbanization and industrialization will reduce this figure gradually. However, we have to get our future food from this land. Kabir *et al.* (2015) mentioned the current NCA to be 7.81 million hectares and they projected it to be 7.71, 7.49 and 7.18 million hectares in 2021, 2031 and 2041, respectively. Mymensingh had the highest NCA followed by Dinajpur and Naogoan districts. Increased NCA might be because of bigger geographical area of the districts and increased arable areas as well. The country's average indicated that DCA was more than the sum of AC, SCA, TCA QCA and more than twice of the SCA or TCA, separately. QCA was quite negligible, which was 0.22% of the NCA. The average CI was 200%.

**Table 1. District-wise land use in Bangladesh (area in hectare), 2014-15.**

District	Annual crop	SCA	DCA	TCA	QCA	Others	NCA	CI (%)	
01	Brahmanbaria	290	59760	67390	10920	50	1040	139450	165
02	Bagerhat	3430	48570	51750	8640	0	1140	113530	161
03	Bandarban	13680	12110	13370	930	0	640	40730	138
04	Barguna	630	19260	41180	37770	0	830	99670	218
05	Barisal	5095	33320	92355	26175	0	1515	158460	192
06	Bhola	5205	9130	105000	65995	0	1050	186380	228
07	Bogra	1520	8940	98550	106610	5070	1460	222150	248
08	Chandpur	945	24100	50200	15480	150	1105	91980	190
09	Chapainawabganj	11160	15280	46170	46980	0	770	120360	217
10	Chittagong	5180	70220	88230	34785	0	1715	200130	180
11	Chuadanga	3400	2220	55880	26110	350	490	88450	224
12	Comilla	980	45675	92540	63550	2300	1855	206900	210
13	CoxBazar	3830	13250	52680	14475	50	1095	85380	197
14	Dhaka	740	17970	32990	15730	0	710	68140	196
15	Dinajpur	4145	800	188505	81350	210	1830	276840	228
16	Faridpur	5590	8530	75990	48750	0	1130	139990	225
17	Feni	280	16300	49785	4810	0	755	71930	183
18	Gaibandha	4110	10540	105980	29680	0	1050	151360	210
19	Gazipur	7520	33775	35095	8250	0	730	85370	161
20	Gopalganj	1790	68200	32775	9665	0	710	113140	146
21	Habiganj	1200	71350	73160	21615	0	1125	168450	170
22	Jamalpur	2810	7950	106340	42600	90	1020	160810	220
23	Jessore	4020	19440	97740	64660	2880	1230	189970	225
24	Jhalakati	2830	10640	29950	7870	0	610	51900	189
25	Jhenaidaha	10150	6790	73590	47780	700	840	139850	223
26	Joypurhat	1500	110	22425	53715	0	750	78500	267
27	Khagrachhari	10220	13140	17960	2170	0	830	44320	151
28	Khulna	1080	54915	65495	4605	0	985	127080	159
29	Kishoreganj	1490	111950	58035	26335	350	1680	199840	156
30	Kurigram	1760	14030	95755	36465	10	1340	149360	214
31	Kushtia	7280	3260	48260	54410	700	870	114780	240
32	Lakshmipur	400	6400	46210	45435	450	1005	99900	240
33	Lalmonirhat	1290	3090	66740	26955	0	765	98840	223
34	Madaripur	1040	16100	44890	20770	0	590	83390	204
35	Magura	1660	2580	28190	42730	0	650	75810	251
36	Manikganj	2350	11500	54070	24680	0	790	93390	212
37	Maulvibazar	1820	48925	66270	9635	0	820	127470	168
38	Meherpur	2340	640	26900	23830	0	380	54090	239
39	Munsiganj	190	17670	39280	3870	0	790	61800	177
40	Mymensingh	6060	34730	208220	38835	100	1715	289660	199
41	Naogaon	2500	33690	143520	86050	3530	1610	270900	221
42	Narail	1670	6450	50330	15110	0	410	73970	210
43	Narayanganj	180	18780	17900	2410	0	410	39680	158
44	Narsingdi	2850	20600	38220	9840	0	730	72240	181
45	Natore	17240	13150	59780	44035	0	1035	135240	210

**Table 1. Continued.**

	District	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	CI (%)
46	Netrokona	310	85560	106545	6005	0	1290	199710	160
47	Nilphamari	2310	2650	81340	34510	0	800	121610	224
48	Noakhali	1540	76910	84750	34215	0	1115	198530	178
49	Pabna	5920	14020	88870	74060	30	1370	184270	230
50	Panchagarh	2310	4130	72200	22860	0	710	102210	216
51	Patuakhali	1345	35950	129250	44035	0	1200	211780	203
52	Pirojpur	2130	36105	35925	7255	0	865	82280	162
53	Rajbari	2360	6670	31800	34390	0	740	75960	234
54	Rajshahi	10420	12320	86100	55820	1100	1360	167120	221
55	Rangamati	14380	17625	10010	910	0	755	43680	128
56	Rangpur	4350	8970	101490	59140	200	1100	175250	227
57	Satkhira	1830	28250	68820	21370	110	1050	121430	193
58	Shariatpur	1260	23185	45540	7250	0	775	78010	178
59	Sherpur	760	4330	77140	17610	0	720	100560	213
60	Sirajganj	2440	27585	111615	40645	0	1235	183520	206
61	Sunamganj	510	206805	55400	3560	0	1135	267410	123
62	Sylhet	1100	110350	88120	8955	0	1625	210150	151
63	Tangail	20250	18640	144385	47820	250	1705	233050	204
64	Thakurgaon	2790	1710	80360	62890	0	640	148390	240
	Bangladesh	243765	1787595	4455305	1996365	18680	64790	8566500	200

**Table 2. List of cropping patterns in Bangladesh, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
001	Boro-Fallow-T. Aman	2306005	26.919	63	426
002	Boro-Fallow-Fallow	1139530	13.302	59	342
003	Fallow-Fallow-T. Aman	509480	5.947	36	162
004	Boro-Aus-T. Aman	209015	2.440	47	177
005	Fallow-Aus-T. Aman	193275	2.256	30	108
006	Mustard-Boro-T. Aman	184620	2.155	51	203
007	Boro-B.Aman	183070	2.137	32	113
008	Potato-Boro-T. Aman	180380	2.106	33	115
009	Wheat-Jute-T. Aman	147210	1.718	43	216
010	Vegetable-Vegetable-Vegetable	143270	1.672	61	283
011	Mustard-Boro-Fallow	143130	1.671	37	112
012	Grasspea-Fallow-T. Aman	108150	1.262	25	80
013	Maize-Fallow-T. Aman	101460	1.184	39	126
014	Wheat-Fallow-T. Aman	90910	1.061	39	100
015	Mungbean-Fallow-T. Aman	89650	1.047	22	70
016	Grasspea-Aus-T. Aman	81610	0.953	19	61
017	Vegetable-Fallow-T. Aman	74710	0.872	45	170
018	Vegetable-Vegetable-Fallow	63935	0.746	59	168
019	Onion-Jute-T. Aman	54185	0.633	39	102
020	Mungbean-Aus-T. Aman	53730	0.627	14	43
021	Chilli-Fallow-T. Aman	52995	0.619	45	146
022	Lentil-Jute-T. Aman	51875	0.606	34	96
023	Vegetable-Vegetable-T. Aman	51745	0.604	49	127

Table 2. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
024	Wheat-Jute-Fallow	48700	0.568	32	82
025	Potato-Maize-T. Aman	47690	0.557	19	68
026	Boro-Aus-Fallow	45865	0.535	34	71
027	Onion-Jute-Fallow	45200	0.528	29	67
028	Boro-Jute-T. Aman	40440	0.472	19	56
029	Felon-Fallow-T. Aman	37675	0.440	14	53
030	Mustard-Boro-B.Aman	36520	0.426	14	32
031	Wheat-Aus-T. Aman	36425	0.425	35	93
032	Mustard-Jute-T. Aman	32740	0.382	29	64
033	Lentil-Jute-Fallow	32360	0.378	27	67
034	Boro-Fish	31400	0.367	3	17
035	Vegetable-Fallow-Fallow	31115	0.363	35	84
036	Groundnut-Fallow-T. Aman	29210	0.341	23	60
037	Vegetable-Aus-T. Aman	28700	0.335	42	87
038	Water Melon-Fallow-T. Aman	28340	0.331	17	49
039	Potato-Jute-T. Aman	28310	0.330	36	95
040	Potato-B.Aman	23900	0.279	9	25
041	Soybean-Fallow-T. Aman	23670	0.276	5	10
042	Soybean-Aus-T. Aman	23170	0.270	5	8
043	Potato-Fallow-T. Aman	22715	0.265	34	108
044	Potato-Aus-T. Aman	22405	0.262	29	79
045	Wheat-Mungbean-T. Aman	21760	0.254	20	50
046	Grasspea-B.Aman	21480	0.251	21	52
047	Maize-Jute-Fallow	21425	0.250	19	33
048	Maize-Jute-T. Aman	21325	0.249	18	38
049	Vegetable-Boro-T. Aman	21220	0.248	22	42
050	Grasspea-Jute-Fallow	21000	0.245	21	39
051	Fish-T. Aman	20400	0.238	3	8
052	Soybean-Jute-T. Aman	20000	0.233	4	6
053	Potato-Boro-Fallow	19360	0.226	17	27
054	Mustard-Boro-Aus	18140	0.212	10	16
055	Mustard-B.Aman	17210	0.201	12	24
056	Mustard-Jute-Fallow	17180	0.201	16	35
057	Sweet Potato-Fallow-T. Aman	16990	0.198	31	103
058	Groundnut-Fallow-Fallow	16485	0.192	35	76
059	Boro-Jute-Fallow	16370	0.191	19	25
060	Fallow-B.Aman	16360	0.191	15	29
061	Wheat-Maize-T. Aman	16320	0.191	9	14
062	Wheat-Aus-Fallow	16200	0.189	17	26
063	Vegetable-Aus-Fallow	15940	0.186	23	41
064	Tobacco-Jute-T. Aman	15200	0.177	9	19
065	Mustard-Fallow-T. Aman	14870	0.174	33	84
066	Groundnut- Aus-T. Aman	14535	0.170	10	18
067	Potato-Jute-Fallow	14515	0.169	25	53
068	Boro-Sesbania-T. Aman	14490	0.169	20	33
069	Chilli-Aus-T. Aman	14240	0.166	21	38
070	Wheat-B.Aman	13835	0.162	16	32

Table 2. Continued.

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
071 Mustard-Aus-T. Aman	13790	0.161	30	52
072 Fallow-Jute-T. Aman	13620	0.159	18	32
073 Maize-Aus-Fallow	13615	0.159	14	18
074 Garlic-Jute-Fallow	13475	0.157	26	48
075 Boro-Vegetable (Float/Norm)	13335	0.156	27	36
076 Boro-Fallow-Blackgram	13270	0.155	27	44
077 Chilli-Jute-Fallow	13260	0.155	22	54
078 Vegetable-Jute-Fallow	13185	0.154	26	47
079 Garlic-Jute-T. Aman	13090	0.153	38	78
080 Wheat-Aus-Blackgram	13000	0.152	6	8
081 Maize-Fallow-Fallow	12920	0.151	22	38
082 Lentil-Fallow-T. Aman	12680	0.148	29	68
083 Potato-Vegetable-T. Aman	12620	0.147	30	59
084 Lentil-Sesame-T. Aman	12450	0.145	14	33
085 Fallow-Aus+Non-rice ( <i>jhum</i> )	11900	0.139	3	20
086 Onion-Vegetable-Vegetable	11735	0.137	39	87
087 Fallow-Sesame-T. Aman	11640	0.136	13	20
088 Vegetable-Jute-T. Aman	11305	0.132	25	51
089 Lentil-Aus-T. Aman	11255	0.131	25	46
090 Onion-B.Aman	10905	0.127	14	27
091 Garlic-B.Aman	10850	0.127	15	21
092 Potato-Sesbania	10770	0.126	5	15
093 Wheat-Sesame-T. Aman	10650	0.124	15	33
094 Water Melon-Aus-T. Aman	10355	0.121	11	14
095 Grasspea-Jute-T. Aman	10300	0.120	25	43
096 Potato-Maize-Fallow	9640	0.113	10	16
097 Chilli-Fallow-Fallow	9265	0.108	40	66
098 Sesame-Fallow-T. Aman	9265	0.108	19	31
099 Felon-Aus-T. Aman	9245	0.108	7	16
100 Boro-Sesbania-Fallow	9180	0.107	12	19
101 Chilli-B.Aman	9120	0.106	10	23
102 Chilli-Vegetable-Fallow	8810	0.103	44	104
103 Onion-Aus-Fallow	8705	0.102	12	17
104 Fallow-Fallow-Blackgram	8695	0.102	34	59
105 Boro-Vegetable-T. Aman	8660	0.101	9	16
106 Boro-Aus-Blackgram	8540	0.100	5	5
107 Sweet Potato-Fallow-Fallow	7980	0.093	37	98
108 Mustard-Boro-Aus-T. Aman	7850	0.092	14	30
109 Blackgram-B.Aman	7625	0.089	11	24
110 Chilli-Aus-Fallow	7565	0.088	14	27
111 Tobacco-Maize-T. Aman	7470	0.087	5	12
112 Potato-Boro-Aus	7420	0.087	4	6
113 Coriander-Jute-Fallow	7390	0.086	15	25
114 Chilli-Jute-T. Aman	7250	0.085	20	35
115 Fallow-Vegetable-T. Aman	7130	0.083	16	29
116 Maize-Vegetable-Fallow	7120	0.083	14	19
117 Vegetable-Boro-Fallow	7100	0.083	9	10

Table 2. Continued.

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
118 Lentil-Mungbean-T. Aman	6955	0.081	11	22
119 Lentil-B.Aman	6550	0.076	16	30
120 Onion-Fallow-T. Aman	6380	0.074	32	64
121 Lentil-Vegetable-Vegetable	6330	0.074	19	30
122 Mustard-Maize-T. Aman	6310	0.074	9	19
123 Wheat-Vegetable-Vegetable	6100	0.071	16	21
124 Tobacco-Aus-T. Aman	6040	0.071	5	12
125 Soybean-B.Aman	5650	0.066	4	4
126 Boro-Fallow-T. Aman +Fish	5410	0.063	3	7
127 Tobacco-Fallow-T. Aman	5310	0.062	7	15
128 Wheat-Vegetable-T. Aman	5205	0.061	15	25
129 Vegetable-B.Aman	5200	0.061	9	17
130 Maize-B.Aman	5030	0.059	10	15
131 Mustard-Aus-Fallow	4935	0.058	15	22
132 Maize-Mungbean-T. Aman	4900	0.057	1	3
133 Mustard-Mungbean-T. Aman	4710	0.055	12	18
134 Chickpea-Fallow-T. Aman	4700	0.055	12	32
135 Grasspea-Boro-Fallow	4690	0.055	8	12
136 Coriander-Jute-T. Aman	4625	0.054	17	30
137 Lentil-Aus-Fallow	4570	0.053	11	15
138 Vegetable-Maize-T. Aman	4500	0.053	9	15
139 Garlic-Vegetable-Vegetable	4385	0.051	27	68
140 Potato-Maize-Aus	4300	0.050	3	4
141 Onion-Aus-T. Aman	4260	0.050	17	26
142 Tobacco-Jute-Fallow	4050	0.047	4	8
143 Wheat-Jute-Blackgram	3910	0.046	7	9
144 Wheat-Fallow-Fallow	3810	0.044	6	8
145 Wheat-Chilli-Fallow	3780	0.044	7	9
146 Maize-Maize-Fallow	3720	0.043	3	5
147 Wheat-Fallow-T. Aman (Orchard)	3700	0.043	1	2
148 Garlic-Fallow-T. Aman	3680	0.043	31	59
149 Lentil-Sesame-Fallow	3680	0.043	15	20
150 Chilli-Boro-Jute	3600	0.042	2	3
151 Maize-Fallow-Blackgram	3600	0.042	4	4
152 Vegetable-Fallow-Blackgram	3525	0.041	16	33
153 Fallow-B.Aus+B.Aman	3470	0.041	3	5
154 Sweet Potato-Jute-Fallow	3380	0.039	13	21
155 Mustard-Sesame-T. Aman	3360	0.039	12	15
156 Vegetable-Onion-Aus	3200	0.037	3	3
157 Tobacco-Aus-Fallow	3180	0.037	5	10
158 Coriander-Fallow-Fallow	3175	0.037	41	64
159 Potato-Boro-Aus-T. Aman	3140	0.037	5	9
160 Onion-Sesame-T. Aman	3080	0.036	4	6
161 Maize-Maize-T. Aman	3070	0.036	6	8
162 Wheat-Maize-Fallow	3070	0.036	2	4
163 Sesame-Fallow-Blackgram	3060	0.036	6	10
164 Maize-Aus-Vegetable	3000	0.035	3	4

Table 2. Continued.

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
165 Mustard-Boro-Jute	3000	0.035	5	7
166 Mustard-Boro-Jute-T. Aman	2980	0.035	7	13
167 Maize-Aus-T. Aman	2970	0.035	17	27
168 Lentil-Maize-T. Aman	2920	0.034	4	8
169 Wheat-Mungbean-Fallow	2875	0.034	5	7
170 Groundnut-B.Aman	2820	0.033	5	7
171 Lentil-Fallow-Fallow(Orchard)	2780	0.032	3	5
172 Fallow-Sesame+B.Aman	2750	0.032	5	7
173 Potato-Groundnut-T. Aman	2720	0.032	3	5
174 Soybean-Fallow-Fallow	2710	0.032	3	4
175 Grasspea-Boro-B.Aman	2700	0.032	3	3
176 Lentil-Vegetable-T. Aman	2660	0.031	11	11
177 Vegetable-Groundnut-T. Aman	2660	0.031	4	5
178 Pea-B.Aman	2620	0.031	11	16
179 Garlic-Mungbean-T. Aman	2500	0.029	1	2
180 Garlic-Aus-T. Aman	2400	0.028	13	20
181 Millet(Kaon)-Fallow-T. Aman	2390	0.028	6	6
182 Muskmelon-Fallow-T. Aman	2310	0.027	10	23
183 Potato-Aus-Fallow	2310	0.027	13	16
184 Tobacco-Boro-T. Aman	2300	0.027	3	4
185 Blackgram-Jute-Fallow	2295	0.027	12	16
186 Grasspea-Fallow-Fallow	2295	0.027	9	11
187 Fallow-Fallow-T. Aman +Fish	2200	0.026	2	2
188 Potato-Maize-Vegetable	2190	0.026	4	4
189 Coriander-Fallow-T. Aman	2185	0.026	31	62
190 Vegetable-Maize-Fallow	2180	0.025	6	7
191 Potato-Boro-Jute-T. Aman	2160	0.025	4	5
192 Sweet Potato-Aus-T. Aman	2150	0.025	2	2
193 Wheat-Mung-Fallow(Orchard)	2150	0.025	2	3
194 Onion-Sesame+B.Aman	2100	0.025	2	3
195 Pea-Jute-Fallow	2100	0.025	10	15
196 Sunflower-Fallow-T. Aman	2100	0.025	7	23
197 Coriander-Vegetable-Fallow	2090	0.024	20	29
198 Potato-Chilli-Fallow	2070	0.024	10	17
199 Potato-Sesame-T. Aman	2060	0.024	15	23
200 Blackgram(Fodder)-Boro-B.Aman	2000	0.023	1	1
201 Wheat-Maize-Vegetable	2000	0.023	2	2
202 Pea-Fallow-T. Aman	1950	0.023	18	27
203 Potato-Sesame-Fallow	1930	0.023	6	10
204 Blackgram-Jute-T. Aman	1900	0.022	11	14
205 Mustard-Aus-Blackgram	1900	0.022	2	2
206 Mustard-Jute-Vegetable	1900	0.022	3	5
207 Wheat-Aus-Onion	1900	0.022	1	1
208 Blackcumin-Jute-Fallow	1840	0.021	6	12
209 Maize-Sesame-T. Aman	1835	0.021	6	9
210 Maize-Vegetable-T. Aman	1810	0.021	11	12
211 Millet(Kaon)+Sesame-Fallow	1810	0.021	5	7

Table 2. Continued.

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
212 Onion-Aus-Blackgram	1810	0.021	5	6
213 Grasspea-Boro-Aus	1800	0.021	1	1
214 Grasspea-Sesame+B.Aman	1800	0.021	2	2
215 Grasspea-Sesame-T. Aman	1790	0.021	5	6
216 Grasspea-Sesbania-Fallow	1780	0.021	4	4
217 Mustard-B.Aus+B.Aman	1780	0.021	4	4
218 Blackgram-Aus-T. Aman	1735	0.020	10	13
219 Mustard-Sesame+B.Aman	1650	0.019	3	4
220 Tobacco-Sesbania-T. Aman	1620	0.019	1	2
221 Vegetable-Aus-Blackgram	1610	0.019	4	4
222 Grasspea-B.Aus+B.Aman	1580	0.018	6	8
223 Maize-Sesame-Fallow	1580	0.018	6	8
224 Groundnut-Aus-Fallow	1550	0.018	5	5
225 Wheat-Sesame-Fallow	1550	0.018	7	8
226 Groundnut-Jute-T. Aman	1530	0.018	7	13
227 Boro-Fallow-Maize	1500	0.018	1	1
228 Tobacco-Vegetable-Vegetable	1500	0.018	1	1
229 Onion-Maize-T. Aman	1490	0.017	7	9
230 Coriander-B.Aman	1480	0.017	11	11
231 Garlic-Aus-Fallow	1450	0.017	12	15
232 Vegetable-Jute-Vegetable	1450	0.017	5	5
233 Chilli-Vegetable-T. Aman	1405	0.016	15	19
234 Fallow-Aus-Fallow	1400	0.016	3	3
235 Maize-Boro-T. Aman	1400	0.016	2	2
236 Maize-Aus-Blackgram	1370	0.016	3	3
237 Cotton-Aus-Fallow	1330	0.016	3	3
238 Grasspea-Sesame-Fallow	1330	0.016	7	10
239 Groundnut-Fallow-Blackgram	1320	0.015	3	3
240 Wheat-Jute-Vegetable	1320	0.015	6	6
241 Pea-Aus-Vegetable	1310	0.015	7	8
242 Onion-Sesame-Fallow	1270	0.015	8	9
243 Blackcumin-Jute-T. Aman	1260	0.015	6	11
244 Sesame-Aus-Fallow	1190	0.014	3	4
245 Sesame-Aus-T. Aman	1180	0.014	4	5
246 Water Melon-Fallow-Fallow	1165	0.014	9	12
247 Pea-Vegetable-Fallow	1160	0.014	4	5
248 Potato-Mungbean-T. Aman	1140	0.013	11	13
249 Potato-Groundnut	1110	0.013	5	8
250 Tobacco-Fallow-Fallow	1045	0.012	5	8
251 Potato-Maize-Aus-Vegetable	1030	0.012	3	3
252 Fallow-Fallow-T. Aman (Orchard)	1000	0.012	1	1
253 Maize-Sesbania-Fallow	1000	0.012	1	1
254 Lentil-Sesame+B.Aman	980	0.011	1	1
255 Maize-Mungbean-Vegetable	950	0.011	3	3
256 Millet (Cheena)-Fallow-Fallow	935	0.011	5	6
257 Potato-Sweet gourd-Aus	910	0.011	6	8
258 Wheat-Fallow-Blackgram	900	0.011	1	1

Table 2. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
259	Mustard-Fallow-Fallow	895	0.010	9	13
260	Coriander-Sesame-T. Aman	845	0.010	5	5
261	Vegetable-Boro-Aus-T. Aman	820	0.010	4	5
262	Vegetable-Boro-Jute	800	0.009	2	3
263	Potato+Sweetgourd-Aus-T. Aman	780	0.009	3	5
264	Wheat-Sesame-Blackgram(Orchard)	760	0.009	3	3
265	Sweet Potato-B.Aman	740	0.009	6	6
266	Mustard-Boro-Sesbania	700	0.008	2	2
267	Potato-Boro-Vegetable	700	0.008	4	4
268	Soybean-Aus-Fallow	700	0.008	1	1
269	Sweet Potato-Jute-T. Aman	675	0.008	10	13
270	Maize-Groundnut	620	0.007	1	1
271	Millet(Cheena)-Jute-Fallow	620	0.007	2	2
272	Sesame+B.Aman-Blackgram	600	0.007	1	1
273	Tobacco-Maize-Vegetable	600	0.007	1	1
274	Tobacco-Sesbania	600	0.007	1	1
275	Wheat-Aus-Cotton	600	0.007	1	1
276	Groundnut-Sesame-Fallow	590	0.007	4	5
277	Potato-Boro-Jute	590	0.007	2	2
278	Wheat-Ginger/Turmeric	580	0.007	2	2
279	Sweet Potato-Vegetable-Fallow	540	0.006	5	9
280	Water Melon-B.Aman	535	0.006	3	3
281	Garlic-Fallow-Fallow	530	0.006	10	14
282	Onion-Maize-Fallow	520	0.006	4	4
283	Potato-Onion-T. Aman	510	0.006	2	2
284	Felon-Aus-Fallow	470	0.005	2	3
285	Grasspea-Mungbean-T. Aman	440	0.005	5	5
286	Boro-Maize-Fallow	410	0.005	2	2
287	Potato+Maize-B.Aman	410	0.005	2	3
288	Felon-Fallow-Fallow	380	0.004	3	4
289	Groundnut-Millet(Kaon)-Fallow	380	0.004	2	2
290	Chickpea-Aus-T. Aman	375	0.004	5	7
291	Potato-Sesame-Aus	360	0.004	4	4
292	Boro-Chilli-Fallow	350	0.004	1	1
293	Boro-Maize-Blackgram	350	0.004	1	1
294	Sesame-B.Aman	330	0.004	2	2
295	Garlic+Muskmelon-B.Aman	320	0.004	1	2
296	Garlic+WaterMelon-B.Aman	320	0.004	1	2
297	Mungbean-Jute-Fallow	300	0.004	6	8
298	Sesame-Jute-T. Aman	290	0.003	2	2
299	Chickpea-Jute-T. Aman	270	0.003	7	11
300	Grasspea-Aus-Blackgram	250	0.003	1	1
301	Musk Melon-B.Aman	215	0.003	2	5
302	Potato+Maize-Vegetable-T. Aman	210	0.002	2	2
303	Mustard-Maize-Jute	200	0.002	1	1
304	Vegetab-Onion-Jute-T. Aman	200	0.002	1	1
305	Mungbean-Jute-T. Aman	180	0.002	9	11

**Table 2. Continued.**

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
306 Soybean-Jute-Fallow	140	0.002	2	2
307 Sunflower-Jute-Fallow	135	0.002	3	3
308 Mungbean-B.Aus+B.Aman	130	0.002	4	4
309 Musk Melon-Fallow-Fallow	125	0.001	5	5
310 Lentil-Mungbean-Jute-T. Aman	100	0.001	1	1
311 Mustard-Mungbean-Aus-T. Aman	100	0.001	1	1
312 Potato+S. gourd-M.bean-T. Aman	80	0.001	1	1
313 Tobacco-Mungbean-T. Aman	50	0.001	1	1
314 Tobacco-Mungbean-Vegetable	40	0.000	1	1
315 Mungbean-Aus-Fallow	20	0.000	1	1
316 Barley-Fallow-Fallow	15	0.000	1	2
Others	64790	0.756	64	486
Annual crops	243765	2.846	64	486
Net cropped area of Bangladesh	8566500	100.000	64	486

In Bangladesh, 316 CPs were found which deserved to be included in the CP list of the study excluding the minor ones (Table 2). Boro-Fallow-T. Aman was the most dominant CP which occupied 26.92% of the NCA. Whereas the last CP was the Barley-Fallow-Fallow which occupied only 0.0002% of the NCA. There had been many more CPs, whose hectarages were quite low, were not considered in the list. Those CPs were kept in 'Other' category where only summation of all of their hectarages was considered. The most dominant CP, Boro-Fallow-T. Aman occupied significantly higher percentage of NCA than that of its next following CP, Boro-Fallow-Fallow which occupied less than half of the percentage of NCA of Boro-Fallow-T. Aman. The next three CPs were Fallow-Fallow-T. Aman, Boro-Aus-T. Aman and Fallow-Aus-T. Aman, respectively. These five CPs occupied 50.86% of the NCA. Interestingly the results unveiled that in these foremost five CPs, no other crop than rice was included. It indicated the dominancy of rice culture in Bangladesh. Sujatha *et al.* (2011) found similar dominancy of rice culture in Tamil Nadu in the neighbouring country, India. Boro and T. Aman contribute the large share in crop production. In T. Aman season, monsoon rain is plenty, however it is usually unreliable whereas in Boro season irrigation is comparatively reliable. Availability of water

in these two seasons brought more area under rice cultivation. Hence Boro-Fallow-T. Aman became the most dominant CP of the country. T. Aman is usually cultivated in medium highland. Therefore, this CP is practiced in medium highland of the country. All other CPs including 'Other' category, that could be few hundreds, constituted the rest 49% of NCA. In Table 2, 'number of upazila' indicates the existence of a specific CP in total number of upazilas. The most dominant CP, Boro-Fallow-T. Aman was present in 426 upazilas out of 486. It was found that higher the percentage of NCA occupied by a CP greater the presence of the CP in different upazilas. In terms of area coverage some of the CPs mentioned in this study were very minor CPs, such as Boro-Fallow-Maize, Maize-Sesbania-Fallow etc. These two CPs were present in one upazila only with low area coverage.

In the earlier table, all the CPs were listed, however, in Table 3, CPs with rice exclusively was separated. There were 17 CPs containing exclusively rice crops. Foremost five of them were most dominant CPs, mentioned in earlier para. Twelve others may be considered as minor. Among these minors, in some CPs fishes were included in rainy season. In another CP, single T. Aman was cultivated in the orchard where fruit trees were still small. All these 17 CPs occupied 54.77% of the NCA. Thus rice exclusive CPs

**Table 3. List of cropping patterns with rice exclusively and area coverage, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01 Boro-Fallow-T. Aman	2306005	26.92	63	426
02 Boro-Fallow-Fallow	1139530	13.30	59	342
03 Fallow-Fallow-T. Aman	509480	5.95	36	162
04 Boro-Aus-T. Aman	209015	2.44	47	177
05 Fallow-Aus-T. Aman	193275	2.26	30	108
06 Boro-B.Aman	183070	2.14	32	113
07 Boro-Aus-Fallow	45865	0.54	34	71
08 Boro-Fish	31400	0.37	3	17
09 Fish-T. Aman	20400	0.24	3	8
10 Fallow-B.Aman	16360	0.19	15	29
11 Boro-Sesbania-T. Aman	14490	0.17	20	33
12 Boro-Sesbania-Fallow	9180	0.11	12	19
13 Boro-Fallow-T. Aman +Fish	5410	0.06	3	7
14 Fallow-B.Aus+B.Aman	3470	0.04	3	5
15 Fallow-Fallow-T. Aman +Fish	2200	0.03	2	2
16 Fallow-Aus-Fallow	1400	0.02	3	3
17 F-F-T. Aman (Orchard)	1000	0.01	1	1
Total of exclusive rice area	4691550	54.77	-	-

**Table 4. List of cropping patterns with Boro crop and area coverage, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01 Boro-Fallow-T. Aman	2306005	26.92	63	426
02 Boro-Fallow-Fallow	1139530	13.30	59	342
03 Boro-Aus-T. Aman	209015	2.44	47	177
04 Mustard-Boro-T. Aman	184620	2.16	51	203
05 Boro-B.Aman	183070	2.14	32	113
06 Potato-Boro-T. Aman	180380	2.11	33	115
07 Mustard-Boro-Fallow	143130	1.67	37	112
08 Boro-Aus-Fallow	45865	0.54	34	71
09 Boro-Jute-T. Aman	40440	0.47	19	56
10 Mustard-Boro-B.Aman	36520	0.43	14	32
11 Boro-Fish	31400	0.37	3	17
12 Vegetable-Boro-T. Aman	21220	0.25	22	42
13 Potato-Boro-Fallow	19360	0.23	17	27
14 Mustard-Boro-Aus	18140	0.21	10	16
15 Boro-Jute-Fallow	16370	0.19	19	25
16 Boro-Sesbania-T. Aman	14490	0.17	20	33
17 Boro-Vegetable (Float/Norm)	13335	0.16	27	36
18 Boro-Fallow-Blackgram	13270	0.15	27	44
19 Boro-Sesbania-Fallow	9180	0.11	12	19
20 Boro-Vegetable-T. Aman	8660	0.10	9	16
21 Boro-Aus-Blackgram	8540	0.10	5	5
22 Mustard-Boro-Aus-T. Aman	7850	0.09	14	30
23 Potato-Boro-Aus	7420	0.09	4	6
24 Vegetable-Boro-Fallow	7100	0.08	9	10
25 Boro-Fallow-T. Aman +Fish	5410	0.06	3	7

**Table 4. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
26	Grasspea-Boro-Fallow	4690	0.05	8	12
27	Chilli-Boro-Jute	3600	0.04	2	3
28	Potato-Boro-Aus-T. Aman	3140	0.04	5	9
29	Mustard-Boro-Jute	3000	0.04	5	7
30	Mustard-Boro-Jute-T. Aman	2980	0.03	7	13
31	Grasspea-Boro-B.Aman	2700	0.03	3	3
32	Tobacco-Boro-T. Aman	2300	0.03	3	4
33	Potato-Boro-Jute-T. Aman	2160	0.03	4	5
34	B.gram(Fodder)-Boro-B.Aman	2000	0.02	1	1
35	Grasspea-Boro-Aus	1800	0.02	1	1
36	Boro-Fallow-Maize	1500	0.02	1	1
37	Maize-Boro-T. Aman	1400	0.02	2	2
38	Vegetab-Boro-Aus-T. Aman	820	0.01	4	5
39	Vegetable-Boro-Jute	800	0.01	2	3
40	Mustard-Boro-Sesbania	700	0.01	2	2
41	Potato-Boro-Vegetable	700	0.01	4	4
42	Potato-Boro-Jute	590	0.01	2	2
43	Boro-Maize-Fallow	410	0.00	2	2
44	Boro-Chilli-Fallow	350	0.00	2	1
45	Boro-Maize-Blackgram	350	0.00	1	1
	Total Boro area	4706310	54.94	-	-

**Table 5. List of cropping patterns with T. Aman rice and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Boro-Fallow-T. Aman	2306005	26.919	63	426
02	Fallow-Fallow-T. Aman	509480	5.947	36	162
03	Boro-Aus-T. Aman	209015	2.440	47	177
04	Fallow-Aus-T. Aman	193275	2.256	30	108
05	Mustard-Boro-T. Aman	184620	2.155	51	203
06	Potato-Boro-T. Aman	180380	2.106	33	115
07	Wheat-Jute-T. Aman	147210	1.718	43	216
08	Grasspea-Fallow-T. Aman	108150	1.262	25	80
09	Maize-Fallow-T. Aman	101460	1.184	39	126
10	Wheat-Fallow-T. Aman	90910	1.061	39	100
11	Mungbean-Fallow-T. Aman	89650	1.047	22	70
12	Grasspea-Aus-T. Aman	81610	0.953	19	61
13	Vegetable-Fallow-T. Aman	74710	0.872	45	170
14	Onion-Jute-T. Aman	54185	0.633	39	102
15	Mungbean-Aus-T. Aman	53730	0.627	14	43
16	Chilli-Fallow-T. Aman	52995	0.619	45	146
17	Lentil-Jute-T. Aman	51875	0.606	34	96
18	Vegetable-Vegetable-T. Aman	51745	0.604	49	127
19	Potato-Maize-T. Aman	47690	0.557	19	68
20	Boro-Jute-T. Aman	40440	0.472	19	56
21	Felon-Fallow-T. Aman	37675	0.440	14	53
22	Mustard-Boro-B.Aman	36520	0.426	14	32
23	Wheat-Aus-T. Aman	36425	0.425	35	93

Table 5. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
24	Mustard-Jute-T. Aman	32740	0.382	29	64
25	Groundnut-Fallow-T. Aman	29210	0.341	23	60
26	Vegetable-Aus-T. Aman	28700	0.335	42	87
27	Water Melon-Fallow-T. Aman	28340	0.331	17	49
28	Potato-Jute-T. Aman	28310	0.330	36	95
29	Potato-B.Aman	23900	0.279	9	25
30	Soybean-Fallow-T. Aman	23670	0.276	5	10
31	Soybean-Aus-T. Aman	23170	0.270	5	8
32	Potato-Fallow-T. Aman	22715	0.265	34	108
33	Potato-Aus-T. Aman	22405	0.262	29	79
34	Wheat-Mungbean-T. Aman	21760	0.254	20	50
35	Maize-Jute-T. Aman	21325	0.249	18	38
36	Vegetable-Boro-T. Aman	21220	0.248	22	42
37	Fish-T. Aman	20400	0.238	3	8
38	Soybean-Jute-T. Aman	20000	0.233	4	6
39	Sweet Potato-Fallow-T. Aman	16990	0.198	31	103
40	Wheat-Maize-T. Aman	16320	0.191	9	14
41	Tobacco-Jute-T. Aman	15200	0.177	9	19
42	Mustard-Fallow-T. Aman	14870	0.174	33	84
43	Groundnut- Aus-T. Aman	14535	0.170	10	18
44	Boro-Sesbania-T. Aman	14490	0.169	20	33
45	Chilli-Aus-T. Aman	14240	0.166	21	38
46	Mustard-Aus-T. Aman	13790	0.161	30	52
47	Fallow-Jute-T. Aman	13620	0.159	18	32
48	Garlic-Jute-T. Aman	13090	0.153	38	78
49	Lentil-Fallow-T. Aman	12680	0.148	29	68
50	Potato-Vegetable-T. Aman	12620	0.147	30	59
51	Lentil-Sesame-T. Aman	12450	0.145	14	33
52	Fallow-Sesame-T. Aman	11640	0.136	13	20
53	Vegetable-Jute-T. Aman	11305	0.132	25	51
54	Lentil-Aus-T. Aman	11255	0.131	25	46
55	Wheat-Sesame-T. Aman	10650	0.124	15	33
56	Water Melon-Aus-T. Aman	10355	0.121	11	14
57	Grasspea-Jute-T. Aman	10300	0.120	25	43
58	Sesame-Fallow-T. Aman	9265	0.108	19	31
59	Felon-Aus-T. Aman	9245	0.108	7	16
60	Boro-Vegetable-T. Aman	8660	0.101	9	16
61	Mustard-Boro-Aus-T. Aman	7850	0.092	14	30
62	Tobacco-Maize-T. Aman	7470	0.087	5	12
63	Chilli-Jute-T. Aman	7250	0.085	20	35
64	Fallow-Vegetable-T. Aman	7130	0.083	16	29
65	Lentil-Mungbean-T. Aman	6955	0.081	11	22
66	Onion-Fallow-T. Aman	6380	0.074	32	64
67	Mustard-Maize-T. Aman	6310	0.074	9	19
68	Tobacco-Aus-T. Aman	6040	0.071	5	12
69	Boro-Fallow-T. Aman +Fish	5410	0.063	3	7
70	Tobacco-Fallow-T. Aman	5310	0.062	7	15

Table 5. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
71	Wheat-Vegetable-T. Aman	5205	0.061	15	25
72	Maize-Mungbean-T. Aman	4900	0.057	1	3
73	Mustard-Mungbean-T. Aman	4710	0.055	12	18
74	Chickpea-Fallow-T. Aman	4700	0.055	12	32
75	Coriander-Jute-T. Aman	4625	0.054	17	30
76	Vegetable-Maize-T. Aman	4500	0.053	9	15
77	Onion-Aus-T. Aman	4260	0.050	17	26
78	Wheat-Fallow-T. Aman (Orchard)	3700	0.043	1	2
79	Garlic-Fallow-T. Aman	3680	0.043	31	59
80	Mustard-Sesame-T. Aman	3360	0.039	12	15
81	Potato-Boro-Aus-T. Aman	3140	0.037	5	9
82	Onion-Sesame-T. Aman	3080	0.036	4	6
83	Maize-Maize-T. Aman	3070	0.036	6	8
84	Mustard-Boro-Jute-T. Aman	2980	0.035	7	13
85	Maize-Aus-T. Aman	2970	0.035	17	27
86	Lentil-Maize-T. Aman	2920	0.034	4	8
87	Potato-Groundnut-T. Aman	2720	0.032	3	5
88	Lentil-Vegetable-T. Aman	2660	0.031	11	11
89	Vegetable-Groundnut-T. Aman	2660	0.031	4	5
90	Garlic-Mungbean-T. Aman	2500	0.029	1	2
91	Garlic-Aus-T. Aman	2400	0.028	13	20
92	Millet(Kaon)-Fallow-T. Aman	2390	0.028	6	6
93	Musk Melon-Fallow-T. Aman	2310	0.027	10	23
94	Tobacco-Boro-T. Aman	2300	0.027	3	4
95	Fallow-Fallow-T. Aman +Fish	2200	0.026	2	2
96	Coriander-Fallow-T. Aman	2185	0.026	31	62
97	Potato-Boro-Jute-T. Aman	2160	0.025	4	5
98	Sweet Potato-Aus-T. Aman	2150	0.025	2	2
99	Sunflower-Fallow-T. Aman	2100	0.025	7	23
100	Potato-Sesame-T. Aman	2060	0.024	15	23
101	Pea-Fallow-T. Aman	1950	0.023	18	27
102	Blackgram-Jute-T. Aman	1900	0.022	11	14
103	Maize-Sesame-T. Aman	1835	0.021	6	9
104	Maize-Vegetable-T. Aman	1810	0.021	11	12
105	Grasspea-Sesame-T. Aman	1790	0.021	5	6
106	Blackgram-Aus-T. Aman	1735	0.020	10	13
107	Tobacco-Sesbania-T. Aman	1620	0.019	1	2
108	Groundnut-Jute-T. Aman	1530	0.018	7	13
109	Onion-Maize-T. Aman	1490	0.017	7	9
110	Chilli-Vegetable-T. Aman	1405	0.016	15	19
111	Maize-Boro-T. Aman	1400	0.016	2	2
112	Blackcumin-Jute-T. Aman	1260	0.015	6	11
113	Sesame-Aus-T. Aman	1180	0.014	4	5
114	Potato-Mungbean-T. Aman	1140	0.013	11	13
115	Fallow-Fallow-T. Aman (Orchard)	1000	0.012	1	1
116	Coriander-Sesame-T. Aman	845	0.010	5	5
117	Vegetable-Boro-Aus-T. Aman	820	0.010	4	5
118	Potato+Sweet gourd-Aus-T. Aman	780	0.009	3	5

**Table 5. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
119	Sweet Potato-Jute- T.Aman	675	0.008	10	13
120	Potato-Onion- T.Aman	510	0.006	2	2
121	Grasspea-Mungbean- T.Aman	440	0.005	5	5
122	Chickpea-Aus-T. Aman	375	0.004	5	7
123	Sesame-Jute- T.Aman	290	0.003	2	2
124	Chickpea-Jute-T. Aman	270	0.003	7	11
125	Potato+Maize-Vegetable- T.Aman	210	0.002	2	2
126	Vegetable-Onion-Jute- T.Aman	200	0.002	1	1
127	Mungbean-Jute- T.Aman	180	0.002	9	11
128	Lentil-Mungbean-Jute- T.Aman	100	0.001	1	1
129	Mustard-Mungbean-Aus- T.Aman	100	0.001	1	1
130	Potato+S. gourd-M.bean- T.Aman	80	0.001	1	1
131	Tobacco-Mungbean- T.Aman	50	0.001	1	1
	Total of T. Aman	5574860	65.077	-	-

**Table 6. List of cropping patterns with B. Aman rice and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Boro-B. Aman	183070	2.14	32	113
02	Mustard-Boro-B. Aman	36520	0.43	14	32
03	Potato-B. Aman	23900	0.28	9	25
04	Grasspea-B. Aman	21480	0.25	21	52
05	Mustard-B. Aman	17210	0.20	12	24
06	Fallow-B. Aman	16360	0.19	15	29
07	Wheat-B. Aman	13835	0.16	16	32
08	Onion-B. Aman	10905	0.13	14	27
09	Garlic-B. Aman	10850	0.13	15	21
10	Chilli-B. Aman	9120	0.11	10	23
11	Blackgram-B. Aman	7625	0.09	11	24
12	Lentil-B. Aman	6550	0.08	16	30
13	Soybean-B. Aman	5650	0.07	4	4
14	Vegetable-B. Aman	5200	0.06	9	17
15	Maize-B. Aman	5030	0.06	10	15
16	Fallow-B. Aus+B. Aman	3470	0.04	3	5
17	Groundnut-B. Aman	2820	0.03	5	7
18	Fallow-Sesame+B. Aman	2750	0.03	5	7
19	Grasspea-Boro-B. Aman	2700	0.03	3	3
20	Pea-B. Aman	2620	0.03	11	16
21	Onion-Sesame+B. Aman	2100	0.02	2	3
22	B.gram(Fodder)-Boro-B.Aman	2000	0.02	1	1
23	Grasspea-Sesame+B. Aman	1800	0.02	2	2
24	Mustard-B.Aus+B. Aman	1780	0.02	4	4
25	Mustard-Sesame+B. Aman	1650	0.02	3	4
26	Grasspea-B.Aus+B. Aman	1580	0.02	6	8
27	Coriander-B. Aman	1480	0.02	11	1
28	Lentil-Sesame+B. Aman	980	0.01	1	1
29	Sweet Potato-B. Aman	740	0.01	6	1
30	Sesame+B. Aman-Blackgram	600	0.01	1	3
31	Water Melon-B. Aman	535	0.01	3	2

**Table 6. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
32	Potato+Maize-B. Aman	410	0.00	2	3
33	Sesame-B. Aman	330	0.00	2	2
34	Garlic+Muskmelon-B. Aman	320	0.00	1	2
35	Garlic+Water Melon-B. Aman	320	0.00	1	2
36	Musk Melon-B. Aman	215	0.00	2	5
37	Mungbean-B. Aus+B. Aman	130	0.00	4	4
	Total of B. Aman	404635	4.72	-	-

**Table 7. List of cropping patterns with Aus rice and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Boro-Aus-T. Aman	209015	2.44	47	177
02	Fallow-Aus-T. Aman	193275	2.26	30	108
03	Grasspea-Aus-T. Aman	81610	0.95	19	61
04	Mungbean-Aus-T. Aman	53730	0.63	14	43
05	Boro-Aus-Fallow	45865	0.54	34	71
06	Wheat-Aus-T. Aman	36425	0.43	35	93
07	Vegetable-Aus-T. Aman	28700	0.34	42	87
08	Soybean-Aus-T. Aman	23170	0.27	5	8
09	Potato-Aus-T. Aman	22405	0.26	29	79
10	Mustard-Boro-Aus	18140	0.21	10	16
11	Wheat-Aus-Fallow	16200	0.19	17	26
12	Vegetable-Aus-Fallow	15940	0.19	23	41
13	Groundnut-Aus-T. Aman	14535	0.17	10	18
14	Chilli-Aus-T. Aman	14240	0.17	21	38
15	Mustard-Aus-T. Aman	13790	0.16	30	52
16	Maize-Aus-Fallow	13615	0.16	14	18
17	Wheat-Aus-Blackgram	13000	0.15	6	8
18	Fallow-Aus+Non-rice ( <i>zhum</i> )	11900	0.14	3	20
19	Lentil-Aus-T. Aman	11255	0.13	25	46
20	Water Melon-Aus-T. Aman	10355	0.12	11	14
21	Felon-Aus-T. Aman	9245	0.11	7	16
22	Onion-Aus-Fallow	8705	0.10	12	17
23	Boro-Aus-Blackgram	8540	0.10	5	5
24	Mustard-Boro-Aus-T. Aman	7850	0.09	14	30
25	Chilli-Aus-Fallow	7565	0.09	14	27
26	Potato-Boro-Aus	7420	0.09	4	6
27	Tobacco-Aus-T. Aman	6040	0.07	5	12
28	Mustard-Aus-Fallow	4935	0.06	15	22
29	Lentil-Aus-Fallow	4570	0.05	11	15
30	Potato-Maize-Aus	4300	0.05	3	4
31	Onion-Aus-T. Aman	4260	0.05	17	26
32	Fallow-B. Aus+B. Aman	3470	0.04	3	5
33	Vegetable-Onion-Aus	3200	0.04	3	3
34	Tobacco-Aus-Fallow	3180	0.04	5	10
35	Potato-Boro-Aus-T. Aman	3140	0.04	5	9
36	Maize-Aus-Vegetable	3000	0.04	3	4
37	Maize-Aus-T. Aman	2970	0.03	17	27

**Table 7. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
38	Garlic-Aus-T. Aman	2400	0.03	13	20
39	Potato-Aus-Fallow	2310	0.03	13	16
40	Sweet Potato-Aus-T. Aman	2150	0.03	2	2
41	Mustard-Aus-Blackgram	1900	0.02	2	2
42	Wheat-Aus-Onion	1900	0.02	1	1
43	Onion-Aus-Blackgram	1810	0.02	5	6
44	Grasspea-Boro-Aus	1800	0.02	1	1
45	Mustard-B. Aus+B. Aman	1780	0.02	4	4
46	Blackgram-Aus-T. Aman	1735	0.02	10	13
47	Vegetable-Aus-Blackgram	1610	0.02	4	4
48	Grasspea-B. Aus+B. Aman	1580	0.02	6	8
49	Groundnut- Aus-Fallow	1550	0.02	5	5
50	Garlic-Aus-Fallow	1450	0.02	12	15
51	Fallow-Aus-Fallow	1400	0.02	3	3
52	Maize-Aus-Blackgram	1370	0.02	3	3
53	Cotton-Aus-Fallow	1330	0.02	3	3
54	Pea-Aus-Vegetable	1310	0.02	7	8
55	Sesame-Aus-Fallow	1190	0.01	3	4
56	Sesame-Aus-T. Aman	1180	0.01	4	5
57	Potato-Maize-Aus-Vegetab	1030	0.01	3	3
58	Potato-Sweet gourd-Aus	910	0.01	6	8
59	Vegetable-Boro-Aus-T. Aman	820	0.01	4	5
60	Potato+S.gourd-Aus-T. Aman	780	0.01	3	5
61	Soybean-Aus-Fallow	700	0.01	1	1
62	Wheat-Aus-Cotton	600	0.01	1	1
63	Felon-Aus-Fallow	470	0.01	2	3
64	Chickpea-Aus-T. Aman	375	0.00	5	7
65	Potato-Sesame-Aus	360	0.00	4	4
66	Grasspea-Aus-Blackgram	250	0.00	1	1
67	Mungbean-B. Aus+B. Aman	130	0.00	4	4
68	Must.-M.bean-Aus-T.Aman	100	0.00	1	1
69	Mungbean-Aus-Fallow	20	0.00	1	1
	Total of Aus	977855	11.41	-	-

**Table 8. List of cropping patterns exclusively with non-rice crops and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Vegetab-Vegetab-Vegetab	143270	1.672	61	283
02	Vegetable-Vegetable-F	63935	0.746	59	168
03	Wheat-Jute-Fallow	48700	0.568	32	82
04	Onion-Jute-Fallow	45200	0.528	29	67
05	Lentil-Jute-Fallow	32360	0.378	27	67
06	Vegetable-Fallow-Fallow	31115	0.363	35	84
07	Maize-Jute-Fallow	21425	0.250	19	33
08	Grasspea-Jute-Fallow	21000	0.245	21	39
09	Mustard-Jute-Fallow	17180	0.201	16	35
10	Groundnut-Fallow-Fallow	16485	0.192	35	76

Table 8. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
11	Potato-Jute-Fallow	14515	0.169	25	53
12	Garlic-Jute-Fallow	13475	0.157	26	48
13	Chilli-Jute-Fallow	13260	0.155	22	54
14	Vegetable-Jute-Fallow	13185	0.154	26	47
15	Maize-Fallow-Fallow	12920	0.151	22	38
16	Onion-Vegetable-Vegetable	11735	0.137	39	87
17	Potato-Sesbania	10770	0.126	05	15
18	Potato-Maize-Fallow	9640	0.113	10	16
19	Chilli-Fallow-Fallow	9265	0.108	40	66
20	Chilli-Vegetable-Fallow	8810	0.103	44	104
21	Fallow-Fallow-Blackgram	8695	0.102	34	59
22	Sweet Potato-Fallow-Fallow	7980	0.093	37	98
23	Coriander-Jute-Fallow	7390	0.086	15	25
24	Maize-Vegetable-Fallow	7120	0.083	14	19
25	Lentil-Vegetable-Vegetable	6330	0.074	19	30
26	Wheat-Vegetable-Vegetable	6100	0.071	16	21
27	Garlic-Vegetable-Vegetable	4385	0.051	27	68
28	Tobacco-Jute-Fallow	4050	0.047	04	8
29	Wheat-Jute-Blackgram	3910	0.046	07	9
30	Wheat-Fallow-Fallow	3810	0.044	06	8
31	Wheat-Chilli-Fallow	3780	0.044	07	9
32	Maize-Maize-Fallow	3720	0.043	03	5
33	Lentil-Sesame-Fallow	3680	0.043	15	20
34	Maize-Fallow-Blackgram	3600	0.042	04	4
35	Vegetable-Fallow-Blackgram	3525	0.041	16	33
36	Sweet Potato-Jute-Fallow	3380	0.039	13	21
37	Coriander-Fallow-Fallow	3175	0.037	41	64
38	Wheat-Maize-Fallow	3070	0.036	02	4
39	Sesame-Fallow-Blackgram	3060	0.036	06	10
40	Wheat-Mungbean-Fallow	2875	0.034	05	7
41	Lentil-F-F (Orchard)	2780	0.032	03	5
42	Soybean-Fallow-Fallow	2710	0.032	03	4
43	Blackgram-Jute-Fallow	2295	0.027	12	16
44	Grasspea-Fallow-Fallow	2295	0.027	09	11
45	Potato-Maize-Vegetable	2190	0.026	04	4
46	Vegetable-Maize-Fallow	2180	0.025	06	7
47	Wheat-M.bean-F(Orchard)	2150	0.025	02	3
48	Pea-Jute-Fallow	2100	0.025	10	15
49	Coriander-Vegetable-Fallow	2090	0.024	20	29
50	Potato-Chilli-Fallow	2070	0.024	10	17
51	Wheat-Maize-Vegetable	2000	0.023	02	2
52	Potato-Sesame-Fallow	1930	0.023	06	10
53	Mustard-Jute-Vegetable	1900	0.022	03	5
54	Blackcumin-Jute-Fallow	1840	0.021	06	12
55	Millet(Kaon)+Sesame-Fallow	1810	0.021	05	7
56	Grasspea-Sesbania-Fallow	1780	0.021	04	4
57	Maize-Sesame-Fallow	1580	0.018	06	8

**Table 8. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
58	Wheat-Sesame-Fallow	1550	0.018	07	8
59	Tobacco-Vegetab-Vegetab	1500	0.018	01	1
60	Vegetab-Jute-Vegetable	1450	0.017	05	5
61	Grasspea-Sesame-Fallow	1330	0.016	07	10
62	G.nut-Fallow-Blackgram	1320	0.015	03	3
63	Wheat-Jute-Vegetable	1320	0.015	06	6
64	Onion-Sesame-Fallow	1270	0.015	08	9
65	Water Melon-Fallow-Fallow	1165	0.014	09	12
66	Pea-Vegetable-Fallow	1160	0.014	04	5
67	Potato-Groundnut	1110	0.013	05	8
68	Tobacco-Fallow-Fallow	1045	0.012	05	8
69	Maize-Sesbania-Fallow	1000	0.012	01	1
70	Maize-Mungbean-Vegetable	950	0.011	03	3
71	Millet (Cheena)-F-F	935	0.011	05	6
72	Wheat-Fallow-Blackgram	900	0.011	01	1
73	Mustard-Fallow-Fallow	895	0.010	09	13
74	Wheat-Sesame-B.gram(Orchard)	760	0.009	03	3
75	Maize-Groundnut	620	0.007	01	1
76	Millet(Cheena)-Jute-Fallow	620	0.007	02	2
77	Tobacco-Maize-Vegetable	600	0.007	01	1
78	Tobacco-Sesbania	600	0.007	01	1
79	Groundnut-Sesame-Fallow	590	0.007	04	5
80	Wheat-Ginger/Turmeric	580	0.007	02	2
81	Sweet Potato-Vegetable-Fallow	540	0.006	05	9
82	Garlic-Fallow-Fallow	530	0.006	10	14
83	Onion-Maize-Fallow	520	0.006	04	4
84	Felon-Fallow-Fallow	380	0.004	03	4
85	Groundnut-Millet(Kaon)-F	380	0.004	02	2
86	Mungbean-Jute-Fallow	300	0.004	06	8
87	Mustard-Maize-Jute	200	0.002	01	1
88	Soybean-Jute-Fallow	140	0.002	02	2
89	Sunflower-Jute-Fallow	135	0.002	03	3
90	Muskmelon-Fallow-Fallow	125	0.001	05	5
91	Tobacco-Mungbean-Vegetable	40	0.000	01	1
92	Barley-Fallow-Fallow	15	0.000	01	2
	Total of exclusive non-rice area	714155	8.337	-	-

**Table 9. List of wheat-based cropping patterns and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Wheat-Jute-T. Aman	147210	1.72	43	216
02	Wheat-Fallow-T. Aman	90910	1.06	39	100
03	Wheat-Jute-Fallow	48700	0.57	32	82
04	Wheat-Aus-T. Aman	36425	0.43	35	93
05	Wheat-Mungbean-T. Aman	21760	0.25	20	50
06	Wheat-Maize-T. Aman	16320	0.19	9	14
07	Wheat-Aus-Fallow	16200	0.19	17	26
08	Wheat-B. Aman	13835	0.16	16	32
09	Wheat-Aus-Blackgram	13000	0.15	6	8

**Table 9. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
10	Wheat-Sesame-T. Aman	10650	0.12	15	33
11	Wheat-Vegetable-Vegetable	6100	0.07	16	21
12	Wheat-Vegetable-T. Aman	5205	0.06	15	25
13	Wheat-Jute-Blackgram	3910	0.05	7	9
14	Wheat-Fallow-Fallow	3810	0.04	6	8
15	Wheat-Chilli-Fallow	3780	0.04	7	9
16	Wheat-F-T. Aman(Orchard)	3700	0.04	1	2
17	Wheat-Maize-Fallow	3070	0.04	2	4
18	Wheat-Mungbean-Fallow	2875	0.03	5	7
19	Wheat-Mungbean-F (Orchard)	2150	0.03	2	3
20	Wheat-Maize-Vegetable	2000	0.02	2	2
21	Wheat-Aus-Onion	1900	0.02	1	1
22	Wheat-Sesame-Fallow	1550	0.02	7	8
23	Wheat-Jute-Vegetable	1320	0.02	6	6
24	Wheat-Fallow-Blackgram	900	0.01	1	1
25	Wheat-Sesame-B.gram(Orchard)	760	0.01	3	3
26	Wheat-Aus-Cotton	600	0.01	1	1
27	Wheat-Ginger/Turmeric	580	0.01	2	2
	Total of wheat	459220	5.36	-	-

**Table 10. List of Maize-based cropping patterns and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Maize-Fallow-T. Aman	101460	1.18	39	126
02	Potato-Maize-T. Aman	47690	0.56	19	68
03	Maize-Jute-Fallow	21425	0.25	19	33
04	Maize-Jute-T. Aman	21325	0.25	18	38
05	Wheat-Maize-T. Aman	16320	0.19	9	14
06	Maize-Aus-Fallow	13615	0.16	14	18
07	Maize-Fallow-Fallow	12920	0.15	22	38
08	Potato-Maize-Fallow	9640	0.11	10	16
09	Tobacco-Maize-T. Aman	7470	0.09	5	12
10	Maize-Vegetable-Fallow	7120	0.08	14	19
11	Mustard-Maize-T. Aman	6310	0.07	9	19
12	Maize-B. Aman	5030	0.06	10	15
13	Maize-Mungbean-T. Aman	4900	0.06	1	3
14	Vegetable-Maize-T. Aman	4500	0.05	9	15
15	Potato-Maize-Aus	4300	0.05	3	4
16	Maize-Maize-Fallow	3720	0.04	3	5
17	Maize-Fallow-Blackgram	3600	0.04	4	4
18	Maize-Maize-T. Aman	3070	0.04	6	
19	Wheat-Maize-Fallow	3070	0.04	2	4
20	Maize-Aus-Vegetable	3000	0.04	3	4
21	Maize-Aus-T. Aman	2970	0.03	17	27
22	Lentil-Maize-T. Aman	2920	0.03	4	8
23	Potato-Maize-Vegetable	2190	0.03	4	4
24	Vegetable-Maize-Fallow	2180	0.03	6	7
25	Wheat-Maize-Vegetable	2000	0.02	2	2

**Table 10. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
26	Maize-Sesame-T. Aman	1835	0.02	6	9
27	Maize-Vegetable-T. Aman	1810	0.02	11	12
28	Maize-Sesame-Fallow	1580	0.02	6	8
29	Boro-Fallow-Maize	1500	0.02	1	1
30	Onion-Maize-T. Aman	1490	0.02	7	9
31	Maize-Boro-T. Aman	1400	0.02	2	2
32	Maize-Aus-Blackgram	1370	0.02	3	3
33	Potato-Maize-Aus-Vegetab	1030	0.01	3	3
34	Maize-Sesbania-Fallow	1000	0.01	1	1
35	Maize-Mungbean-Vegetable	950	0.01	3	3
36	Maize-Groundnut	620	0.01	1	1
37	Tobacco-Maize-Vegetable	600	0.01	1	1
38	Onion-Maize-Fallow	520	0.01	4	4
39	Boro-Maize-Fallow	410	0.00	2	2
40	Potato+Maize-B. Aman	410	0.00	2	3
41	Boro-Maize-Blackgram	350	0.00	1	1
42	Potato+Maize-Veg-T. Aman	210	0.00	2	2
43	Mustard-Maize-Jute	200	0.00	1	1
	Total of maize	330030	3.85	-	-

**Table 11. List of cropping patterns with tuber crops and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Potato-Boro-T. Aman	180380	2.11	33	115
02	Potato-Maize-T. Aman	47690	0.56	19	68
03	Potato-Jute-T. Aman	28310	0.33	36	95
04	Potato-B. Aman	23900	0.28	9	25
05	Potato-Fallow-T. Aman	22715	0.27	34	108
06	Potato-Aus-T. Aman	22405	0.26	29	79
07	Potato-Boro-Fallow	19360	0.23	17	27
08	S.Potato-Fallow-T. Aman	16990	0.20	31	103
09	Potato-Jute-Fallow	14515	0.17	25	53
10	Potato-Vegetable-T. Aman	12620	0.15	30	59
11	Potato-Sesbania	10770	0.13	5	15
12	Potato-Maize-Fallow	9640	0.11	10	16
13	Sweet Potato-Fallow-Fallow	7980	0.09	37	98
14	Potato-Boro-Aus	7420	0.09	4	6
15	Potato-Maize-Aus	4300	0.05	3	4
16	Sweet Potato-Jute-Fallow	3380	0.04	13	21
17	Potato-Boro-Aus-T. Aman	3140	0.04	5	9
18	Potato-Groundnut-T. Aman	2720	0.03	3	5
19	Potato-Aus-Fallow	2310	0.03	13	16
20	Potato-Maize-Vegetable	2190	0.03	4	4
21	Potato-Boro-Jute-T. Aman	2160	0.03	4	5
22	S.Potato-Aus-T. Aman	2150	0.03	2	2
23	Potato-Chilli-Fallow	2070	0.02	10	17
24	Potato-Sesame-T. Aman	2060	0.02	15	23
25	Potato-Sesame-Fallow	1930	0.02	6	10

**Table 11. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
26	Potato-Mungbean-T. Aman	1140	0.01	11	13
27	Potato-Groundnut	1110	0.01	5	8
28	Potato-Maize-Aus-Vegetable	1030	0.01	3	3
29	Potato-Sweet gourd-Aus	910	0.01	6	8
30	Potato+S. gourd-Aus-T. Aman	780	0.01	3	5
31	Sweet Potato-B. Aman	740	0.01	6	6
32	Potato-Boro-Vegetable	700	0.01	4	4
33	Sweet Potato-Jute-T. Aman	675	0.01	10	13
34	Potato-Boro-Jute	590	0.01	2	2
35	Sweet Potato-Vegetable-Fallow	540	0.01	5	9
36	Potato-Onion-T. Aman	510	0.01	2	2
37	Potato+Maize-B. Aman	410	0.00	2	3
38	Potato-Sesame-Aus	360	0.00	4	4
39	Potato+Maize-Vegetab-T. Aman	210	0.00	2	2
40	Potato+S.gourd-Mung-T Aman	80	0.00	1	1
	Total of tuber crops	462890	5.40	-	-

not only indicated their dominance, but also their combination diversity among themselves in growing seasons round the year. Because of increasing projected population importance of rice will increase furthermore in future (Kabir *et al.*, 2015). In this table, it was noticeable that only single rice containing CPs occupied large area of the country. The most dominant of them was Boro-Fallow-Fallow followed by Fallow-Fallow-T. Aman. These two CPs occupied 13.3% and 5.95% of the NCA, respectively and together occupied 19.25% of the NCA. Boro-Fallow-Fallow is practiced in medium lowland to very lowland where inclusion of other crop is difficult. However, some of these areas, DWR can be included after Boro or short duration mustard can be included before Boro. Farmers are reluctant to cultivate DWR because of its low yield. However, short duration mustard can be included in it even with zero tillage. Single T. Aman CP is practiced in constraints soils e.g., in drought prone Barind tract or in tidal wetland. Soil in Barind tract quickly dries up in Rabi season and Rabi crop cultivation is not possible if there is no irrigation facility. In tidal saline wetland, salinity restricts other crops to be included in dry season. In nonsaline tidal wetland, in many areas water recedes late, however inundation by tidal water starts early. So Rabi crop is difficult to grow. Some of

these CPs, may possess scope of improvement in suitable areas by including non-rice crops in it and hence increase intensity and diversity. For example, short duration mustard can be included in Boro-Fallow-Fallow CP. Similarly short duration Rabi crops may be included in Fallow-Fallow-T. Aman CP.

Among the rice growing seasons, Boro is the most favourable where irrigation is made ensured. Though the area coverage of Boro stands second, next to T. Aman, it produces the highest amount of rice. Boro rice is cultivated in about 4.7 million hectares of land and Boro containing CPs occupied about 55% of NCA (Table 4). The highest Boro containing CP was Boro-Fallow- T. Aman with 26.92% of NCA. The area under this CP was about 2.3 million hectares. This CP was followed by Boro-Fallow-Fallow and then Boro-Aus- T. Aman with 13.3% and 2.44 % of NCA. There were also some minor CPs with Boro e.g., Blackgram (Fodder)-Boro-B. Aman, Grasspea-Boro-Aus etc.

In traditional agriculture, Aman was considered as the most suited season for rice culture in Bangladesh. Before the development of modern irrigation system it was only the major season for rice culture. Rice requires enough water for successful culture. Monsoon rain provides Aman rice with enough water. However, unlike Boro, it is practically rainfed

and rainfall in its growing period is unreliable. During this time other sources of water like flood, tidal water etc may be available and are adjusted to its culture. Because of different growing environments of Aman rice there are different types of Aman of which transplanted and broadcasted are the common types. Because of these varied growing environments, Aman grows in many CPs. Table 5 presents T. Aman containing CPs. There were 131 CPs containing T. Aman in it. Boro-Fallow-T. Aman was the most dominant CP accounting for about 26.92% of the NCA. The following CPs were Fallow-Fallow-T. Aman, Boro-Aus-T. Aman, Fallow-Aus-T. Aman accounting for about 5.95%, 2.44% and 2.26% of the NCA, respectively. There were some minor CPs in terms of area coverage containing T. Aman in them. Such as Lentil-Mungbean-Jute-T. Aman, Mustard-Mungbean-Aus-T. Aman, Potato Sweet gourd-Mungbean-T. Aman, Tobacco-Mungbean-T. Aman etc and each of which accounts for about 0.001% of NCA, separately.

Broadcast Aman is suited well in flood prone areas. Table 6 presents CPs with B. Aman. There were 37 CPs containing B. Aman. The most dominant CP was Boro-B. Aman covering about 2.14% of NCA. This was followed by Mustard-Boro-B. Aman, Potato-Fallow-B. Aman etc. Some B. Aman rice is cultivated as mixed crop with B. Aus or sesame where after harvest of Aus or sesame puddling is not possible and hence T. Aman cultivation is not possible. So, broadcast Aus and Aman are sown together. In some B. Aman-based CPs scavenging fish cultivation may be included in some pocket area in future to utilize the flood water.

Currently, Aus is basically cultured as transplanted crop. In the table, Aus means T. Aus and in case of broadcast Aus it is denoted by B. Aus. There were 69 CPs containing Aus in it (Table 7). These CPs have the coverage of 11.41% of NCA. The most dominant CP containing Aus in it was Boro-Aus-T. Aman which covered 2.44% of NCA. This CP was followed by Fallow-Aus- T. Aman and then Grasspea-Aus- T. Aman.

Rice and other cereal containing CPs occupied huge areas of the country (Tables 2 and 3). Contrarily there were other CPs they excluded rice in it. Ninety-two CPs were found excluding rice (Table 8). These CPs were minor considering their area coverage and altogether they contributed to 8.34% of NCA. Many nonrice crops are cultivated in our country. Thus their combination in CPs gave rise to a big number of list of CPs. Because of some special features, these CPs were developed without rice in it. As for example, in the vicinity of a city, vegetable are more profitable, so farmer grows vegetable round the year. Similarly in some charlands only groundnut is cultivated successfully and gives rise to a Groundnut-Fallow-Fallow CP.

There were 27 wheat-based CPs which occupying 5.36% of NCA (Table 9). Wheat-Jute-T. Aman was the most dominant CP followed by Wheat-Fallow-T. Aman with a NCA of 1.72% and 1.06%, respectively.

In Bangladesh, maize is cultivated in Rabi and Kharif-I seasons. In recent years, area and production of maize increased considerably. Table 10 presents maize-based CPs. The most dominant CP with maize was Maize-Fallow-T. Aman, which occupied 1.18% of NCA. Maize-based CPs altogether covered 3.85% of NCA.

Potato and sweet potato are major tuber crops. These tuber crops occupied 5.4% of the NCA (Table 11). There were 40 CPs containing potato or sweet potato. Potato-Boro-T. Aman was the most dominant CP which was followed by Potato-Maize-T. Aman CP. These CPs occupied 2.11% and 0.56% of the NCA, respectively.

In Bangladesh there are several edible oil seed crops. Mustard is the major one. Others are very minor. Mustard containing CPs are listed in Table 12. There was 24 mustard containing CPs. All these 24 CPs occupied 520,470 hectares of land accounting for over 6% of the NCA. Among those, the most dominant CP was Mustard-Boro-T. Aman and it was followed by Mustard-Boro-Fallow which occupied 184,620 and 143,130 hectares of land and found in 203 and 112 upazilas, respectively.

**Table 12. List of mustard-based cropping patterns and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Mustard-Boro-T. Aman	184620	2.16	51	203
02	Mustard-Boro-Fallow	143130	1.67	37	112
03	Mustard-Boro-B. Aman	36520	0.43	14	32
04	Mustard-Jute-T. Aman	32740	0.38	29	64
05	Mustard-Boro-Aus	18140	0.21	10	16
06	Mustard-B. Aman	17210	0.20	12	24
07	Mustard-Jute-Fallow	17180	0.20	16	35
08	Mustard-Fallow-T. Aman	14870	0.17	33	84
09	Mustard-Aus-T. Aman	13790	0.16	30	52
10	Mustard-Boro-Aus-T. Aman	7850	0.09	14	30
11	Mustard-Maize-T. Aman	6310	0.07	9	19
12	Mustard-Aus-Fallow	4935	0.06	15	22
13	Mustard-M.bean-T. Aman	4710	0.05	12	18
14	Mustard-Sesame-T. Aman	3360	0.04	12	15
15	Mustard-Boro-Jute	3000	0.04	5	7
16	Mustard-Boro-Jute-T. Aman	2980	0.03	7	13
17	Mustard-Aus-Blackgram	1900	0.02	2	2
18	Mustard-Jute-Vegetable	1900	0.02	3	5
19	Mustard-B. Aus+B. Aman	1780	0.02	4	4
20	Mustard-Sesame+B. Aman	1650	0.02	3	4
21	Mustard-Fallow-Fallow	895	0.01	9	13
22	Mustard-Boro-Sesbania	700	0.01	2	2
23	Mustard-Maize-Jute	200	0.00	1	1
24	Mustard-M.bean-Aus-T.Aman	100	0.00	1	1
	Total mustard	520470	6.08	-	-

They occupied 2.16% and 1.67% of the NCA. Mustard containing other CPs neither occupied large area nor showed their presence in greater number of upazilas. Mustard accompanied in these CPs with different rice, maize, jute, mungbean, sesame etc.

There are other edible oil seed crops, which are minor in terms of area coverage. These are sesame, groundnut, soybean, sunflower etc. There were 52 CPs containing minor edible oil seed crops (Table 13). The most dominant CP was Groundnut-Fallow-T. Aman followed by Soybean-Fallow-T. Aman. These CPs occupied only 0.341% and 0.276% of the NCA, respectively. The CP, Groundnut-Fallow-Fallow had low coverage but were present comparatively higher number of 76 upazilas. All these CPs, though occupied few areas (2.81% of NCA), perhaps were well fitted to suitable ecosystems in pocket areas.

Grasspea, mungbean, lentil, blackgram, field pea, felon are common pulses of Bangladesh. Most of the pulses are grown in Rabi season. Mungbean is grown in Kharif-I and blackgram is in Kharif-II seasons. There were 83 CPs containing pulses (Table 14). Pulses accompanied in these CPs with different rices, cereals, jute, oil crops, tuber crops. All these 83 CPs together occupied 8.78% of the NCA. Among those, the most dominant CP was Grasspea-Fallow-T. Aman. This CP was followed by Mungbean-Fallow-T. Aman. The corresponding coverages of these two patterns were 108,150 and 89,650 hectares found in 80 and 70 upazilas, respectively. These CPs occupied 1.26% and 1.06% of the NCA. Pulse containing other CPs neither occupied large area nor were present in large number of upazilas. Pulses containing CPs altogether covered 8.78% of the NCA.

In Bangladesh there are several fibre crops. Jute is the major one. It grows in Kharif-I season. There were 56 jute containing CPs (Table 15). These 56 CPs occupied 9.09% of the NCA. Among those, the most dominant CP was Wheat-Jute-T. Aman and it was followed by Onion-Jute-T. Aman which occupied 147,210 and 54,185 hectares of land and were found in 216 and 102 upazilas, respectively. These CPs occupied separately 1.72% and 0.63% of the NCA. Jute containing other CPs neither occupied large area nor were present in large number of upazilas. Jute accompanied in these CPs with different rices, mungbean,

sesame etc. Jute containing CPs usually contained Rabi or Boro crops before jute and T. Aman and fallow after jute.

CP with tobacco was cultivated in about 49,000 hectares of land (Table 16). There were 14 tobacco containing CPs and all of these together occupied 0.572% of NCA. The most dominant CP with tobacco was Tobacco-Jute-T. Aman which was followed by Tobacco-Maize-T. Aman. Tobacco was cultivated only in 12 districts in three to four clusters viz, Kushtia, Jhenaidaha, Meherpur, Lalmonirhat, Rangpur, Nilphamari, Rangamati, Bandarban, Khagrachhari, Coxsbazaar and Manikganj.

**Table 13. List of cropping pattern with minor oil crops and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
1	Groundnut-Fallow-T. Aman	29210	0.341	23	60
2	Soybean-Fallow-T. Aman	23670	0.276	5	10
3	Soybean-Aus-T. Aman	23170	0.270	5	8
4	Soybean-Jute-T. Aman	20000	0.233	4	6
5	Groundnut-Fallow-Fallow	16485	0.192	35	76
6	Groundnut- Aus-T. Aman	14535	0.170	10	18
7	Lentil-Sesame-T. Aman	12450	0.145	14	33
8	Fallow-Sesame-T. Aman	11640	0.136	13	20
9	Wheat-Sesame-T. Aman	10650	0.124	15	33
10	Sesame-Fallow-T. Aman	9265	0.108	19	31
11	Soybean-B. Aman	5650	0.066	4	4
12	Lentil-Sesame-Fallow	3680	0.043	15	20
13	Mustard-Sesame-T. Aman	3360	0.039	12	15
14	Onion-Sesame-T. Aman	3080	0.036	4	6
15	Sesame-Fallow-Blackgram	3060	0.036	6	10
16	Groundnut-B. Aman	2820	0.033	5	7
17	Fallow-Sesame+B. Aman	2750	0.032	5	7
18	Potato-Groundnut-T. Aman	2720	0.032	3	5
19	Soybean-Fallow-Fallow	2710	0.032	3	4
20	Vegetable-Groundnut-T. Aman	2660	0.031	4	5
21	Onion-Sesame+B. Aman	2100	0.025	2	3
22	Sunflower-Fallow-T. Aman	2100	0.025	7	23
23	Potato-Sesame-T. Aman	2060	0.024	15	23
24	Potato-Sesame-Fallow	1930	0.023	6	10
25	Maize-Sesame-T. Aman	1835	0.021	6	9
26	Millet(Kaon)+Sesame-Fallow	1810	0.021	5	7
27	Grasspea-Sesame+B. Aman	1800	0.021	2	2
28	Grasspea-Sesame-T. Aman	1790	0.021	5	6
29	Mustard-Sesame+B. Aman	1650	0.019	3	4
30	Maize-Sesame-Fallow	1580	0.018	6	8

**Table 13. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
31	Wheat-Sesame-Fallow	1550	0.018	7	8
32	Groundnut- Aus-Fallow	1550	0.018	5	5
33	Groundnut-Jute-T.Aman	1530	0.018	7	13
34	Grasspea-Sesame-Fallow	1330	0.016	7	10
35	Groundnut-Fallow-Blackgram	1320	0.015	3	3
36	Onion-Sesame-Fallow	1270	0.015	8	9
37	Sesame-Aus-Fallow	1190	0.014	3	4
38	Sesame-Aus-T. Aman	1180	0.014	4	5
39	Potato-Groundnut	1110	0.013	5	8
40	Lentil-Sesame+B. Aman	980	0.011	1	1
41	Coriander-Sesame-T. Aman	845	0.010	5	5
42	Wheat-Sesame-Blackgram (Orchard)	760	0.009	3	3
43	Soybean-Aus-Fallow	700	0.008	1	1
44	Maize-Groundnut	620	0.007	1	1
45	Sesame+B.Aman-Blackgram	600	0.007	1	1
46	Groundnut-Sesame-Fallow	590	0.007	4	5
47	Groundnut-Millet ( <i>kaon</i> )-Fallow	380	0.004	2	2
48	Potato-Sesame-Aus	360	0.004	4	4
49	Sesame-B. Aman	330	0.004	2	2
50	Sesame-Jute-T. Aman	290	0.003	2	2
51	Soybean-Jute-Fallow	140	0.002	2	2
52	Sunflower-Jute-Fallow	135	0.002	3	3
	Total for minor edible oil crops	240980	2.813	-	-

**Table 14. List of cropping patterns with pulse crops and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
1	Grasspea-Fallow-T. Aman	108150	1.26	25	80
2	Mungbean-Fallow-T. Aman	89650	1.05	22	70
3	Grasspea-Aus-T. Aman	81610	0.95	19	61
4	Mungbean-Aus-T. Aman	53730	0.63	14	43
5	Lentil-Jute-T. Aman	51875	0.61	34	96
6	Felon-Fallow-T. Aman	37675	0.44	14	53
7	Lentil-Jute-Fallow	32360	0.38	27	67
8	Wheat-Mungbean-T. Aman	21760	0.25	20	50
9	Grasspea-B. Aman	21480	0.25	21	52
10	Grasspea-Jute-Fallow	21000	0.25	21	39
11	Boro-Fallow-Blackgram	13270	0.15	27	44
12	Wheat-Aus-Blackgram	13000	0.15	6	8
13	Lentil-Fallow-T. Aman	12680	0.15	29	68
14	Lentil-Sesame-T. Aman	12450	0.15	14	33
15	Lentil-Aus-T. Aman	11255	0.13	25	46
16	Grasspea-Jute-T. Aman	10300	0.12	25	43
17	Felon-Aus-T. Aman	9245	0.11	7	16
18	Fallow-Fallow-Blackgram	8695	0.10	34	59
19	Boro-Aus-Blackgram	8540	0.10	5	5
20	Blackgram-B. Aman	7625	0.09	11	24

Table 14. Continued.

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
21	Lentil-Mungbean-T. Aman	6955	0.08	11	22
22	Lentil-B. Aman	6550	0.08	16	30
23	Lentil-Vegetable-Vegetable	6330	0.07	19	30
24	Maize-Mungbean-T. Aman	4900	0.06	1	3
25	Mustard-Mungbean-T. Aman	4710	0.05	12	18
26	Chickpea-Fallow-T. Aman	4700	0.05	12	32
27	Grasspea-Boro-Fallow	4690	0.05	8	12
28	Lentil-Aus-Fallow	4570	0.05	11	15
29	Wheat-Jute-Blackgram	3910	0.05	7	9
30	Lentil-Sesame-Fallow	3680	0.04	15	20
31	Maize-Fallow-Blackgram	3600	0.04	4	4
32	Vegetable-Fallow-Blackgram	3525	0.04	16	33
33	Sesame-Fallow-Blackgram	3060	0.04	6	10
34	Lentil-Maize-T. Aman	2920	0.03	4	8
35	Wheat-Mungbean-Fallow	2875	0.03	5	7
36	Lentil-Fallow-Fallow (Orchard)	2780	0.03	3	5
37	Grasspea-Boro-B. Aman	2700	0.03	3	3
38	Lentil-Vegetable-T. Aman	2660	0.03	11	11
39	Fieldpea-B. Aman	2620	0.03	11	16
40	Garlic-Mungbean-T. Aman	2500	0.03	1	2
41	Blackgram-Jute-Fallow	2295	0.03	12	16
42	Grasspea-Fallow-Fallow	2295	0.03	9	11
43	Wheat-Mung-Fallow (Orchard)	2150	0.03	2	3
44	Fieldpea-Jute-Fallow	2100	0.02	10	15
45	Blackgram(Fodder)-Boro-B. Aman	2000	0.02	1	1
46	Fieldpea-Fallow-T. Aman	1950	0.02	18	27
47	Blackgram-Jute-T. Aman	1900	0.02	11	14
48	Mustard-Aus-Blackgram	1900	0.02	2	2
49	Onion-Aus-Blackgram	1810	0.02	5	6
50	Grasspea-Boro-Aus	1800	0.02	1	1
51	Grasspea-Sesame+B. Aman	1800	0.02	2	2
52	Grasspea-Sesame-T. Aman	1790	0.02	5	6
53	Grasspea-Sesbania-Fallow	1780	0.02	4	4
54	Blackgram-Aus-T. Aman	1735	0.02	10	13
55	Vegetab-Aus-Blackgram	1610	0.02	4	4
56	Grasspea-B. Aus+B. Aman	1580	0.02	6	8
57	Maize-Aus-Blackgram	1370	0.02	3	3
58	Grasspea-Sesame-Fallow	1330	0.02	7	10
59	Groundnut-Fallow-Blackgram	1320	0.02	3	3
60	Fieldpea-Aus-Vegetable	1310	0.02	7	8
61	Fieldpea-Vegetable-Fallow	1160	0.01	4	5
62	Potato-Mungbean-T. Aman	1140	0.01	11	13
63	Lentil-Sesame+B. Aman	980	0.01	1	1
64	Maize-Mungbean-Vegetable	950	0.01	3	3
65	Wheat-Fallow-Blackgram	900	0.01	1	1
66	Wheat-Sesame-B.gram (Orchard)	760	0.01	3	3
67	Sesame+B. Aman-Blackgram	600	0.01	1	1

**Table 14. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
68	Felon-Aus-Fallow	470	0.01	2	3
69	Grasspea-Mungbean-T. Aman	440	0.01	5	5
70	Felon-Fallow-Fallow	380	0.00	3	4
71	Chickpea-Aus-T. Aman	375	0.00	5	7
72	Boro-Maize-Blackgram	350	0.00	1	8
73	Mungbean-Jute-Fallow	300	0.00	6	8
74	Chickpea-Jute-T. Aman	270	0.00	7	11
75	Grasspea-Aus-Blackgram	250	0.00	1	1
76	Mungbean-Jute-T. Aman	180	0.00	9	11
77	Mungbean-B. Aus+B. Aman	130	0.00	4	4
78	Lentil-Mungbean-Jute-T. Aman	100	0.00	1	1
79	Mustard-Mung-Aus-T. Aman	100	0.00	1	1
80	Potato+S. gourd-Mung-T Aman	80	0.00	1	1
81	Tobacco-Mungbean-T. Aman	50	0.00	1	1
82	Tobacco-Mungbean-Vegetable	40	0.00	1	1
83	Mungbean-Aus-Fallow	20	0.00	1	1
	Total of pulses	752435	8.78	-	-

**Table 15. List of jute-based cropping patterns and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Wheat-Jute-T. Aman	147210	1.72	43	216
02	Onion-Jute-T. Aman	54185	0.63	39	102
03	Lentil-Jute-T. Aman	51875	0.61	34	96
04	Wheat-Jute-Fallow	48700	0.57	32	82
05	Onion-Jute-Fallow	45200	0.53	29	67
06	Boro-Jute-T. Aman	40440	0.47	19	56
07	Mustard-Jute-T. Aman	32740	0.38	29	64
08	Lentil-Jute-Fallow	32360	0.38	27	67
09	Potato-Jute-T. Aman	28310	0.33	36	95
10	Maize-Jute-Fallow	21425	0.25	19	33
11	Maize-Jute-T. Aman	21325	0.25	18	38
12	Grasspea-Jute-Fallow	21000	0.25	21	39
13	Soybean-Jute-T. Aman	20000	0.23	4	6
14	Mustard-Jute-Fallow	17180	0.20	16	35
15	Boro-Jute-Fallow	16370	0.19	19	25
16	Tobacco-Jute-T. Aman	15200	0.18	9	19
17	Potato-Jute-Fallow	14515	0.17	25	53
18	Fallow-Jute-T. Aman	13620	0.16	18	32
19	Garlic-Jute-Fallow	13475	0.16	26	48
20	Chilli-Jute-Fallow	13260	0.15	22	54
21	Vegetable-Jute-Fallow	13185	0.15	26	47
22	Garlic-Jute-T. Aman	13090	0.15	38	78
23	Vegetable-Jute-T. Aman	11305	0.13	25	51
24	Grasspea-Jute-T. Aman	10300	0.12	25	43
25	Coriander-Jute-Fallow	7390	0.09	15	25
26	Chilli-Jute-T. Aman	7250	0.08	20	35
27	Coriander-Jute-T. Aman	4625	0.05	17	30

**Table 15. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
28	Tobacco-Jute-Fallow	4050	0.05	4	8
29	Wheat-Jute-Blackgram	3910	0.05	7	9
30	Chilli-Boro-Jute	3600	0.04	2	3
31	Sweet Potato-Jute-Fallow	3380	0.04	13	21
32	Mustard-Boro-Jute	3000	0.04	5	7
33	Mustard-Boro-Jute-T. Aman	2980	0.03	7	13
34	Blackgram-Jute-Fallow	2295	0.03	12	16
35	Potato-Boro-Jute-T. Aman	2160	0.03	4	5
36	Fieldpea-Jute-Fallow	2100	0.02	10	15
37	Blackgram-Jute-T. Aman	1900	0.02	11	14
38	Mustard-Jute-Vegetable	1900	0.02	3	5
39	Blackcumin-Jute-Fallow	1840	0.02	6	12
40	Groundnut-Jute-T. Aman	1530	0.02	7	13
41	Vegetable-Jute-Vegetable	1450	0.02	5	5
42	Wheat-Jute-Vegetable	1320	0.02	6	6
43	Blackcumin-Jute-T. Aman	1260	0.01	6	11
44	Vegetable-Boro-Jute	800	0.01	2	3
45	Sweet Potato-Jute-T. Aman	675	0.01	10	13
46	Millet (Cheena)-Jute-Fallow	620	0.01	2	2
47	Potato-Boro-Jute	590	0.01	2	2
48	Mu ngbean-Jute-Fallow	300	0.00	6	8
49	Sesame-Jute-T. Aman	290	0.00	2	2
50	Chickpea-Jute-T. Aman	270	0.00	7	11
51	Mu stard-Maize-Jute	200	0.00	1	1
52	Veg.-Onion-Jute-T. Aman	200	0.00	1	1
53	Mungbean-Jute-T. Aman	180	0.00	9	11
54	Soybean-Jute-Fallow	140	0.00	2	2
55	Sunflower-Jute-Fallow	135	0.00	3	3
56	Lentil-Mungbean-Jute-T. Aman	100	0.00	1	1
57	Total jute	778710	9.09	-	-

**Table 16. List of cropping patterns with tobacco and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Tobacco-Jute-T. Aman	15200	0.177	9	19
02	Tobacco-Maize-T. Aman	7470	0.087	5	12
03	Tobacco-Aus-T. Aman	6040	0.071	5	12
04	Tobacco-Fallow-T. Aman	5310	0.062	7	15
05	Tobacco-Jute-Fallow	4050	0.047	4	8
06	Tobacco-Aus-Fallow	3180	0.037	5	10
07	Tobacco-Boro-T. Aman	2300	0.027	3	4
08	Tobacco-Sesbania-T. Aman	1620	0.019	1	2
09	Tobacco-Vegetab-Vegetab	1500	0.018	1	1
10	Tobacco-Fallow-Fallow	1045	0.012	5	8
11	Tobacco-Maize-Vegetable	600	0.007	1	1
12	Tobacco-Sesbania	600	0.007	1	1
13	Tobacco-Mung-T. Aman	50	0.001	1	1
14	Tobacco-Mung-Vegetable	40	0.000	1	1
	Total tobacco	49005	0.572	-	-

Vegetable is cultivated in fertile and well-drained soil often near the cities and towns. It is grown round the year in three seasons or in two seasons or in one season in a piece of land (Table 17). The most dominant vegetable containing CP is Vegetable-Vegetable-Vegetable which covered 143,270 hectares of land and 1.67% of NCA and was found to cultivate in 283 upazilas. The next CP was Vegetable-Fallow-T. Aman which

covered about half of the land area of the first one and was found to cultivate in 172 upazilas. In low lying areas vegetables are usually not suitable. However, in some low lying areas vegetables are successfully cultivated in *dhap* or in sorjan system or in the bank of the *gher*. Potato, sweet potato and sweet gourd were considered separately and were not included in the vegetable containing CP's table.

**Table 17. List of cropping patterns with vegetables and area coverage, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
01	Vegetable-Vegetable-Vegetable	143270	1.672	61	283
02	Vegetable-Fallow-T. Aman	74710	0.872	45	170
03	Vegetable-Vegetable-Fallow	63935	0.746	59	168
04	Vegetab-Vegetable-T. Aman	51745	0.604	49	127
05	Vegetable-Fallow-Fallow	31115	0.363	35	84
06	Vegetable-Aus-T. Aman	28700	0.335	42	87
07	Vegetable-Boro-T. Aman	21220	0.248	22	42
08	Vegetable-Aus-Fallow	15940	0.186	23	41
09	Boro-Vegetable	13335	0.156	27	36
10	Vegetable-Jute-Fallow	13185	0.154	26	47
11	Potato-Vegetable-T. Aman	12620	0.147	30	59
12	Onion-Vegetable-Vegetable	11735	0.137	39	87
13	Vegetable-Jute-T. Aman	11305	0.132	25	51
14	Chilli-Vegetable-Fallow	8810	0.103	44	104
15	Boro-Vegetable-T. Aman	8660	0.101	9	16
16	Fallow-Vegetable-T. Aman	7130	0.083	16	29
17	Maize-Vegetable-Fallow	7120	0.083	14	19
18	Vegetable-Boro-Fallow	7100	0.083	9	10
19	Lentil-Vegetable-Vegetable	6330	0.074	19	30
20	Wheat-Vegetable-Vegetable	6100	0.071	16	21
21	Wheat-Vegetable-T. Aman	5205	0.061	15	25
22	Vegetable-B. Aman	5200	0.061	9	17
23	Vegetable-Maize-T. Aman	4500	0.053	9	15
24	Garlic-Vegetable-Vegetable	4385	0.051	27	68
25	Vegetable-Fallow-Blackgram	3525	0.041	16	33
26	Vegetable-Onion-Aus	3200	0.037	3	3
27	Maize-Aus-Vegetable	3000	0.035	3	4
28	Lentil-Vegetable-T. Aman	2660	0.031	11	11
29	Vegetable-Groundnut-T. Aman	2660	0.031	4	5
30	Potato-Maize-Vegetable	2190	0.026	4	4
31	Vegetable-Maize-Fallow	2180	0.025	6	7
32	Coriander-Vegetable-Fallow	2090	0.024	20	29
33	Wheat-Maize-Vegetable	2000	0.023	2	2
34	Mustard-Jute-Vegetable	1900	0.022	3	5
35	Maize-Vegetable-T. Aman	1810	0.021	11	12

**Table 17. Continued.**

	Cropping pattern	Area (ha)	% of NCA	No. of district	No. of upazila
36	Vegetable–Aus–Blackgram	1610	0.019	4	4
37	Tobacco–Vegetable–Vegetable	1500	0.018	1	1
38	Vegetable–Jute–Vegetable	1450	0.017	5	5
39	Chilli–Vegetable–T. Aman	1405	0.016	15	19
40	Wheat–Jute–Vegetable	1320	0.015	6	6
41	Pea–Aus–Vegetable	1310	0.015	7	8
42	Fieldpea–Vegetable–Fallow	1160	0.014	4	5
43	Potato–Maize–Aus–Vegetable	1030	0.012	3	3
44	Maize–Mungbean–Vegetable	950	0.011	3	3
45	Vegetable–Boro–Aus–T. Aman	820	0.010	4	5
46	Vegetable–Boro–Jute	800	0.009	2	3
47	Potato–Boro–Vegetable	700	0.008	4	4
48	Tobacco–Maize–Vegetable	600	0.007	1	1
49	Sweet Potato–Vegetable–Fallow	540	0.006	5	9
50	Potato+Maize–Vegetable–T. Aman	210	0.002	2	2
51	Vegetable–Onion–Jute–T. Aman	200	0.002	1	1
52	Tobacco–Mungbean–Vegetable	40	0.000	1	1
	Total of CP with vegetable	606215	7.077	-	-

If a single one CP is considered, its geographical distribution also produce valuable information. Table 18 presents district-wise distribution of the most dominant CP, Boro-Fallow-T. Aman. This CP generally occupies medium high land area. Maximum area under this CP was in Mymensingh district with 188,650 hectares of land followed by Dinajpur district with 138,400

hectares of land. This CP was practiced in 63 districts. However, in Munshiganj, there was no Boro-Fallow-T. Aman CP. Because here, T. Aman is extremely rare. The lowest area under this CP was in Borguna. In Mymensingh, this CP occupied about 65.13% of its NCA as indicated by ‘% of district NCA’. In Mymensingh, the area under this CP was 8.18% of its total area of the country.

**Table 18. Distribution of the most dominant Boro-Fallow- T. Aman cropping pattern and area coverage in Bangladesh, 2014-15.**

	District	Area (ha)	% of district NCA	% coverage of the pattern in BD
01	Mymensingh	188650	65.13	8.18
02	Dinajpur	138400	49.99	6.00
03	Netrokona	98300	49.22	4.26
04	Gaibandha	96670	63.87	4.19
05	Naogaon	96400	35.59	4.18
06	Tangail	84000	36.04	3.64
07	Kurigram	83500	55.91	3.62
08	Rangpur	81300	46.39	3.53
09	Jessore	80700	42.48	3.50
10	Bogra	80200	36.10	3.48
11	Jamalpur	75300	46.83	3.27
12	Sherpur	69000	68.62	2.99
13	Nilphamari	65300	53.70	2.83
14	Jhenaidaha	54900	39.26	2.38
15	Chittagong	46420	23.19	2.01
16	Thakurgaon	45050	30.36	1.95
17	Lalmonirhat	44600	45.12	1.93

Table 18. Continued.

District	Area (ha)	% of district NCA	% coverage of the pattern in BD
18 Sunamganj	43100	16.12	1.87
19 CoxBazar	42400	49.66	1.84
20 Satkhira	40950	33.72	1.78
21 Kishoreganj	40300	20.17	1.75
22 Comilla	38710	18.71	1.68
23 Sirajganj	38200	20.82	1.66
24 Bhola	35650	19.13	1.55
25 Sylhet	34200	16.27	1.48
26 B.Baria	34010	24.39	1.47
27 Panchagarh	32400	31.70	1.41
28 Narsingdi	31500	43.60	1.37
29 Barisal	31050	19.59	1.35
30 Chuadanga	28800	32.56	1.25
31 Feni	28800	40.04	1.25
32 Gazipur	27100	31.74	1.18
33 Natore	25490	18.85	1.11
34 Narail	24950	33.73	1.08
35 Maulvibazar	24650	19.34	1.07
36 Rajshahi	22400	13.40	0.97
37 Magura	20800	27.44	0.90
38 Lakshmipur	20200	20.22	0.88
39 Khulna	19870	15.64	0.86
40 Bagerhat	19600	17.26	0.85
41 Joypurhat	19200	24.46	0.83
42 Habiganj	19070	11.32	0.83
43 Kushtia	17900	15.60	0.78
44 Chandpur	14690	15.97	0.64
45 Chapainawabganj	14100	11.71	0.61
46 Noakhali	12460	6.28	0.54
47 Meherpur	9800	18.12	0.42
48 Khagrachhari	9570	21.59	0.42
49 Pabna	8650	4.69	0.38
50 Pirojpur	6540	7.95	0.28
51 Faridpur	6080	4.34	0.26
52 Jhalakati	5450	10.50	0.24
53 Rajbari	5450	7.17	0.24
54 Bandarban	5170	12.69	0.22
55 Rangamati	4660	10.67	0.20
56 Gopalganj	2900	2.56	0.13
57 Narayanganj	2200	5.54	0.10
58 Dhaka	2040	2.99	0.09
59 Madaripur	1800	2.16	0.08
60 Patuakhali	1670	0.79	0.07
61 Shariatpur	1455	1.87	0.06
62 Manikganj	980	1.05	0.04
63 Barguna	350	0.35	0.02
Bangladesh	2306005	26.92	100.00

Table 19 presents district-wise distribution of the second most dominant CP, Boro-Fallow-Fallow. This CP is usually distributed in low lying areas like flood-prone areas, *haor*, *bil*, *charland* and riverbank areas. This CP was dominantly present in Sunamganj, Kishoreganj, Netrokona and Gopalganj districts. In Sunamganj, about 68% of its NCA was under this CP. Therefore, rest of about 32% of land remained for other CPs in the district. It indicated the suitability of Boro-Fallow-Fallow CP in Sunamganj as it is mainly consisted of low lying areas. This CP in Sunamganj occupied about 16% of the total of this CP in Bangladesh.

In Bangladesh, in some areas, there are some special conditions because of which crop cultivation is difficult in different seasons, e.g., in saline-prone areas or in tidal nonsaline areas or in extreme drought-prone areas with no irrigation facility. In these areas only T. Aman crop is cultivated in Kharif-II season which gives rise to Fallow-Fallow-T. Aman CP. Table 20 presents district-wise distribution of this CP. The highest coverage of this CP was found in Chittagong district which covered 33% of the area of this district. This CP in Chittagong district contributed 13% of this CP's total coverage of the country. In 36 districts this CP was noticed.

Similarly district-wise distribution of 4th, 5th and 6th dominant CPs viz, Boro-Aus-T. Aman, Fallow-Aus-T. Aman and Mustard-Boro-T. Aman are presented (Tables 21, 22 and 23).

Districtwise distribution of AC is presented in Table 24. The major ACs viz, banana, betel leaf, ginger, papaya, pineapple, sugarcane and turmeric were included in it. Individual AC and total AC area are mentioned in this table. AC production was the highest in Tangail which was followed by Natore and then Rangamati.

Districtwise total number of CPs, total number of crops, diversity index of CPs and crops are presented in Table 25. Comilla had the highest number of different CPs of 117 which was followed by Kushtia of 116 and then Jessore 101. The maximum number of 30 crops were cultivated in Munshiganj

which was followed by the four districts viz, Comilla, Faridpur, Manikganj and Noakhali each of which cultivated 28 crops. Pabna had the highest CP diversity which was followed by Rajshahi and then Kushtia. Pabna had the highest crop diversity which was followed by Rajshahi and then Kushtia as well.

## CONCLUSION

A better understanding of the crop growing systems is essential to formulate ecologically and socioeconomically sustainable crop production programme. Therefore, quantitative measurement of crop distribution in an area is very important. To explore the potential of CPs it is necessary to integrate the available technologies to increase the total yield. Extension of agricultural land is not possible in Bangladesh. Moreover, NCA is decreasing at an alarming rate because of high population pressure. Identification of major CPs and exploring their potential is important. Increase production through utilizing fallow period in CP can create scope for sustainable improvement of agricultural production system.

This study had made this scope of improvement by creating relevant data base. This study identified all the CPs of Bangladesh. Ecologically well adjusted CPs dominated for their area coverage in appropriate environments. Regional distribution of CPs was also identified. These results will hopefully help further planning of potentials of CPs for production.

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**Table 19. Distribution of the 2<sup>nd</sup> dominant Boro-Fallow-Fallow cropping pattern and area coverage in Bangladesh, 2014-15.**

District	Area (ha)	% of district NCA	% coverage of the pattern in BD
01 Sunamganj	181600	67.91	15.94
02 Kishoreganj	102000	51.04	8.95
03 Netrokona	78200	39.16	6.86
04 Gopalganj	66300	58.60	5.82
05 B.Barua	58050	41.63	5.09
06 Habiganj	55900	33.18	4.91
07 Sylhet	44450	21.15	3.90
08 Noakhali	43000	21.66	3.77
09 Comilla	34630	16.74	3.04
10 Mymensing	30320	10.47	2.66
11 Gazipur	25150	29.46	2.21
12 Naogaon	24100	8.90	2.11
13 Moulvibazar	22850	17.93	2.01
14 Chandpur	22100	24.03	1.94
15 Sirajganj	21700	11.82	1.90
16 Sariatpur	21500	27.56	1.89
17 Barisal	21450	13.54	1.88
18 Jessore	19030	10.02	1.67
19 Madaripur	18700	22.42	1.64
20 Dhaka	17750	26.05	1.56
21 Munsiganj	16400	26.54	1.44
22 Narayanganj	16400	41.33	1.44
23 Narsingdi	16100	22.29	1.41
24 Bagerhat	13700	12.07	1.20
25 Natore	12830	9.49	1.13
26 Tangail	12550	5.39	1.10
27 Pirojpur	11100	13.49	0.97
28 Kurigram	10600	7.10	0.93
29 Pabna	9600	5.21	0.84
30 Rajshahi	9150	5.48	0.80
31 Rangpur	7470	4.26	0.66
32 Khulna	7150	5.63	0.63
33 Satkhira	7000	5.76	0.61
34 Faridpur	6700	4.79	0.59
35 Gaibandha	6700	4.43	0.59
36 Jhenaidah	6560	4.69	0.58
37 Rajbari	6550	8.62	0.57
38 Narail	6200	8.38	0.54
39 Bogra	6000	2.70	0.53
40 Jamalpur	5180	3.22	0.45
41 Manikganj	5180	5.55	0.45
42 Rangamati	4250	9.73	0.37
43 Laxmipur	4200	4.20	0.37
44 Chapainawabganj	4050	3.36	0.36
45 Sherpur	2950	2.93	0.26
46 Kushtia	2450	2.13	0.22

**Table 19. Continued.**

District	Area (ha)	% of district NCA	% coverage of the pattern in BD
47 Chuadanga	2200	2.49	0.19
48 Jhalkathi	2200	4.24	0.19
49 Lalmonirhat	2100	2.12	0.18
50 Magura	1970	2.60	0.17
51 Nilphamari	1450	1.19	0.13
52 Coxsbazar	860	1.01	0.08
53 Bandarban	700	1.72	0.06
54 Meherpur	600	1.11	0.05
55 Thakurgaon	500	0.34	0.04
56 Chittagong	400	0.20	0.04
57 Patuakhali	350	0.17	0.03
58 Feni	250	0.35	0.02
59 Dinajpur	150	0.05	0.01
Total	1139530	13.30	100.00

**Table 20. Distribution of the 3<sup>rd</sup> dominant Fallow-Fallow-T. Aman cropping pattern and area coverage in Bangladesh, 2014-15.**

District	Area (ha)	% of district NCA	% coverage of the pattern in country
01 Chittagong	66500	33.23	13.05
02 Sylhet	58250	27.72	11.43
03 Khulna	42000	33.05	8.24
04 Patuakhali	35600	16.81	6.99
05 Bagerhat	33700	29.68	6.61
06 Noakhali	32900	16.57	6.46
07 Moulvibazar	25070	19.67	4.92
08 Pirojpur	24620	29.92	4.83
09 Sunamganj	21900	8.19	4.30
10 Satkhira	21200	17.46	4.16
11 Borguna	19200	19.26	3.77
12 Feni	15600	21.69	3.06
13 Habiganj	12340	7.33	2.42
14 Chapainawab	11800	9.80	2.32
15 Barisal	11130	7.02	2.18
16 Coxsbazar	10400	12.18	2.04
17 Khagrachhari	9050	20.42	1.78
18 Jhalkathi	8200	15.80	1.61
19 Gazipur	7850	9.20	1.54
20 Naogaon	7300	2.69	1.43
21 Bhola	7200	3.86	1.41
22 Bandarban	5030	12.35	0.99
23 Netrokona	5000	2.50	0.98
24 Rangamati	3530	8.08	0.69
25 Comilla	3430	1.66	0.67
26 Mymensing	2600	0.90	0.51
27 Kishoreganj	2260	1.13	0.44
28 Tangail	1700	0.73	0.33
29 Bogra	1550	0.70	0.30
30 Sherpur	1320	1.31	0.26
31 Rangpur	350	0.20	0.07

**Table 20. Continued.**

	District	Area (ha)	% of district NCA	% coverage of the pattern in country
32	Jessore	300	0.16	0.06
33	Dinajpur	200	0.07	0.04
34	Laxmipur	200	0.20	0.04
35	Narsingdi	100	0.14	0.02
36	Panchgarh	100	0.10	0.02
	Total	509480	5.95	100.00

**Table 21. Distribution of the 4<sup>th</sup> dominant Boro-Aus-T. Aman cropping pattern and area coverage in Bangladesh, 2014-15.**

	District	Area (ha)	% of district NCA	% coverage of the pattern in country
01	Comilla	50680	24.49	24.25
02	Bogra	14290	6.43	6.84
03	Habiganj	14200	8.43	6.79
04	Naogaon	13600	5.02	6.51
05	Kishoreganj	12350	6.18	5.91
06	Jessore	11500	6.05	5.50
07	Bhola	10000	5.37	4.78
08	Chandpur	9280	10.09	4.44
09	Chittagong	9250	4.62	4.43
10	Mymensing	8000	2.76	3.83
11	Kushtia	6650	5.79	3.18
12	Chapainawabganj	6640	5.52	3.18
13	Brahmanbaria	4870	3.49	2.33
14	Rangpur	4570	2.61	2.19
15	Coxsbazar	3500	4.10	1.67
16	Natore	3400	2.51	1.63
17	Moulvibazar	3040	2.38	1.45
18	Pabna	2950	1.60	1.41
19	Satkhira	2780	2.29	1.33
20	Sirajganj	2450	1.34	1.17
21	Laxmipur	2200	2.20	1.05
22	Jhenaidah	1700	1.22	0.81
23	Rajshahi	1650	0.99	0.79
24	Dinajpur	1575	0.57	0.75
25	Sherpur	1350	1.34	0.65
26	Gazipur	1120	1.31	0.54
27	Noakhali	1070	0.54	0.51
28	Bagerhat	950	0.84	0.45
29	Kurigram	880	0.59	0.42
30	Sylhet	600	0.29	0.29
31	Magura	500	0.66	0.24
32	Khagrachhari	200	0.45	0.10
33	Rangamati	200	0.46	0.10
34	Gaibandha	170	0.11	0.08
35	Khulna	165	0.13	0.08
36	Jhalkathi	100	0.19	0.05
37	Pirojpur	100	0.12	0.05

**Table 21. Continued.**

	District	Area (ha)	% of district NCA	% coverage of the pattern in country
38	Sariatpur	100	0.13	0.05
39	Narsingdi	90	0.12	0.04
40	Bandarban	80	0.20	0.04
41	Feni	50	0.07	0.02
42	Jalpur	50	0.03	0.02
43	Rajbari	50	0.07	0.02
44	Patuakhali	30	0.01	0.01
45	Nilphamari	20	0.02	0.01
46	Joypurhat	10	0.01	0.00
47	Tangail	5	0.00	0.00
	Total	209015	2.44	100.00

**Table 22. Distribution of the 5<sup>th</sup> dominant Fallow-Aus-T. Aman cropping pattern and area coverage in Bangladesh, 2014-15.**

	District	Area (ha)	% of district NCA	% coverage of the pattern in country
01	Sylhet	35600	16.94	18.42
02	Moulvibazar	33900	26.59	17.54
03	Habiganj	23825	14.14	12.33
04	Jhalkathi	12300	23.70	6.36
05	Noakhali	12200	6.15	6.31
06	Chittagong	9290	4.64	4.81
07	Pirojpur	8800	10.70	4.55
08	Borguna	8540	8.57	4.42
09	Barisal	8400	5.30	4.35
10	Mymensing	8400	2.90	4.35
11	Rajshahi	4500	2.69	2.33
12	Feni	4200	5.84	2.17
13	Sunamganj	3730	1.39	1.93
14	Comilla	3350	1.62	1.73
15	Bhola	2900	1.56	1.50
16	Kishoreganj	2200	1.10	1.14
17	Patuakhali	2060	0.97	1.07
18	Bagerhat	1740	1.53	0.90
19	Naogaon	1620	0.60	0.84
20	Laxmipur	1200	1.20	0.62
21	Khagrachhari	1110	2.50	0.57
22	Sherpur	1100	1.09	0.57
23	Brahmanbaria	810	0.58	0.42
24	Netrokona	410	0.21	0.21
25	Satkhira	380	0.31	0.20
26	Coxsazar	250	0.29	0.13
27	Rangamati	210	0.48	0.11
28	Khulna	100	0.08	0.05
29	Tangail	100	0.04	0.05
30	Gazipur	50	0.06	0.03
	Total	193275	2.26	100.00

**Table 23. Distribution of the 6<sup>th</sup> dominant Mustard-Boro-T. Aman cropping pattern and area coverage in Bangladesh, 2014-15.**

District	Area (ha)	% of district NCA	% coverage of the pattern in country
01 Naogaon	22600	8.34	12.24
02 Bogra	19800	8.91	10.72
03 Tangail	14150	6.07	7.66
04 Jamalpur	11500	7.15	6.23
05 Dinajpur	10250	3.70	5.55
06 Joypurhat	9900	12.61	5.36
07 Sirajganj	9810	5.35	5.31
08 Kurigram	8000	5.36	4.33
09 Thakurgaon	7650	5.16	4.14
10 Jhenaidaha	7050	5.04	3.82
11 Gaibandha	6650	4.39	3.60
12 Jessore	6000	3.16	3.25
13 Sherpur	5450	5.42	2.95
14 Magura	5100	6.73	2.76
15 Manikganj	4720	5.05	2.56
16 Rangpur	3950	2.25	2.14
17 Mymensing	2930	1.01	1.59
18 Nilphamari	2850	2.34	1.54
19 Bhola	2570	1.38	1.39
20 Meherpur	2400	4.44	1.30
21 Satkhira	2390	1.97	1.29
22 Dhaka	1710	2.51	0.93
23 Narsingdi	1610	2.23	0.87
24 Madaripur	1510	1.81	0.82
25 Kishoreganj	1450	0.73	0.79
26 Lalmonirhat	1390	1.41	0.75
27 Chapainawabganj	1300	1.08	0.70
28 Rajshahi	1250	0.75	0.68
29 Chandpur	1000	1.09	0.54
30 Narail	950	1.28	0.51
31 Netrokona	940	0.47	0.51
32 B.Barua	900	0.65	0.49
33 Panchagarh	820	0.80	0.44
34 Kushtia	700	0.61	0.38
35 Pabna	600	0.33	0.32
36 Natore	500	0.37	0.27
37 Sunamganj	500	0.19	0.27
38 Coxsbazar	420	0.49	0.23
39 Chuadanga	400	0.45	0.22
40 Chittagong	210	0.10	0.11
41 Comilla	200	0.10	0.11
42 Gazipur	110	0.13	0.06
43 Narayanganj	100	0.25	0.05
44 Khulna	80	0.06	0.04
45 Barisal	70	0.04	0.04
46 Habiganj	50	0.03	0.03
47 Rajbari	50	0.07	0.03
48 Faridpur	30	0.02	0.02
49 Lakshmipur	30	0.03	0.02
50 Khagrachhari	10	0.02	0.01
51 Maulvibazar	10	0.01	0.01
<b>Total</b>	<b>184620</b>	<b>2.16</b>	<b>100.00</b>

**Table 24. Distribution of annual crops in different districts of Bangladesh, 2014-15.**

	District	Banana	Betel leaf	Ginger	Papaya	Pineapple	Sugarcane	Turmeric	Total
01	Brahmanbaria	17	0	75	34	0	80	84	290
02	Bagerhat	1290	1080	0	110	0	920	30	3430
03	Bandarban	7120	0	1410	840	2835	215	1260	13680
04	Barguna	150	355	0	65	3	57	0	630
05	Barisal	1235	2678	6	465	0	600	111	5095
06	Bhola	2735	510	60	490	15	1060	335	5205
07	Bogra	973	0	128	165	0	84	170	1520
08	Chandpur	195	200	63	15	0	410	62	945
09	Chapainawabganj	590	0	100	220	0	10150	100	11160
10	Chittagong	2320	420	710	842	162	381	345	5180
11	Chuadanga	480	2000	10	10	0	645	255	3400
12	Comilla	286	130	37	71	30	360	66	980
13	Coxsbazar	464	2705	80	136	25	350	70	3830
14	Dhaka	310	0	30	270	0	60	70	740
15	Dinajpur	1095	40	280	55	0	2050	625	4145
16	Faridpur	1315	20	0	480	0	3525	250	5590
17	Feni	95	0	0	35	0	150	0	280
18	Gaibandha	998	130	190	47	0	2415	330	4110
19	Gazipur	3575	0	305	2205	120	775	540	7520
20	Gopalganj	515	5	0	240	0	1020	10	1790
21	Habiganj	157	120	132	98	200	310	183	1200
22	Jamalpur	550	40	70	0	120	1935	95	2810
23	Jessore	1050	1130	50	135	0	475	1180	4020
24	Jhalakati	1515	580	3	420	0	190	122	2830
25	Jhenaidaha	4335	2335	5	495	0	1880	1100	10150
26	Joypurhat	562	0	59	31	0	520	328	1500
27	Khagrachhari	1800	0	3020	160	415	345	4480	10220
28	Khulna	190	570	10	45	0	80	185	1080
29	Kishoreganj	747	0	77	232	0	267	167	1490
30	Kurigram	713	5	350	72	0	270	350	1760
31	Kushtia	2380	2120	25	80	0	1925	750	7280
32	Laksmipur	160	20	0	40	0	140	40	400
33	Lalmonirhat	160	0	330	10	0	110	680	1290
34	Madaripur	210	192	0	140	0	493	5	1040
35	Magura	455	154	0	71	0	200	780	1660
36	Manikganj	110	0	40	50	0	2100	50	2350
37	Maulvibazar	480	25	255	20	750	20	270	1820
38	Meherpur	1460	0	0	0	0	170	710	2340
39	Munsiganj	55	0	15	10	0	85	25	190
40	Mymensingh	435	267	450	136	228	2669	1875	6060
41	Naogaon	730	0	125	150	0	1225	270	2500
42	Narail	255	235	5	35	0	825	315	1670
43	Narayanganj	40	0	0	30	0	110	0	180
44	Narsingdi	2140	300	0	160	190	60	0	2850
45	Natore	1110	10	50	110	0	15040	920	17240
46	Netrokona	27	0	82	32	0	27	142	310
47	Nilphamari	210	0	870	45	0	175	1010	2310

**Table 24. Continued.**

	District	Banana	Betel leaf	Ginger	Papaya	Pineapple	Sugarcane	Turmeric	Total
48	Noakhali	1350	10	0	68	0	112	0	1540
49	Pabna	305	10	0	90	0	4605	910	5920
50	Panchagarh	175	20	260	5	0	1150	700	2310
51	Patuakhali	353	634	0	90	0	157	111	1345
52	Pirojpur	880	478	8	105	5	373	281	2130
53	Rajbari	600	0	0	25	0	1245	490	2360
54	Rajshahi	1080	295	0	590	0	8045	410	10420
55	Rangamati	7666	0	2420	305	1245	199	2545	14380
56	Rangpur	1285	50	865	50	0	1200	900	4350
57	Satkhira	460	445	10	59	21	132	703	1830
58	Shariatpur	365	80	0	120	0	635	60	1260
59	Sherpur	40	5	270	0	0	25	420	760
60	Sirajganj	280	0	200	120	0	1670	170	2440
61	Sunamganj	145	0	28	100	10	195	32	510
62	Sylhet	68	0	5	759	203	50	15	1100
63	Tangail	6085	30	1685	275	7530	955	3690	20250
64	Thakurgaon	290	0	100	50	0	1950	400	2790
	Bangladesh	69221	20433	15358	12413	14107	79651	32582	243765

**Table 25. Crop diversity and cropping intensity of different districts in Bangladesh, 2014-15.**

	District	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01	B.Barria	62	18	0.757	0.883	165
02	Bagerhat	53	20	0.848	0.921	161
03	Bandarban	49	24	0.953	0.963	138
04	Barguna	29	17	0.868	0.939	218
05	Barisal	74	20	0.911	0.955	192
06	Bhola	61	25	0.933	0.972	228
07	Bogra	96	27	0.803	0.925	248
08	Chandpur	74	22	0.880	0.945	190
09	ChapaiN.ganj	62	18	0.944	0.975	217
10	Chittagong	63	25	0.826	0.924	180
11	Chuadanga	48	23	0.867	0.945	224
12	Comilla	117	28	0.868	0.932	210
13	CoxBazar	44	22	0.725	0.856	197
14	Dhaka	67	25	0.889	0.937	196
15	Dinajpur	75	22	0.723	0.889	228
16	Faridpur	96	28	0.942	0.972	225
17	Feni	34	22	0.777	0.879	183
18	Gaibandha	52	23	0.583	0.807	210
19	Gazipur	47	26	0.801	0.880	161
20	Gopalganj	57	25	0.643	0.824	146

Table 25. Continued.

District	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
21 Habiganj	46	21	0.827	0.916	170
22 Jamalpur	77	22	0.762	0.898	220
23 Jessore	101	25	0.799	0.920	225
24 Jhalakati	40	21	0.891	0.944	189
25 Jhenaidaha	76	26	0.833	0.931	223
26 Joypurhat	45	19	0.697	0.879	267
27 Khagrachhari	47	23	0.900	0.929	151
28 Khulna	52	21	0.839	0.922	159
29 Kishoreganj	91	21	0.694	0.852	156
30 Kurigram	78	25	0.673	0.854	214
31 Kushtia	116	26	0.955	0.982	240
32 Lakshmipur	44	21	0.878	0.945	240
33 Lalmonirhat	44	22	0.750	0.897	223
34 Madaripur	57	24	0.910	0.967	204
35 Magura	55	26	0.878	0.980	251
36 Manikganj	75	28	0.917	0.958	212
37 Maulvibazar	47	20	0.819	0.894	168
38 Meherpur	40	21	0.932	0.973	239
39 Munsiganj	38	30	0.835	0.915	177
40 Mymensingh	71	24	0.562	0.779	199
41 Naogaon	90	23	0.848	0.936	221
42 Narail	37	21	0.850	0.932	210
43 Narayanganj	45	27	0.800	0.906	158
44 Narsingdi	54	23	0.753	0.861	181
45 Natore	68	22	0.939	0.972	210
46 Netrokona	54	20	0.603	0.746	160
47 Nilphamari	59	21	0.695	0.875	224
48 Noakhali	49	28	0.892	0.953	178
49 Pabna	90	29	0.970	0.987	230
50 Panchagarh	65	24	0.862	0.938	216
51 Patuakhali	51	22	0.893	0.951	203
52 Pirojpur	50	24	0.858	0.930	162
53 Rajbari	50	26	0.937	0.971	234
54 Rajshahi	99	27	0.964	0.984	221
55 Rangamati	41	25	0.944	0.954	128
56 Rangpur	70	22	0.768	0.907	227
57 Satkhira	62	22	0.840	0.923	193
58 Shariatpur	72	25	0.905	0.963	178
59 Sherpur	44	20	0.522	0.785	213
60 Sirajganj	100	30	0.891	0.950	206
61 Sunamganj	52	24	0.506	0.656	123
62 Sylhet	38	21	0.820	0.894	151
63 Tangail	89	29	0.842	0.922	204
64 Thakurgaon	50	23	0.887	0.955	240
Bangladesh	316	48	0.896	0.952	200

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## REFERENCES

- Ali, M Y. 2014. Farming Systems of Bangladesh: Poverty Escape Pathways and Livelihood Improvement. Pub. by: Anjuman Ara, D-186/7, Nazrul Sarani, Middle Sayabithi, Joorpukur, Gazipur 1700, Bangladesh.
- Anonymous. 2016a. Statistical Year Book of Bangladesh 2015. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning.
- Anonymous. 2016b. Year Book of Agricultural Statistics-2015. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning.
- Catling, H D, D W Puckridge and D H Lambers. 1988. The environment of Asian deepwater rice. *In: Proceeding of the 1987 international deepwater rice workshop.* International Rice Research Institute, P. O. Box 933, Manila, Philippines.
- Chowdhury, M K A, M R I Mondal and M A Quayyum. 2008. Proceedings of the National Workshop on Research and Development of Multiple Cropping Systems in Bangladesh held at Bangladesh Agriculture Research Council, Farmgate, Dhaka-1215, Bangladesh, held on 23-24 April, 2008.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p
- Hasan, M N, M S Hossain, M A Bari and M R Islam. 2013. Agricultural land availability in Bangladesh. SRDI, Dhaka, Bangladesh.
- Hossain, M I, M Y Rahman and P Bala. 2016. Agricultural adaptations for climate change in Dacope upazila of Bangladesh. Bangladesh Res. Pub. J. 12 (1): 60-70.
- Kabir, M S, M U Salam, A Chowdhury, N M F Rahman, K M Iftekharuddaula, M S Rahman, M H Rashid, S S Dipti, A Islam, M A Latif, A K M S Islam, M M Hossain, B Nessa, T H Ansari, M A Ali and J K Biswas. 2015. Rice vision for Bangladesh: 2050 and beyond. Bangladesh Rice J. 19(2): 1-18.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, IRRI, Philippines.
- Khush G S. 1984. Terminology for rice growing environments. *In: Terminology for rice growing environments.* International Rice Research Institute, P. O. Box 933, Manila, Philippines.
- Miah, N M, A U Ahmed and B A A Mustafi. 2004. Adopting modern rice technologies in flood-prone areas: status, constraints and opportunities. *In: Rice research and development in the flood-prone ecosystem. Proceedings of the international workshop on flood-prone rice systems held in Gazipur, Bangladesh, 9-11 January 2001.* International Rice Research Institute, P. O. Box 933, Manila, Philippines.
- Nur-E-Elahi, A H Khan, M R Siddique, A Saha, M Nasim, M I U Mollah and S M Shahidullah. 2001. Existing Cropping Patterns of Bangladesh, Potential Technologies and Strategies for Improving Systems Productivity. *In: Proceedings of the Workshop on Modern Rice Cultivation in Bangladesh, held on 14-16 February 1999 at Bangladesh Rice Research Institute, Gazipur.* BRRI Publication No. 132.
- Rahman, M M, M A Aziz, M A Musa and J Kumar. 1995. Prospects of pulse crops in the rice-based cropping system in Bangladesh. *In: Fragile lives in fragile ecosystems. Proceedings of the international rice research conference, 13-17 February 1995.* International Rice Research Institute, P.O. Box 933, Manila, Philippines.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Sujatha, P J, S Punithavathi, Tamilenthil and R Baskaran. 2011. Land use pattern and cropping pattern of Orthanadu Block, Thanjavur district, Tamil Nadu using GIS. *J. Experimental Sci.* 2(5): 19-23.



# 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 3<sup>rd</sup> 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 Daulatkhani	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 2<sup>nd</sup> 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 3<sup>rd</sup> 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 3<sup>rd</sup>

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 4<sup>th</sup> 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 5<sup>th</sup> 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
<b>Barisal region</b>	<b>103</b>	<b>32</b>	<b>0.931</b>	<b>0.968</b>	<b>204</b>

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.

## REFERENCES

- Alam, M S. 1994. Optimum cropping patterns of the small farmers under risk: a micro level study in Bangladesh. PhD thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.
- Singh, J. and R S Sidhu. 2006. Accounting for impact of environmental degradation in agriculture of Indian Punjab. *Agric. Economics Res. Rev.* 19: 37-48.
- Tscharntke, T, R Bommarco, Y Clough, T O Crist, D Klein, T A Rand, J M Tylanakis, S vanNouhuys, and S Vidal. 2007. Conservation biological control and enemy diversity on a landscape scale. *Biol. Control.* 43: 294-309.
- Tscharntke, T., A M Klein, A Kruess, I S Dewenter, and C Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity-ecosystem service management. *Ecol. Lett.* 8: 857-874.

**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

# Diversity of Cropping Pattern in Bogra

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## ABSTRACT

With a view to document the existing cropping patterns, cropping intensity and crop diversity, a study was carried out over all the upazilas of Bogra agricultural region during 2015-16. A pre-tested semi-structured questionnaire was properly used for this purpose. In the findings it was recorded that 21.88% of net cropped area (NCA) of the region was occupied by the cropping pattern Boro-Fallow-T. Aman. This pattern was found to be distributed over 27 upazilas out of 35. The second largest area, 13.26% of NCA, was covered by Potato-Boro-T. Aman, which was spread over 17 upazilas. A total of 177 cropping patterns were identified in the whole region in this investigation. The highest number of cropping patterns was identified 36 in Nandigram upazila and the lowest was six in Dupchachia and Kahalu upazila of Bogra district. The lowest crop diversity index (CDI) was reported 0.718 in Raiganj upazila of Sirajganj district followed by 0.734 in Kalai of Joypurhat. The highest value of CDI was observed 0.978 in Pabna sadar followed by 0.972 in Bera upazila. The range of cropping intensity values was recorded 183-291%. The maximum value was for Khetlal upazila of Joypurhat district and minimum for Bera of Pabna. As a whole the CDI of Bogra region was calculated 0.966 and the average cropping intensity at regional level was 234%.

**Key words:** Diversity index, land use, cropping system and flash flood

## INTRODUCTION

A total of 35 upazilas of four districts formed the Bogra agricultural region. It has a wide diversity in land topography and soil characters ranging from river-eroded area to Barind Tract. This region belongs to Tista Meander Floodplain (AEZ-3), Karatoa-Bangali Floodplain (AEZ-4), Lower Atrai Basin (AEZ-5), Active Brahmaputra-Jamuna Floodplain (AEZ-7), Active Ganges Floodplain (AEZ-10), High Ganges River Floodplain (AEZ-11), Low Ganges River Floodplain (AEZ-12), Level Barind Tract (AEZ-25) and North-eastern Barind Tract (AEZ-27) (FAO, 1988).

Majority area of this region is very suitable for agricultural crop production especially in cereals and vegetables. The cropping intensity is much higher than the other region of the country. Shortage of surface water, serious flooding and river erosion are location-specific critical problems. Low moisture-holding capacity, low organic matter content and low

natural fertility are special characters of the Barind Tract.

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

The yields of cereal crops are tending to stagnation, even in favourable environments. Moreover, cultivable land area is decreasing

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day by day in the country. To increase the system productivity of the total environment it needs to bring diversity in enterprises for better utilization of limited resources. Detailed information on land situation and cropping systems is a prerequisite for a fruitful development programme. 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). 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 adaptation or inequity in the society over long term. Existing trends of available agricultural lands is most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these contexts, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The specific objectives of the present study were to:

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

## METHODOLOGY

Thirty-five upazilas of Bogra, Joypurhat, Pabna, and Sirajganj districts under Bogra 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 35 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during October 2015 at upazila level. SAAOs were purposively pre-

selected by Agriculture Extension Officers (AEO), Additional Agriculture Officer (AAO) and Upazila Agriculture Officer (UAO) or altogether. Prior to data collection, the pre-tested questionnaire was explained along with proper guidelines to the AEOs or UAOs or both and handed over to them at each Deputy Director's office of Department of Agricultural Extension (DAE) during monthly meeting for the sake of accurate data collection. The filled questionnaires were collected by the scientists of RFS Division, checked and analyzed to find the inconsistencies of the supplied data before validation workshop. All the inconsistencies among the information were documented. The collected data along with documented inconsistencies were discussed in district level workshop for necessary correction and validation. Second stage of data collection was a day-long data validation workshop at district level. The workshop dates were 26 November 2015 for Sirajganj; 14 January 2016 for Bogra; 2 February 2016 for Pabna; and 20 September 2016 for Joypurhat. Four field-workers i.e. one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRI regional station, Kushtia, and Rangpur, participated in the data validation workshop. The number of participants of validation workshop ranged from 50 to 92 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFS scientists to finalize and validate the data and authenticated data were captured. Crop diversity index was calculated by using the following equation described by Kshirsagar *et al.* (1997).

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

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

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

## RESULTS AND DISCUSSION

### Land use

Table 1 presents the status of agricultural land utilization. The net cropped area of the Bogra region is 668,440 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, sugarcane, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 10 to 3,500 ha. The annual crops area accounted only 1.70 % of the net cropped area (NCA) in the region. At a glance the region possesses 7.58% single cropped area (SCA), 48.09% double cropped area (DCA), 41.15% triple cropped area (TCA). The quadruple cropped area also exists as a very negligible portion (0.76%) and was limited in only six upazilas viz Bogra, Dhunat, Nandigram, Sherpur, Sonatola and Atghoria. Most of the upazilas of Bogra and Joypurhat district cropping intensity was very high (246%-291%) which were dominating by the TCA over SCA and DCA (Table 1). The TCA had the major share of NCA in Adamdighi, Bogra *sadar*, Dupchachia, Kahalu, Nandigram, Shibganj and Sonatola upazilas of Bogra district, all five upazilas of Joypurhat district, Iswardi, Pabna sadar and Santhia of Pabna district and Kazipur of Sirajganj district. A few upazilas were dominated by DCA viz-Dhunat, Gabtali, Sariahandi, Sherpur and Shajahanpur of Bogra district. In Pabna district Atghoria, Bera, Bhangura, Chatmohar, Faridpur and Sujanager upazilas and in Sirajganj district all upzilas except Kazipur were dominated by DCA over SCA and TCA (Table 1). The area which could not defined under SCA, DCA,

TCA or QCA was considered as others whose coverage is less than 1% of the NCA. For availability of irrigation water in dry season, supply of modern varieties of various crops, skilled technology transfer system, knowledge of modern crop management practices, good communication and marketing facilities helped increasing land use efficiency in a given area (FAO, 1988).

### Cropping patterns of Bogra

In total 177 cropping patterns were observed in Bogra region of which six cropping patterns with exclusive rice crop covers about 34% of the NCA. There were 55 cropping patterns with exclusive non-rice crop occupying over 12% of the NCA. Rest of the NCA i.e. about 54% area is covered by 116 rice - non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Table 2 presents six cropping patterns where rice was the only crop round the year. It comprises about 34% of the NCA in the region. Among them single rice, double rice and triple rice areas represent around 6%, 25% and 3% respectively. It reflects the unparallel dominance of rice in the cropping systems in Bogra region. In case of individual pattern, Boro-Fallow-T. Aman has the highest coverage (approx. 22%) and was recorded in 27 upazilas out of 35. The second dominant pattern single Boro area occupied 5.68% of NCA which was reported in 21 upazilas. Boro-Aus-T. Aman covered 3% of NCA and was obsrved in 15 upazilas. Single T. Aman area was very negligible (0.23%) with its existence in only two upazilas.

In the current investigation, 55 cropping patterns were identified that was free from rice. Among these 55 patterns first 40 have been arranged in descending order in Table 3. The rest 15 patterns with negligible area coverage (Table 9) where they are arranged with other patterns of different categories. Aggregate of the 55 patterns have engaged 82,815 hectares of land, which is equivalent to more than 12% of NCA in the region. In critical comparison it is clear that exclusive rice area is about three

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Adamdighi	16890	40	200	4450	7920	0	130	12740	261
02 Bogra	17734	150	0	1940	8700	300	110	11200	282
03 Dhunat	24712	50	920	14750	3570	150	100	19540	215
04 Dubchachia	16426	30	0	3090	10490	0	110	13720	277
05 Gabtali	24375	120	1210	12980	4710	0	140	19160	218
06 Kahalu	23879	30	60	4700	14310	0	130	19230	274
07 Nandigram	26551	10	0	9000	9500	3700	100	22310	276
08 Sariakandi	40858	40	3700	15620	4850	0	130	24340	205
09 Sherpur	29640	130	1490	15010	6390	790	130	16040	227
10 Shibganj	31148	150	0	3360	21960	0	120	23950	282
11 Shajahanpur	22108	620	630	7860	7290	0	130	26070	241
12 Sonatola	15693	150	730	5790	6920	130	130	13850	246
13 Akkelpur	14046	90	0	4100	6505	0	145	10840	260
14 Joyprhat	23864	800	100	6030	12340	0	130	19400	259
15 Kalai	16636	10	0	1485	12280	0	135	13910	289
16 Khetlal	14260	30	10	1010	10490	0	140	11680	291
17 Panchbibi	27853	570	0	9800	12100	0	200	22670	251
18 Atghoria	18380	220	800	6710	6130	30	130	14020	237
19 Bera	24871	700	3540	12330	1250	0	180	18000	183
20 Bhangura	13428	80	2170	6890	1780	0	160	11080	196
21 Chatmohar	29405	120	1150	17950	5700	0	150	25070	218
22 Faridpur	13897	40	1000	9350	1000	0	150	11540	200
23 Iswardi	26947	3500	30	2590	12530	0	150	18800	247
24 Pabna sadar	44259	700	1580	11000	22200	0	120	35600	256
25 Santhia	33152	270	0	5950	19100	0	150	25470	274
26 Sujanagar	33444	290	3750	16100	4370	0	180	24690	201
27 Belkuchi	16254	50	0	10300	2440	0	160	12950	219
28 Chowhali	23209	10	4440	4220	3940	0	100	12710	196
29 Kazipur	34763	300	9280	5840	7350	0	130	22900	190
30 Kamarkhanda	9163	120	540	4220	2700	0	140	7720	227
31 Raiganj	26667	400	1100	17880	2300	0	120	21800	203
32 Shahjadpur	32462	10	1870	16900	6000	0	120	24900	217
33 Sirajganj	30855	1500	1240	16550	4220	0	190	23700	206
34 Tarash	29732	10	3675	17635	3305	0	125	24750	198
35 Ullapara	41461	40	5440	18070	8390	0	150	32090	209
Bogra region		11380	50655	321460	275030	5100	4815	668440	234

SCA-Single cropped area, DCA-Double cropped area, TCA-Triple cropped are, QCA-Quadruple cropped area, NCA-Net cropped area and C.I.-Cropping Intensity.

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-T. Aman	146250	21.87	27
02 Boro-Fallow-Fallow	37300	5.58	21
03 Boro-Aus-T. Aman	19700	2.95	15
04 Boro-B. Aman	18650	2.79	10
05 Fallow-Fallow-T. Aman	1550	0.23	2
06 Boro-Aus-Fallow	670	0.10	3
Total area for exclusive rice	225000	33.66	-

NCA-Net cropped area.

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	16030	2.40	22
02 Onion-Jute-Fallow	10080	1.51	5
03 Lentil-Jute-Fallow	6650	0.99	10
04 Chilli-Jute-Fallow	4620	0.69	10
05 Groundnut-Fallow-Fallow	4280	0.64	9
06 Wheat-Jute-Fallow	4090	0.61	11
07 Vegetab-Vegetab-Fallow	3730	0.56	10
08 Maize-Jute-Fallow	3300	0.49	6
09 Onion-Vegetab-Vegetab	3100	0.46	14
10 Maize-Fallow-Fallow	2520	0.38	5
11 Wheat-Vegetab-Vegetab	2100	0.31	3
12 Millet ( <i>kaon</i> )+Sesame-Fallow	1720	0.26	4
13 Chilli-Vegetab-Fallow	1650	0.25	10
14 Potato-Maize-Vegetab	1500	0.22	1
15 Vegetab-Jute-Fallow	1240	0.19	4
16 Fallow-Fallow-Blackgram	1210	0.18	6
17 Grasspea-Fallow-Fallow	1005	0.15	3
18 Vegetab-Onion-Aus	1000	0.15	1
19 Wheat-Sesame-Fallow	1000	0.15	3
20 Vegetab-Fallow-Fallow	900	0.13	3
21 Wheat-Fallow-Blackgram	900	0.13	1
22 Lentil-Sesame-Fallow	810	0.12	4
23 Groundnut-Fallow-Blackgram	800	0.12	1
24 S.Potato-Jute-Fallow	780	0.12	3
25 Chilli-Fallow-Fallow	710	0.11	4
26 S.Potato-Fallow-Fallow	675	0.10	14
27 Coriander-Vegetab-Fallow	630	0.09	2
28 Grasspea-Jute-Fallow	550	0.08	3
29 Sesame-Fallow-Blackgram	500	0.07	1
30 Wheat-Jute-Blackgram	500	0.07	1
31 Garlic-Jute-Fallow	430	0.06	2
32 Grasspea-Sesbania-Fallow	400	0.06	1
33 Groundnut-Millet ( <i>kaon</i> )-Fallow	380	0.06	2
34 Vegetab-Jute-Vegetab	380	0.06	1
35 Onion-Sesame-Fallow	350	0.05	2
36 Garlic-Vegetab-Vegetab	345	0.05	9
37 Groundnut-Sesame-Fallow	300	0.04	1
38 Lentil-Vegetab-Vegetab	270	0.04	5
39 Wheat-Fallow-Fallow	230	0.03	1
40 Vegetab-Fallow-Blackgram	200	0.03	3
41-55 Other 15 patterns (in Table 9)	950	0.14	-
Total area for non-rice exclusive	82815	12.39	

folds of exclusive non-rice area. In Bogra region crop diversity is much wider than that of other regions like Sylhet and Chittagong where exclusive rice area covers 37 folds and 23 folds, respectively of exclusive non-rice

area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). 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).

### **Deep water rice**

Table 4 presents deep water rice dominating 21 patterns which together covered 9.48% of NCA. Among them, first 18 patterns cover 63,160 ha whereas other three minutely distributed patterns cover only 220 ha (Table 9). Boro-B. Aman cropping pattern covers the highest area of 18,650 hectares which represents about 2.79% of the regions NCA. This pattern is distributed over 10 upazilas out of 35. The second highest Wheat-B. Aman cropping pattern covers 7,920 hectares and distributed over only six upazilas. Grasspea-B. Aman is the third dominant cropping pattern under deep water ecosystem which is distributed over the highest number of upazilas. Deep water rice with lentil, maize, pea and grass pea were the narrow existence covered only 0.3 % of NCA. The water level of this ecosystem ranges between 150 and 400 cm, and water usually remains 3-4 months. Special rice varieties known as 'floating rice' are planted in these areas. In the past Bangladesh had had a land coverage of 3 million hectares for deepwater rice (Jackson *et al.*, 1972). In course of time the continuous effort on modern agriculture shifted DWR area mainly to modern Boro. Now the area under deep water rice in Bangladesh is reduced to 0.4 million hectares (Nasim *et al.*, 2017). Though this cropping system is less productive than other modern cropping systems, however, the specific fragile ecosystem still struggling because of no other alternatives.

### **Non-rice cereal crops**

There were forty-three cropping patterns recorded in Table 5. In these patterns wheat and maize were major crops whereas barley and millets (*cheena* and *kaon*) were recognized as minor crops. Wheat-Jute-T. Aman was the most dominant pattern which possessed 2.18% of NCA and reported in 24 upazilas out of 35.

In this documentation the aggregate of non-rice cereal cropping patterns covered 9.61% of NCA. The total area coverage under non-rice cereal crops is 64,475 ha where the first 31 patterns presented in the Table 5 covered 63,730 ha. The remaining 12 patterns are scatteredly distributed over the region which is presented in Table 9. The area coverage of these 12 patterns is only 745 ha which is about 0.11% of the net cropped area.

### **Oil-seed crops**

Table 6 presents 31 cropping patterns of oil seed crops. Among the patterns the first 34 patterns possessed 135,700 ha whereas other five patterns covered only 385 ha (Table 9). Mustard is covering the largest area whereas groundnut is cultivated in the smallest area among the oil-seed crops. The mustard crop alone was leading 15 cropping patterns with an area coverage of 111,050 ha which is equivalent to 16.61% of NCA in the region and it is four-fifths of the total oil-seed crop area. Mustard-Boro-T. Aman is a favorite cropping pattern reported in 25 upazilas in this region and the area coverage is about 6.00% of NCA although the highest area coverage among the oil-seed crops is covered by Mustard-Boro-Fallow cropping pattern (7.62% of NCA).

### **Pulse crops**

In total 41 cropping patterns of the pulse crops are enlisted in the Table 7. Among them grasspea was covering the largest area (17,445 ha) whereas pea is cultivated in the smallest area (680 ha). Lentil-Jute-Fallow was the dominant cropping pattern in respect of area coverage under pulse crop in the region on the other hand Grasspea-B. Aman was the most widely distributed pulse crop pattern over the region (Table 7). The total area coverage of pulse crop is about 49,585 hectares of which 34 patterns listed in the Table 7 covered 48,880 ha area. The remaining 705 ha area is covered by other seven patterns which are presented in the Table 9. In case of pea there are only two cropping patterns viz Pea-B. Aman and Pea-Aus-Vegetable. These two patterns together occupied only 0.1% of NCA. In the documentation of pulse

**Table 4. Cropping patterns under deep water rice ecosystem in Bogra region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-B. Aman	18650	2.79	10
02 Wheat-B. Aman	7920	1.18	6
03 Grasspea-B. Aman	6470	0.97	12
04 Mustard-Boro-B. Aman	5000	0.75	4
05 Onion-B. Aman	3650	0.55	7
06 Garlic-B. Aman	3100	0.46	4
07 Blackgram-B. Aman	2950	0.44	5
08 Grasspea-Boro-B. Aman	2600	0.39	2
09 Mustard-B. Aman	2300	0.34	3
10 Blackgram (Fod)-Boro-B. Aman	2000	0.30	1
11 Onion-Sesame+B. Aman	1800	0.27	2
12 Grasspea-Sesame+B. Aman	1700	0.25	1
13 Fallow-Sesame+B. Aman	1400	0.21	2
14 Lentil-Sesame+B. Aman	980	0.15	1
15 Mustard-B. Aus+B. Aman	800	0.12	1
16 Lentil-B. Aman	790	0.12	4
17 Maize-B. Aman	650	0.10	2
18 Pea-B. Aman	400	0.06	2
19-21 Other three patterns (in Table 9)	220	0.03	-
Total DW rice	63380	9.48	

**Table 5. Cropping patterns for non-rice cereal crops in Bogra region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Jute-T. Aman	14540	2.18	24
02 Wheat-B. Aman	7920	1.18	6
03 Wheat-Aus-Fallow	4700	0.70	2
04 Wheat-Jute-Fallow	4090	0.61	11
05 Wheat-Aus-T. Aman	3630	0.54	13
06 Maize-Jute-Fallow	3300	0.49	6
07 Maize-Fallow-Fallow	2520	0.38	5
08 Wheat-Sesame-T. Aman	2470	0.37	7
09 Maize-Jute-T. Aman	2255	0.34	4
10 Wheat-Vegetab-Vegetab	2100	0.31	3
11 Wheat-Mungbean-T. Aman	1990	0.30	6
12 Millet ( <i>kaon</i> )+Sesame-Fallow	1720	0.26	4
13 Wheat-Fallow-T. Aman	1560	0.23	3
14 Millet ( <i>kaon</i> )-Fallow-T. Aman	1500	0.22	1
15 Potato-Maize-Vegetab	1500	0.22	1
16 Potato-Maize-T. Aman	1200	0.18	4
17 Wheat-Sesame-Fallow	1000	0.15	3
18 Wheat-Fallow-Blackgram	900	0.13	1
19 Wheat-Maize-T. Aman	700	0.10	1
20 Maize-B. Aman	650	0.10	2
21 Maize-Fallow-T. Aman	640	0.10	5
22 Wheat-Jute-Blackgram	500	0.07	1
23 Groundnut-Millet ( <i>kaon</i> )-Fallow	380	0.06	2
24 Maize-Maize-T. Aman	330	0.05	4
25 Maize-Aus-Fallow	320	0.05	3
26 Maize-Sesame-T. Aman	300	0.04	1
27 Potato-Maize-Aus	300	0.04	1
28 Potato-Maize-Aus-Vegetab	300	0.04	1
29 Wheat-Fallow-Fallow	230	0.03	1
30 Millet ( <i>cheena</i> )-Jute-Fallow	170	0.03	1
31 Barley-Fallow-Fallow	15	0.00	2
32-43 Other 12 patterns (in Table 9)	745	0.11	-
Total for non-rice cereal crops	64475	9.61	

**Table 6. Cropping patterns of oil-seed crops in Bogra region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-Fallow	50940	7.62	15
02 Mustard-Boro-T. Aman	40110	6.00	25
03 Mustard-Boro-B. Aman	5000	0.75	4
04 Groundnut-Fallow-Fallow	4280	0.64	9
05 Mustard-Jute-T. Aman	2700	0.40	3
06 Mustard-Boro-Aus	2560	0.38	2
07 Wheat-Sesame-T. Aman	2470	0.37	7
08 Mustard-Boro-Aus-T. Aman	2330	0.35	4
09 Mustard-B. Aman	2300	0.34	3
10 Mustard-Aus-T. Aman	2200	0.33	4
11 Onion-Sesame-T. Aman	2200	0.33	2
12 Onion-Sesame+B. Aman	1800	0.27	2
13 Millet ( <i>kaon</i> )+Sesame-Fallow	1720	0.26	4
14 Grasspea-Sesame+B. Aman	1700	0.25	1
15 Lentil-Sesame-T. Aman	1680	0.25	6
16 Fallow-Sesame+B. Aman	1400	0.21	2
17 Wheat-Sesame-Fallow	1000	0.15	3
18 Lentil-Sesame+B. Aman	980	0.15	1
19 Grasspea-Sesame-T. Aman	970	0.15	2
20 Lentil-Sesame-Fallow	810	0.12	4
21 Groundnut-Fallow-Blackgram	800	0.12	1
22 Mustard-B.Aus+B. Aman	800	0.12	1
23 Mustard-Boro-Jute	700	0.10	1
24 Potato-Sesame-T. Aman	600	0.09	2
25 Groundnut-Jute-T. Aman	500	0.07	1
26 Sesame-Fallow-Blackgram	500	0.07	1
27 Mustard-Aus-Blackgram	400	0.06	1
28 Mustard-Mungbean-T. Aman	400	0.06	1
29 Groundnut-Millet ( <i>kaon</i> )-Fallow	380	0.06	2
30 Onion-Sesame-Fallow	350	0.05	2
31 Mustard-Sesame-T. Aman	320	0.05	2
32 Groundnut-Sesame-Fallow	300	0.04	1
33 Maize-Sesame-T. Aman	300	0.04	1
34 Sesame-Aus-Fallow	200	0.03	1
35-39 Other five patterns (in Table 9)	385	0.06	-
Total oil-seed crops	136085	20.36	

crop grasspea reported its widest spreading in the region. One pattern is available in 12 out of 35 upazilas. Finally the aggregate area of the pulse crop cropping system stands for 7.42% of the NCA in Bogra region.

### Vegetables and spices crops

Fifty-three cropping patterns have been arranged in descending order according to area coverage (Table 8). Potato and other vegetables of Rabi, Kharif-I and Kharif-II; spices viz chilli, onion, garlic are included in this list. A row is included at the end of the Table 8 representing

an aggregate of 25 patterns of vegetables and spices, which is elaborately presented in the Table 9 with other patterns of different categories. The most contributing cropping pattern is Potato-Boro-T. Aman covering about 13.26% of NCA, which was distributed over 17 upazilas. Year round vegetable was the second most dominant cropping pattern which possessed 16,030 ha covering 2.40% of NCA and recorded in 22 upazilas out of 35. Onion-Jute-Fallow is the third dominant pattern but exists only in five upazilas. Among the spices onion occupied the major area under

**Table 7. Cropping patterns of pulse crops in Bogra region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Lentil-Jute-Fallow	6650	0.99	10
02 Grasspea-B. Aman	6470	0.97	12
03 Lentil-Aus-T. Aman	3340	0.50	9
04 Blackgram-B. Aman	2950	0.44	5
05 Grasspea-Boro-Fallow	2950	0.44	5
06 Grasspea-Boro-B. Aman	2600	0.39	2
07 B.gram(Fodder)-Boro-B. Aman	2000	0.30	1
08 Wheat-Mungbean-T. Aman	1990	0.30	6
09 Boro-Fallow-Blackgram	1960	0.29	7
10 Grasspea-Sesame+B. Aman	1700	0.25	1
11 Lentil-Sesame-T. Aman	1680	0.25	6
12 Fallow-Fallow-Blackgram	1210	0.18	6
13 Grasspea-Fallow-Fallow	1005	0.15	3
14 Lentil-Sesame+B. Aman	980	0.15	1
15 Lentil-Jute-T. Aman	975	0.15	7
16 Grasspea-Sesame-T. Aman	970	0.15	2
17 Wheat-Fallow-Blackgram	900	0.13	1
18 Lentil-Sesame-Fallow	810	0.12	4
19 Grasspea-Jute-T. Aman	800	0.12	1
20 Groundnut-Fallow-Blackgram	800	0.12	1
21 Lentil-B. Aman	790	0.12	4
22 Onion-Aus-Blackgram	740	0.11	3
23 Grasspea-Jute-Fallow	550	0.08	3
24 Sesame-Fallow-Blackgram	500	0.07	1
25 Wheat-Jute-Blackgram	500	0.07	1
26 Boro-Aus-Blackgram	410	0.06	2
27 Grasspea-Sesbania-Fallow	400	0.06	1
28 Mustard-Aus-Blackgram	400	0.06	1
29 Mustard-Mungbean-T. Aman	400	0.06	1
30 Pea-B. Aman	400	0.06	2
31 Lentil-Aus-Fallow	300	0.04	3
32 Pea-Aus-Vegetab	280	0.04	1
33 Lentil-Vegetab-Vegetab	270	0.04	5
34 Vegetab-Fallow-Blackgram	200	0.03	3
35-41 Other seven patterns (in Table 9)	705	0.11	
Total pulse crop	49585	7.42	

cultivation. Vegetables like colocasia, okra, amaranths, brinjal, cucurbits, etc are grown in medium upland adjacent to rice fields during rainy season and potato, sweet gourd, cole crops, leafy vegetables etc are grown during winter season in Tripura (Das *et al.*, 2015).

#### **Sporadic and distinct cropping patterns**

There are some cropping patterns which are extremely location-specific, however, with a large area coverage. The Blackgram (fodder)-Boro-B. Aman is grown on 2,000 hectares (Table 7) in Shahjadpur upazila of Sirajganj

district. It is a unique pattern in Bangladesh. Shahjadpur is the main centre of the milch cattle/cow under the supervision of Milk Vita Cooperative Systems. Now-a-days other NGO and private enterprises are also going there for milk collection. For feeding these cattle the farmers of the locality has adopted this cropping system. In this system blackgram is grown as relay crop where the seeds of blackgram are broadcast in the standing deepwater rice at flowering stage. After harvesting of rice, blackgram is rapidly grown and are subjected to cattle feeding at green stage. Grasspea-

**Table 8. Cropping patterns for vegetables and spices crops in Bogra region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Boro-T. Aman	88610	13.26	17
02 Vegetab-Vegetab-Vegetab*	16030	2.40	22
03 Onion-Jute-Fallow	10080	1.51	5
04 Onion-Jute-T. Aman	9330	1.40	12
05 Vegetab-Boro-T. Aman	4760	0.71	7
06 Chilli-Jute-Fallow	4620	0.69	10
07 Boro-Vegetab(Float/Norm**)	4000	0.60	6
08 Vegetab-Vegetab-Fallow	3730	0.56	10
09 Onion-B. Aman	3650	0.55	7
10 Garlic-B. Aman	3100	0.46	4
11 Onion-Vegetab-Vegetab	3100	0.46	14
12 Chilli-Jute-T. Aman	2300	0.34	2
13 Potato-Boro-Aus-T. Aman	2250	0.34	2
14 Onion-Sesame-T. Aman	2200	0.33	2
15 Wheat-Vegetab-Vegetab	2100	0.31	3
16 Vegetab-Aus-Fallow	2060	0.31	5
17 Onion-Aus-T. Aman	1910	0.29	3
18 Onion-Sesame+B. Aman	1800	0.27	2
19 Vegetab-Fallow-T. Aman	1790	0.27	6
20 Potato-Vegetab-T. Aman	1670	0.25	5
21 Vegetab-Aus-T. Aman	1665	0.25	6
22 Chilli-Vegetab-Fallow	1650	0.25	10
23 Potato-Maize-Vegetab	1500	0.22	1
24 Potato-Jute-T. Aman	1280	0.19	7
25 Vegetab-Jute-Fallow	1240	0.19	4
26 Chilli-Aus-Fallow	1210	0.18	4
27 Potato-Maize-T. Aman	1200	0.18	4
28 Vegetab-Vegetab-T. Aman	1030	0.15	4
29 Garlic-Aus-T. Aman	1010	0.15	2
30 Vegetab-Onion-Aus	1000	0.15	1
31 Vegetab-Jute-T. Aman	980	0.15	3
32 Vegetab-Fallow-Fallow	900	0.13	3
33 Potato-Boro-Fallow	750	0.11	3
34 Onion-Aus-Blackgram	740	0.11	3
35 Chilli-Fallow-Fallow	710	0.11	4
36 Garlic-Jute-T. Aman	700	0.10	6
37 Coriander-Vegetab-Fallow	630	0.09	2
38 Potato-Sesame-T. Aman	600	0.09	2
39 Chilli-Aus-T. Aman	430	0.06	2
40 Garlic-Jute-Fallow	430	0.06	2
41 Garlic-Fallow-T. Aman	420	0.06	5
42 Vegetab-Jute-Vegetab	380	0.06	1
43 Onion-Sesame-Fallow	350	0.05	2
44 Garlic-Vegetab-Vegetab	345	0.05	9
45 Potato-Boro-Vegetab	300	0.04	1
46 Potato-Maize-Aus	300	0.04	1
47 Potato-Maize-Aus-Vegetab	300	0.04	1
48 Vegetab-Boro-Jute	300	0.04	2
49 Pea-Aus-Vegetab	280	0.04	1
50 Lentil-Vegetab-Vegetab	270	0.04	5
51 Boro-Vegetab-T. Aman	200	0.03	2
52 Potato-Fallow-T. Aman	200	0.03	1
53 Vegetab-Fallow-Blackgram	200	0.03	3
54-78 Other 25 patterns (in Table 9)	1485	0.22	-
Total vegetab and spices	194075	29.03	

**Table 9. Rare cropping patterns covering non-significant area in Bogra region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Mustard-Maize-T. Aman	190	0.03	1	Sherpur
02	Potato-Aus-T. Aman	180	0.03	2	Shahjahanpur+Pabna sadar
03	Blackgram-Jute-Fallow	170	0.03	2	Sonatola+Kazipur
04	Millet( <i>cheena</i> )-Jute-Fallow	170	0.03	1	Sariakandi
05	Vegetab-Boro-Fallow	170	0.03	1	Chowhali
06	Grasspea-B.Aus+B. Aman	160	0.02	2	Kazipur+Sirajganj sadar
07	Coriander-Fallow-Fallow	150	0.02	2	Bhangura+Chowhali
08	S.Potato-Fallow-T. Aman	115	0.02	3	Kalai+Khetlal+Kazipara
09	Wheat-Mungbean-Fallow	105	0.02	2	Pabna sadar+Tarash
10	Lentil-Mungbean-T. Aman	100	0.02	1	Pabna sadar
11	Maize-Aus-T. Aman	100	0.02	2	Shajahanpur+Pabna sadar
12	Mustard-Boro-Jute-T. Aman	100	0.02	1	Sonatola
13	Potato-Boro-Jute-T. Aman	90	0.01	1	Sherpur
14	Onion-Fallow-T. Aman	80	0.01	2	Dubchachia+Khetlal
15	Pea-Fallow-T. Aman	80	0.01	1	Chowhali
16	Vegetab-Maize-T. Aman	80	0.01	2	Shajahanpur+Tarash
17	Maize-Vegetab-T. Aman	70	0.01	1	Shajahanpur
18	Onion-Aus-Fallow	70	0.01	2	Adamdighi+Kazipur
19	Onion-Maize-T. Aman	70	0.01	1	Sherpur
20	Potato-S.gourd-Aus	70	0.01	2	Gabtali+Akkelpur
21	Garlic-Fallow-Fallow	60	0.01	1	Dhunat
22	Coriander-Sesame-T. Aman	55	0.01	2	Pabna+Tarash
23	Blackgram-Aus-T. Aman	50	0.01	1	Sherpur
24	S.Potato-Vegetab-Fallow	50	0.01	1	Bogra sadar
25	Blackcumin-Jute-Fallow	40	0.01	1	Chowhali
26	Chilli-Vegetab-T. Aman	40	0.01	1	Dubchachia
27	Grasspea-Aus-T. Aman	40	0.01	1	Atghoria
28	Maize-Maize-Fallow	40	0.01	1	Shajahanpur
29	Muskmelon-Fallow-Fallow	40	0.01	1	Sirajganj sadar
30	Chilli-B. Aman	30	0.00	1	Bera
31	Coriander-Jute-Fallow	30	0.00	1	Kazipur
32	Garlic-Aus-Fallow	30	0.00	1	Adamdighi
33	Maize-Sesame-Fallow	30	0.00	1	Tarash
34	Potato+S.gourd-Aus-T. Aman	30	0.00	1	Sonatola
35	W.Melon-B. Aman	30	0.00	1	Tarash
36	Blackcumin-Jute-T. Aman	20	0.00	1	Kazipur
37	Maize-Vegetab-Fallow	20	0.00	1	Shibganj
38	Potato-Maize-Fallow	20	0.00	1	Sirajganj sadar
39	Barley-Fallow-Fallow	15	0.00	2	Chowhali+Tarash
40	Chilli-Fallow-T. Aman	10	0.00	1	Kalai
41	Fallow-Sesame-T. Aman	10	0.00	1	Sherpur
42	Millet( <i>cheena</i> )-Fallow-Fallow	10	0.00	1	Sonatola
43	Potato-Onion-T. Aman	10	0.00	1	Khetlal
44	Wheat-Vegetab-T. Aman	10	0.00	1	Khetlal
45	S.Potato-Jute-T. Aman	5	0.00	1	Akkelpur
	Total	3045	0.46		

Sesame+B. Aman is grown on 1,700 hectares in Chowhali upazila of the same district. Millet (*kaon*)–Fallow–T. Aman is cultivated on 1,500 hectares only in Sariakandi of Bogra district. The millet is a small grain cereal crop, which stands on the bank of extinction for its low yield and less economic value, although it is a very nutritious food. Only some marginal land like *charland* is used for its cultivation (FAO, 1988).

### Rare cropping patterns

In the present investigation, 45 cropping patterns have been identified as rare cropping patterns with negligible area coverage with seldom existence (Table 9). These are location specific system and are limited in one or two upazilas of the region. Total area coverage of the 45 patterns is far less than 1% of NC Among them the highest area was allotted for Mustard–Maize–T. Aman (190 ha) and it is recorded only in Sherpur upazila of Bogra district. The smallest area was recorded for S.Potato–Jute–T. Aman cropping patterns whose coverage was only five hectares (Table 9) and is recorded only in Akkelpur upazila of Joypurhat district.

### Most dominant cropping pattern

Boro–Fallow–T. Aman was the most dominant cropping pattern in Bogra region. It covers 21.88% of NCA in the region and is available in 27 upazilas out of 35 (Table 10). The highest area under this cropping was recorded 16,500 hectares in Raiganj upazila of Sirajganj district which represents 11.28% of the total Boro–Fallow–T. Aman area of the region. In consideration of individual upazila it also covered the highest area and it is 77.10% of its NCA for this pattern alone. Chatmohar and Bhangura upazila of Pabna district had negligible area coverage for this pattern. In some portion of the double rice area some short duration Rabi crops can be grown before Boro transplanting if appropriate varieties and other related technologies are made available (FAO, 1988). In the country-wide compilation of data it was observed that Boro–F–T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### Second dominant cropping pattern

The second dominant cropping pattern in Bogra region is Potato–Boro–T. Aman. It belongs to 13.26% of NCA of the region and spread over 17 upazilas (Table 11). Shibganj upazila of Bogra district holds the highest area coverage (18,200 ha) under this cropping pattern. Kalai upazila ranks in second position in terms of area coverage (11,800 ha) however this upazila allotted the biggest share (84.83%) of the upazila NCA. In the country-wide compilation of data it was observed that Potato–Boro–T. Aman was the 8<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.80 lac ha (2.11% of NCA in the country) with its distribution in 115 upazilas of 33 districts (Nasim *et al.*, 2017).

### Third dominant cropping pattern

Mustard–Boro–Fallow cropping pattern holds the third largest area coverage 50,940 hectares in Bogra region. This area is an equivalent to 7.62% of NCA in the region. This pattern Mustard–Boro–Fallow is distributed over only 15 upazilas. Shahjadpur and Ullapara upazila have the highest area coverage under this pattern and it is 13,000 ha for both the upazilas which stands for 25.52% of the total area under this pattern in the region for both the locations (Table 12). Belkuchi upazila ranks in third position for this cropping pattern, however, Panchbibi, Santhia and Kazipur covers a minute area of 200 ha for each upazila.

### Fourth dominant cropping pattern

Fourth dominant cropping pattern Mustard–Boro–T. Aman has occupied 40,110 hectares representing 6.0% share of NCA in Bogra region (Table 13). This pattern is distributed over 25 upazilas where Kahalu ranked in top position. This upazila has 4,800 ha area of Mustard–Boro–T. Aman which is 24.96% of upazila NCA. Dupchachia upazila ranks in third position with 3,700 ha area for this pattern; however, this upazila has allotted the biggest share (26.94%) of its NCA.

### Fifth dominant cropping pattern

Fifth dominant cropping pattern Boro–Fallow–Fallow had been covering 37,300 hectares

**Table 10. Distribution of the most dominant Boro-F-T. Aman cropping patterns in Bogra region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Raiganj	16500	77.10	11.28
02 Sherpur	13600	57.14	9.30
03 Dhunat	13100	67.18	8.96
04 Gabtali	11500	60.37	7.86
05 Sirajganj sadar	9000	40.54	6.15
06 Tarash	8700	35.15	5.95
07 Nandigram	8000	35.87	5.47
08 Sariakandi	8000	32.92	5.47
09 Panchbibi	7900	35.75	5.40
10 Shajahanpur	6500	40.88	4.44
11 Joypurhat sadar	5700	30.65	3.90
12 Kahalu	4700	24.48	3.21
13 Sonatola	4700	34.31	3.21
14 Atghoria	4500	32.61	3.08
15 Adamdighi	4100	32.28	2.80
16 Akkelpur	3900	36.28	2.67
17 Kazipur	3200	14.16	2.19
18 Dubchachia	3000	21.90	2.05
19 Iswardi	2000	13.07	1.37
20 Bogra sadar	1800	16.29	1.23
21 Sujanagar	1800	7.38	1.23
22 Kalai	1400	10.07	0.96
23 Shibganj	1200	4.72	0.82
24 Kamarkhanda	800	10.53	0.55
25 Khetlal	300	2.58	0.21
26 Chatmohar	200	0.80	0.14
27 Bhangura	150	1.36	0.10
Bogra region	146250	21.88	100.00

**Table 11. Distribution of the 2<sup>nd</sup> dominant Potato-Boro-T. Aman cropping pattern in Bogra region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Shibganj	18200	75.99	20.54
02 Kalai	11800	84.83	13.32
03 Khetlal	8900	76.20	10.04
04 Kahalu	8600	44.72	9.71
05 Dubchachia	6600	48.05	7.45
06 Pachbibi	6100	26.90	6.88
07 Bogra sadar	6000	53.56	6.77
08 Joypurhat sadar	5500	28.35	6.21
09 Akkelpur	5000	46.12	5.64
10 Shajahanpur	4000	16.98	4.51
11 Adamdighi	3300	25.90	3.72
12 Sonatola	2300	16.61	2.60
13 Gabtali	1300	6.78	1.47
14 Sherpur	360	1.38	0.41
15 Ullapara	250	0.78	0.28
16 Kamarkhanda	200	2.59	0.23
17 Tarash	200	0.81	0.23
Bogra region	88610	13.26	100.00

**Table 12. Distribution of the 3<sup>rd</sup> dominant Mustard- Boro–Fallow cropping pattern in Bogra region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Shahjadpur	13000	52.20	25.52
02 Ullapara	13000	40.51	25.52
03 Belkuchi	6000	46.33	11.78
04 Tarash	5100	20.60	10.01
05 Chatmohar	4000	15.96	7.85
06 Faridpur	4000	34.64	7.85
07 Bera	1400	7.80	2.75
08 Bhangura	1100	9.92	2.16
09 Raiganj	800	3.66	1.57
10 Gabtali	740	3.86	1.45
11 Sujanagar	700	2.84	1.37
12 Sirajganj	500	2.11	0.98
13 Panchbibi	200	0.88	0.39
14 Santhia	200	0.79	0.39
15 Kazipur	200	0.87	0.39
Bogra region	50940	7.62	100.00

**Table 13. Distribution of the 4<sup>th</sup> dominant Mustard-Boro–T. Aman cropping pattern in Bogra region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
1 Kahalu	4800	24.96	11.97
2 Panchbibi	4200	18.52	10.47
3 Dubchachia	3700	26.94	9.22
4 Ullapara	3700	11.53	9.22
5 Adamdighi	3200	25.12	7.98
6 Joypurhat	3000	15.46	7.48
7 Dhunat	2000	10.23	4.99
8 Kamarkhanda	2000	25.86	4.99
9 Sirajganj	1600	6.74	3.99
10 Khettal	1400	11.99	3.49
11 Sonatola	1300	9.39	3.24
12 Shariakandi	1200	4.93	2.99
13 Sherpur	1100	4.67	2.74
14 Shibganj	1100	4.22	2.74
15 Akkelpur	1100	10.15	2.74
16 Belkuchi	1000	7.72	2.49
17 Raiganj	900	4.11	2.24
18 Bogra	800	7.14	1.99
19 Shajahanpur	600	3.74	1.50
20 Kazipur	350	1.53	0.87
21 Tarash	260	1.05	0.65
22 Kalai	200	1.44	0.50
23 Atghoria	200	1.43	0.50
24 Bhangura	200	1.80	0.50
25 Santhia	200	0.79	0.50
Bogra region	40110	6.00	100.00

representing 5.58% share of NCA in Bogra region (Table 14). This pattern is distributed over 21 upazilas where Kazipur ranked in top position. This upazila had 7,600 ha area for single Boro pattern which is 33.17% of upazila NCA. Ullapara upazila ranked in second position in respect to area coverage. In the country-wide

compilation of data it was observed that the single Boro was the 2<sup>nd</sup> 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). This pattern is frequent and concurrently experienced by early flash

**Table 14. Distribution of the 5<sup>th</sup> dominant Boro–F–F cropping pattern in Bogra region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Kazipur	7600	33.17	20.38
02 Ullapara	5400	16.83	14.48
03 Tarash	3000	12.12	8.04
04 Chowhali	2400	18.88	6.43
05 Bhangura	2100	18.94	5.63
06 Sariakandi	2000	8.21	5.36
07 Sujanagar	1800	7.29	4.83
08 Shahjadpur	1800	7.23	4.83
09 Pabna	1500	4.21	4.02
10 Bera	1400	7.80	3.75
11 Gabtali	1200	6.26	3.22
12 Sherpur	1000	3.84	2.68
13 Chatmohar	1000	3.99	2.68
14 Faridpur	1000	8.66	2.68
15 Raiganj	1000	4.57	2.68
16 Atghoria	800	5.70	2.14
17 Shajahanpur	600	2.55	1.61
18 Sonatola	600	4.33	1.61
19 Kamarkhanda	500	6.46	1.34
20 Dhunat	400	2.05	1.07
21 Adamdighi	200	1.57	0.54
Bogra region	37300	5.58	100.00

in April and cold injury at 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).

#### **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 177 cropping patterns were identified in the whole area of Bogra region under this investigation. The highest number of cropping patterns was identified 36 in Kazipur upazila of Sirajganj district and that was 34 in Sonatola upazila in Bogra district (Table 15). The lowest number of cropping patterns was identified six in Nandigram followed by nine in Dubchachia and Kahalu upazila. The higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were related to either low land area or water logging or both. The highest value of

diversity index for cropping pattern was found 0.950 in Bera upazila that was followed by 0.912 in Chatmohar upazila. The lowest CDI was reported 0.718 in Raiganj of Sirajganj district followed by 0.734 in Kalai upazila in Joypurhat. The highest value of CDI was observed 0.978 in Pabna sadar followed by 0.972 in Bera upazila. The range of cropping intensity values was recorded 183-291%. The maximum value was for Khetlal upazila of Joypurhat district and minimum for Bera upazila of Pabna district. As a whole the CDI of Bogra region was calculated 0.966 and the average cropping intensity at regional level was 234%. 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). The farmers of Kerala diversified their cropping pattern to minimize risk of crop failures and price fluctuations (Mahesh, 1999).

**Table 15. Crop diversity and cropping intensity in Bogra region, 2014-15.**

	Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01	Adamdighi	14	13	0.762	0.909	261
02	Bogra	16	18	0.675	0.879	282
03	Dhunat	22	17	0.535	0.794	215
04	Dubchachia	9	13	0.827	0.866	277
05	Gabtali	20	16	0.614	0.831	218
06	Kahalu	9	11	0.677	0.878	274
07	Nandigram	6	7	0.692	0.893	276
08	Sariakandi	19	17	0.852	0.929	205
09	Sherpur	32	15	0.660	0.863	227
10	Shibganj	16	15	0.499	0.810	282
11	Shajahanpur	22	14	0.761	0.905	241
12	Sonatola	34	22	0.835	0.936	246
13	Akkelpur	19	15	0.647	0.859	260
14	Joypurhat	14	15	0.795	0.920	259
15	Kalai	12	13	0.270	0.734	289
16	Khetlal	17	12	0.402	0.783	291
17	Panchbibi	13	10	0.768	0.908	251
18	Atghroria	28	13	0.868	0.949	237
19	Bera	29	20	0.950	0.972	183
20	Bhangura	16	13	0.859	0.931	196
21	Chatmohar	20	16	0.912	0.961	218
22	Faridpur	11	14	0.816	0.906	200
23	Iswardi	18	17	0.904	0.954	247
24	Pabna sadar	34	21	0.942	0.978	256
25	Santhia	25	16	0.891	0.962	274
26	Sujanagar	28	19	0.843	0.922	201
27	Belkuchi	14	14	0.759	0.894	219
28	Chowhali	26	26	0.901	0.944	196
29	Kazipur	36	21	0.845	0.940	190
30	Kamarkhanda	19	18	0.832	0.919	227
31	Raiganj	21	17	0.425	0.718	203
32	Shahjadpur	19	16	0.703	0.870	217
33	Sirajganj	25	21	0.831	0.917	206
34	Tarash	28	22	0.799	0.899	198
35	Ullapara	26	18	0.777	0.900	209
	Bogra region	177	35	0.919	0.966	234

## CONCLUSION

The cropping intensity of the Bogra region was higher than the national average. Boro-Fallow-T. Aman, Potato-Boro-T. Aman, Mustard-Boro-Fallow, Mustard-Boro-T. Aman and single Boro were the dominant cropping patterns in the region. Exclusive rice area is about three folds of exclusive non-rice area. In Bogra region crop diversity is much wider than that of other regions. 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.
- Effort might be given so that a portion of double-rice area could be brought under Potato-Boro-T. Aman and/or Mustard-Boro-T. Aman cropping systems.
- In the single Boro area suitable vegetables 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.

- Scope might be explored for the establishment of agro-food industry on the basis of potato crop.

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. *American Society of Agronomy, Madison, Wisconsin.* 27: 2-3.
- Blade, S F and A E Slinkard 2002. *New Crop Development: The Canadian Experience. In: Trends in New Crops and New Uses.* J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- Das, Anup., G I Ramkrushna, G S Yadav, J Layek, C Debnath, B U Choudhury, K P Mohaptara, S V Ngachan and S Das. 2015. Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India. *Applied Ecology and Environmental Sciences.* 3(4): 100-107.
- FAO, 1988. *Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh.* Food and Agriculture Organization of the United Nations, Rome, Italy. 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Jackson, B R, A Yantasast, C Prechachat, M A Chowdhury and S M H Zaman. 1972. Breeding rice for deepwater areas. *International Rice Research Institute, Rice Breeding, Los Baños, Philippines.* in:517-528.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapura.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Ind. Jn. of Agri. Econ.* 68(2): 169-181.
- Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 283-298.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2):213-238.
- Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-123.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49 (3): 301-318.

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

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
001 Boro-Fallow-T. Aman	146250	067 Chilli-Aus-Fallow	1210
002 Potato-Boro-T. Aman	88610	068 Fallow-Fallow-Blackgram	1210
003 Mustard-Boro-Fallow	50940	069 Potato-Maize-T. Aman	1200
004 Mustard-Boro-T. Aman	40110	070 Vegetab-Vegetab-T. Aman	1030
005 Boro-Fallow-Fallow	37300	071 Garlic-Aus-T. Aman	1010
006 Boro-Aus-T. Aman	19700	072 Grasspea-Fallow-Fallow	1005
007 Boro-B. Aman	18650	073 Vegetab-Onion-Aus	1000
008 Vegetab-Vegetab-Vegetab	16030	074 Wheat-Sesame-Fallow	1000
009 Wheat-Jute-T. Aman	14540	075 Lentil-Sesame+B. Aman	980
010 Onion-Jute-Fallow	10080	076 Vegetab-Jute-T. Aman	980
011 Onion-Jute-T. Aman	9330	077 Lentil-Jute-T. Aman	975
012 Wheat-B. Aman	7920	078 Grasspea-Sesame-T. Aman	970
013 Boro-Jute-T. Aman	7020	079 Vegetab-Fallow-Fallow	900
014 Lentil-Jute-Fallow	6650	080 Wheat-Fallow-Blackgram	900
015 Grasspea-B. Aman	6470	081 Boro-Sesbania-T. Aman	880
016 Mustard-Boro-B. Aman	5000	082 Lentil-Sesame-Fallow	810
017 Vegetab-Boro-T. Aman	4760	083 Grasspea-Jute-T. Aman	800
018 Wheat-Aus-Fallow	4700	084 Groundnut-F-Blackgram	800
019 Chilli-Jute-Fallow	4620	085 Mustard-B.Aus+B. Aman	800
020 Groundnut-Fallow-Fallow	4280	086 Lentil-B. Aman	790
021 Wheat-Jute-Fallow	4090	087 S.Potato-Jute-Fallow	780
022 Boro-Vegetab(Float/Norm)	4000	088 Potato-Boro-Fallow	750
023 Vegetab-Vegetab-Fallow	3730	089 Onion-Aus-Blackgram	740
024 Onion-B. Aman	3650	090 Chilli-Fallow-Fallow	710
025 Wheat-Aus-T. Aman	3630	091 Garlic-Jute-T. Aman	700
026 Lentil-Aus-T. Aman	3340	092 Mustard-Boro-Jute	700
027 Maize-Jute-Fallow	3300	093 Wheat-Maize-T. Aman	700
028 Garlic-B. Aman	3100	094 S.Potato-Fallow-Fallow	675
029 Onion-Vegetab-Vegetab	3100	095 Boro-Aus-Fallow	670
030 Blackgram-B. Aman	2950	096 Maize-B. Aman	650
031 Grasspea-Boro-Fallow	2950	097 Maize-Fallow-T. Aman	640
032 Mustard-Jute-T. Aman	2700	098 Coriander-Vegetab-Fallow	630
033 Grasspea-Boro-B. Aman	2600	099 Potato-Sesame-T. Aman	600
034 Mustard-Boro-Aus	2560	100 Grasspea-Jute-Fallow	550
035 Maize-Fallow-Fallow	2520	101 Groundnut-Jute-T. Aman	500
036 Wheat-Sesame-T. Aman	2470	102 Sesame-Fallow-Blackgram	500
037 Boro-Sesbania-Fallow	2450	103 Wheat-Jute-Blackgram	500
038 Mustard-Boro-Aus-T. Aman	2330	104 Chilli-Aus-T. Aman	430
039 Chilli-Jute-T. Aman	2300	105 Garlic-Jute-Fallow	430
040 Mustard-B. Aman	2300	106 Garlic-Fallow-T. Aman	420
041 Maize-Jute-T. Aman	2255	107 Boro-Aus-Blackgram	410
042 Potato-Boro-Aus-T. Aman	2250	108 Grasspea-Sesbania-Fallow	400
043 Mustard-Aus-T. Aman	2200	109 Mustard-Aus-Blackgram	400
044 Onion-Sesame-T. Aman	2200	110 Mustard-Mungbean-T. Aman	400
045 Wheat-Vegetab-Vegetab	2100	111 Pea-B. Aman	400
046 Vegetab-Aus-Fallow	2060	112 Groundnut-Millet( <i>kaon</i> )-F	380
047 B.gram(Fod)-Boro-B. Aman	2000	113 Vegetab-Jute-Vegetab	380
048 Wheat-Mungbean-T. Aman	1990	114 Onion-Sesame-Fallow	350
049 Boro-Fallow-Blackgram	1960	115 Garlic-Vegetab-Vegetab	345
050 Onion-Aus-T. Aman	1910	116 Maize-Maize-T. Aman	330
051 Boro-Jute-Fallow	1900	117 Maize-Aus-Fallow	320
052 Onion-Sesame+B. Aman	1800	118 Mustard-Sesame-T. Aman	320
053 Vegetab-Fallow-T. Aman	1790	119 Groundnut-Sesame-Fallow	300
054 Millet( <i>kaon</i> )+Sesame-F	1720	120 Lentil-Aus-Fallow	300
055 Grasspea-Sesame+B. Aman	1700	121 Maize-Sesame-T. Aman	300
056 Lentil-Sesame-T. Aman	1680	122 Potato-Boro-Vegetab	300
057 Potato-Vegetab-T. Aman	1670	123 Potato-Maize-Aus	300
058 Vegetab-Aus-T. Aman	1665	124 Potato-Maize-Aus-Vegetab	300
059 Chilli-Vegetab-Fallow	1650	125 Vegetab-Boro-Jute	300
060 Wheat-Fallow-T. Aman	1560	126 Pea-Aus-Vegetab	280
061 Fallow-Fallow-T. Aman	1550	127 Lentil-Vegetab-Vegetab	270
062 Millet( <i>kaon</i> )-F-T. Aman	1500	128 Wheat-Fallow-Fallow	230
063 Potato-Maize-Vegetab	1500	129 Boro-Vegetab-T. Aman	200
064 Fallow-Sesame+B. Aman	1400	130 Potato-Fallow-T. Aman	200
065 Potato-Jute-T. Aman	1280	131 Sesame-Aus-Fallow	200
066 Vegetab-Jute-Fallow	1240	132 Vegetab-Fallow-Blackgram	200
		133-177 Other 45 patterns (Table 9)	3045

# Crop Diversity and Cropping Patterns of Comilla Region

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## ABSTRACT

Comilla region is highly diverse in respect to topography, agro-ecology, land-use pattern and cropping systems. Planning of agricultural development largely depends on the reliable and comprehensive statistics of the existing cropping patterns, cropping intensity and crop diversity of a particular area, which will provide guideline to our policy makers, researchers, extensionists and development workers. The study was conducted over all 33 upazilas of Comilla region during 2016 using pre-tested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity. From the present study it was observed that 73.56% of net cropped area (NCA) is covered by exclusive rice cropping systems whereas deep water rice cropping system occupied 16.09% of the regional NCA. The most dominant cropping pattern single Boro alone occupied 26.18% of NCA with its distribution over 30 out of 33 upazilas. The second largest area, 19.93% of NCA, was covered by Boro-Fallow-T. Aman cropping pattern, which was spread over 25 upazilas. One hundred and forty-six cropping patterns were identified in the whole region under this investigation. The highest, 36 cropping patterns were identified in Debidwar upazila of Comilla district and the lowest, seven were in Akhura and Ashuganj of B.Barua and Comilla Adarsha upazila. The lowest crop diversity index (CDI) was reported 0.481 in Comilla Adarsha upazila followed by 0.637 in Hajiganj of Chandpur. The highest value of CDI was observed 0.964 in Haimchar of Chandpur followed by 0.956 in Muradnagar of Comilla. The range of cropping intensity (CI) value was recorded 126-292%. The maximum value was for Barua of Comilla and minimum for Hajiganj of Chandpur district. The grand mean of CDI values for Comilla region was calculated 0.935 and the average cropping intensity at regional level was 192%.

**Key words:** Cropping pattern, diversity index, Akhaura terrace and Floodplain

## INTRODUCTION

Comilla region comprises 33 upazilas of Comilla, Chandpur and Brahmanbaria districts covering plains, char lands, terrace, basins and Lalmai hills. Comilla is the biggest district with 16 upazilas, located about 100 kilometers south-east of the capital city, Dhaka. The economy is mainly based on agriculture; the economy of Comilla has been flourished through trade and cottage industries, especially the 'Khadi' textile. Brahmanbaria and Chandpur include nine and eight upazilas respectively, also with agriculture based economy; Ashuganj fertilizer factory in Brahmanbaria and Chanpur CIP project are of major importance institutions in agriculture. Major rivers passing through

Comilla region include the Meghna, Gumti, Titas, Little Feni etc. Comilla region is bordered by Habiganj and Kishoreganj districts to the north, Noakhali, Laxmipur and Feni districts to the south, Tripura of India to the east, and Meghna river, Narsingdi, Narayanganj, Munsiganj and Shariatpur districts to the west. The tropic of cancer passes through the heart of the Comilla city; the climate is subtropical biased. Eight agro-ecological zones comprises the whole Comilla region, which are briefly described below (FAO, 1988).

**Active Brahmaputra-Jamuna Floodplain (AEZ-7).** Parts of Chandpur district belongs to this floodplain, which comprises the belt of unstable alluvial land along the Brahmaputra-Jamuna rivers where land is constantly being

formed and eroded by shifting river channels. It has an irregular relief of broad and narrow ridges and depressions. The area is occupied by sandy and silty alluvium, rich in weatherable K minerals that are slightly alkaline in reaction. Organic matter status is low and fertility status is low to medium.

**Middle Meghna River Floodplain (AEZ-16).** Parts of all the three districts of Comilla, Brahmanbaria and Chandpur districts belong to this flood plain. This floodplain occupies an abandoned channel of the Brahmaputra river on the border between the greater Dhaka and Comilla districts. The region includes areas of old Brahmaputra chars within the Meghna river as well as adjoining parts of the mainland. Soils of the area are grey loam on the ridges and grey to dark grey clays in the basins. The dominant general soil type is non-calcareous grey floodplain soil. Topsoils are strongly acidic and subsoils are slightly acidic to slightly alkaline.

**Lower Meghna River Floodplain (AEZ-17).** Parts of Chandpur district belongs to this floodplain, this area occupies the transitional area between the middle Meghna river floodplain and the young Meghna estuarine floodplain. Soils of this area are relatively uniform, silt loams occupy relatively higher areas and silty clay loams occupy the depressions. Non-calcareous dark grey floodplain and calcareous grey floodplain soils are major components of general soil types. Topsoils are moderately acidic and subsoils neutral in reaction. General fertility level is medium to high with low to medium organic matter status and K-bearing minerals.

**Old Meghna Estuarine Floodplain (AEZ-19).** Parts of all the three districts of Comilla, Brahmanbaria and Chandpur districts belong to this flood plain, which occupies a large area, mainly low-lying land between the south of the Surma-Kushiyara floodplain and the northern edge of the young Meghna estuarine floodplain. Silt loam soils predominate on highlands and silty clay to clay on lowlands. Organic matter content of the soils is moderate. Topsoils are moderately acidic, but subsoils are neutral in reaction. General fertility level is medium with low N and organic matter.

**Sylhet Basin (AEZ-21).** Parts of Brahmanbaria district belong to Sylhet Basin which occupies the lower, western side of the Surma-Kushiyara floodplain. Relief is locally irregular near rivers. Soils of the area are grey silty clay loams and clay loam on the higher parts that dry out seasonally and grey clays in the wet basins. The soils have a moderate content of organic matter and soil reaction is mainly acidic. Fertility level is medium to high.

**Northern and Eastern Piedmont Plains (AEZ-22).** Parts of Brahmanbaria and Comilla belong to this piedmont plain, which is a discontinuous region occurring as a narrow strip of land at the foot of the northern and eastern hills. The region comprises merging alluvial fans which slope gently outward from the foot of the northern and eastern hills into smooth, low-lying basins. Grey piedmont soils and non-calcareous grey floodplain soils are the major general soil types of the area. Soils of the area are loams to clays, slightly acidic to strongly acidic in reaction. General fertility level is low to medium.

**Northern and Eastern Hills (AEZ-29).** Small part of Comilla district is included in the country's hill areas. Highland comprises 93% of the total floodplain, relief is complex. Hills have been dissected to different degrees over different rocks. In general, slopes are very steep and few low hills have flat summits. Brown hill soil is the predominant general soil type of the area. Organic matter content and general fertility level are low.

**Akhaura Terrace (AEZ-30).** The region occupies the eastern border of Brahmanbaria district. The main soils in the uplands have strong brown clay. The valley soils range from silty clay to clays. Deep red brown terrace soils, grey piedmont soils and acid basin clays are the major components of the general soil types of the area. The general fertility including organic matter status is low. The soils are strongly acidic in reaction.

Cropping system is the crop production activity of a farm which includes all cropping patterns grown on the farm resources, other household enterprises and the physical, biological, technological and socioeconomic

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

The yields of cereal crops are tending to stagnation, even in favourable environments. Moreover, cultivable land area is decreasing day by day in the country. In this context, there is no other alternative but to address less favourable and unfavourable environments. To increase the system productivity of the total environment it needs to bring diversity in enterprises for better utilization of limited resources. Detailed information on land situation and cropping systems is a prerequisite for a fruitful development programme. Upazila level office of the Department of Agricultural Extension (DAE) maintains a statistics on individual crop, which has some limitation for getting a real picture of existing cropping patterns and land utilization. The specific objectives of the present study were to:

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

## METHODOLOGY

Thirty-three upazilas of Comilla, Brahmanbaria and Chandpur districts under Comilla 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 33 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during November 2015 at upazila level. SAAOs were purposively pre-selected by Agriculture Extension Officers (AEO), Additional Agriculture Officer (AAO) and Upazila Agriculture Officer (UAO) or altogether. Prior to data collection, the pre-tested questionnaire was explained along with proper guidelines to the AEOs or UAOs or both and handed over to them at each Deputy Director's office of 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 for necessary correction and validation. Second stage of data collection was day-long data validation workshop at district level. The workshop dates were 26 January for Brahmanbaria; 18 February for Chandpur; and 8 May 2016 for Comilla. Four field-workers i.e. one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRI regional station, Comilla participated in the data validation workshop. The number of participants of validation workshop ranged from 54 to 111 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFS scientists to finalize and validate the data and authenticated data were captured. Crop diversity index was calculated by using the following equation described by Kshirsagar *et al.* (1997).

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

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

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

## RESULTS AND DISCUSSION

### Land use pattern

Table 1 shows upazila-wise land use pattern including net crop area (NCA) and CI. NCA of the whole region is about 4.4 lac hectare with 192% CI, which is somewhat lower than the national average. Barura upazila of Comilla shows the highest CI of 292% followed by Debidwar (265%) and Chandina (250%) upazilas of the same district which are much more higher than the national average rendering those upazilas as the most intensive cropping area of the country. The highest CI

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Akhaura	9888	20	1940	4100	320	0	90	6470	174
02 Ashuganj	6759	20	300	3650	1050	0	80	5100	215
03 B.Barua	23744	10	4800	8280	1820	50	140	15100	181
04 Bijoynagar	22007	70	8500	5630	350	0	120	14670	144
05 Bancharampur	21738	20	8060	5580	0	0	110	13770	141
06 Kasba	21000	110	3500	8800	2830	0	120	15360	195
07 Nabinagar	35750	20	10900	12340	3000	0	160	26420	170
08 Nasirnagar	30262	10	12260	12820	870	0	100	26060	156
09 Sarail	21527	10	9500	6190	680	0	120	16500	146
10 Chandpur	30880	130	4220	6900	400	0	80	11730	166
11 Faridganj	23150	200	2820	8070	580	40	190	11900	180
12 Haimchar	17400	230	1040	1930	1640	0	140	4980	208
13 Hajiganj	18991	40	9000	2610	250	0	140	12040	126
14 Kachua	24725	10	1300	10480	4760	0	150	16700	221
15 Matlab.N	27760	300	1120	6720	6540	80	120	14880	236
16 Matlab.S	13175	20	2900	6060	10	0	110	9100	168
17 Shaharasti	15400	15	1700	7430	1300	30	175	10650	197
18 Barura	24165	170	0	1460	14290	450	100	16470	292
19 Brahmanpara	12850	10	1870	3640	3870	0	110	9500	221
20 Burichang	16376	30	200	5880	5300	0	110	11520	244
21 Chauddagam	27730	30	3730	12980	1610	10	120	18480	188
22 Chandina	19804	80	760	4785	6205	340	110	12280	250
23 Com.Adarsha	12269	10	5120	2130	0	0	100	7360	129
24 Com.South	24073	80	600	9120	6600	450	130	16980	240
25 Daudkandi	21021	180	8200	6030	230	0	140	14780	144
26 Debidwar	23836	100	525	4435	10050	270	120	15500	265
27 Homna	13279	50	2500	7045	210	0	95	9900	176
28 Nangolkot	22595	20	1900	7400	5160	750	90	15320	231
29 Laksam	15652	20	4310	980	4780	30	100	10220	205
30 Meghna	9455	10	2100	4860	0	0	130	7100	170
31 Monoharganj	15940	30	6260	3915	115	0	110	10430	140
32 Muradnagar	34093	150	2630	15870	4980	0	120	23750	209
33 Titas	11465	10	4970	2010	150	0	170	7310	132
Comilla region		2215	129535	210130	89950	2500	4000	438330	192

of Barura upazila was resulted from 14,290 ha triple cropped area which is about 87% of the NCA, at the same time the upazila is lacking single crop area (SCA). Four crop or quadruple crop area (QCA) of more than 300 ha is observed in Nangolkot, Barura, Chandina and Comilla south upazilas of Comilla district. Hajiganj upazila of Chandpur district possesses the lowest cropping intensity of 126% followed by Comilla Adarsha (129%) and Titas (132%) upazilas of Comilla district. Single cropped area (SCA) is the major land use pattern of those upazilas. Area under annual crops is the highest in Matlab South upazila (350 ha) followed by Haimchar (230 ha) and Faridganj (200 ha) upazilas of Chandpur district, while the lowest area (five hectares) under annual crops is found in B. Baria sadar and Sarail upazilas of B. Baria district. For availability of irrigation water, both surface and ground sources in dry season, supply of HYV of various crops, knowledge of modern crop management practices, good communication facilities help increasing land use efficiency in a given area (FAO, 1988).

### **Cropping patterns of Comilla**

In total 146 cropping patterns is observed in Comilla region of which nine major cropping patterns with exclusive rice crop covers 73.5% of the NCA, while all 37 cropping patterns with exclusive non-rice crop covers only 8.5% of the NCA and the rest 18% of the NCA is covered by 100 rice - non rice cropping patterns (Appendix 1).

### **Rice and non-rice crops at a glance**

Table 2 presents nine cropping patterns where rice is the only crop round the year. It comprises 73.56% of the NCA in the region. Among them single rice, double rice and triple areas represent 27.40%, 14.78% and 31.38% respectively. It reflects the unparallel dominance of rice in the cropping systems in Comilla region. In case of individual pattern single has the highest coverage (26.18%) and was recorded in 30 upazilas out of 33. The second dominant pattern Boro-Fallow-T. Aman area occupied 19.93% of NCA which was distributed in 25 upazilas. Triple rice area for Boro-Aus-T. Aman covered

14.78% area with its considerable existence in 26 upazilas.

In the current investigation, 37 cropping patterns were identified that was free from rice. Among these 37 patterns first 23 has been arranged in descending order in Table 3. The rest 14 patterns with negligible area coverage can be found in Table 7 where they are arranged with other patterns of different categories. Aggregate of the 37 patterns have had only 8.51% of NCA. In critical comparison it is clear that exclusive rice area is about nine folds of exclusive non-rice area. Among these 37 patterns, three patterns comprise year-round vegetables distributed over majority of the upazilas. They had the highest coverage (3.43%) which is practiced mainly at or around homestead area.

### **Deep water rice ecosystem**

Deep water is a special type of ecosystem in the country. In context of Comilla region this ecosystem represents a large portion. The cropping patterns under deep water ecosystem are listed in the Table 4. Among the listed 24 patterns Boro-B. Aman cropping pattern covers the highest area coverage of 38,360 hectares which represents 8.75% of the region's NCA. This pattern is distributed throughout 19 upazilas out of 33. The second highest Mustard-B. Aman cropping pattern covers 9,690 hectares and distributed in nine upazilas. The first two patterns jointly covered 10.96% NCA and this area is about two-thirds of the total area under deep water ecosystem of the region. The water level of this ecosystem ranges between 150 and 400 cm, and water usually remains 3-4 months. Special rice varieties known as 'floating rice' are planted in these areas. In the past Bangladesh had had a land coverage of 3 million hectares for deepwater rice (Jackson *et al.*, 1972). In course of time the continuous effort on modern agriculture shifted DWR area mainly to modern Boro. Now the area under deep water rice in Bangladesh is reduced to 0.4 million hectares (Nasim *et al.*, 2017). Though this cropping system is less productive than the other modern cropping systems, however, the specific fragile ecosystem still struggling because of no other alternatives.

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-Fallow	114780	26.18	30
02 Boro-Fallow-T. Aman	87410	19.93	25
03 Boro-Aus-T. Aman	64830	14.78	26
04 Boro-B.Aman	38360	8.75	19
05 Boro-Aus-Fallow	4670	1.06	8
06 Fallow-Aus-T. Aman	4160	0.95	4
07 Fallow-Fallow-T. Aman	3430	0.78	1
08 Boro-Sesbania-T. Aman	3000	0.68	2
09 Boro-Sesbania-Fallow	1910	0.44	6
Total	322550	73.56	-

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Maize-Fallow	7050	1.61	5
02 Vegetab-Vegetab-Vegetab	7030	1.60	22
03 Vegetab-Vegetab-Fallow	6840	1.56	16
04 Potato-Jute-Fallow	3870	0.88	11
05 Maize-Fallow-Fallow	1500	0.34	2
06 Vegetab-Fallow-Fallow	1180	0.27	6
07 S.Potato-Fallow-Fallow	1060	0.24	10
08 Maize-Vegetab-Fallow	800	0.18	1
09 Wheat-Jute-Fallow	780	0.18	5
10 Mustard-Jute-Fallow	730	0.17	5
11 Chilli-Jute-Fallow	725	0.17	6
12 Coriander-Fallow-Fallow	700	0.16	4
13 Soybean-Fallow-Fallow	700	0.16	2
14 Chilli-Fallow-Fallow	600	0.14	3
15 Potato-Sesbania	550	0.13	2
16 Onion-Jute-Fallow	400	0.09	2
17 Garlic-Jute-Fallow	390	0.09	2
18 Lentil-Jute-Fallow	360	0.08	3
19 Fallow-Fallow-Blackgram	350	0.08	5
20 Vegetab-Jute-Fallow	335	0.08	6
21 S.Potato-Vegetab-Fallow	330	0.08	4
22 Chilli-Vegetab-Fallow	220	0.05	5
23 Lentil-Sesame-Fallow	170	0.04	3
24-37 Other 14 patterns (in Table 8)	625	0.14	-
Total	37295	8.51	-

### Oil-seed crops

Mustard is the most important one among the oil-seed crops in Comilla region. There are 31 cropping patterns for oil-seed crops among which 14 patterns had been led by mustard alone (Tables 5 and 7). The total share of oil-seed cropping patterns is 6.03% of NCA whereas Mustard alone occupies over 5%. The second prevailing soybean covers less than

1%. The most dominant Mustard-B.Aman pattern is distributed in nine upazilas whereas 2<sup>nd</sup> dominant Mustard-Boro-Fallow pattern is distributed in 12 upazilas out of 33.

### Pulse crops

Twenty-two cropping patterns are holding different pulse crops (Table 6). Among them lentil is covering the largest area whereas pea is

**Table 4. Cropping patterns under deep-water rice ecosystem in Comilla region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-B.Aman	38360	8.75	19
02 Mustard-B.Aman	9690	2.21	9
03 Chilli-B.Aman	3820	0.87	9
04 Potato-B.Aman	3720	0.85	8
05 Lentil-B.Aman	2970	0.68	10
06 Vegetab-B.Aman	2480	0.57	7
07 Wheat-B.Aman	2140	0.49	9
08 Grasspea-B.Aman	1785	0.41	9
09 Fallow-Sesame+B.Aman	950	0.22	2
10 Coriander-B.Aman	790	0.18	3
11 Soybean-B.Aman	550	0.13	1
12 Mustard-Boro-B.Aman	500	0.11	4
13 Mustard-Sesame+B.Aman	500	0.11	1
14 Maize-B.Aman	450	0.10	3
15 S.Potato-B.Aman	440	0.10	2
16 Onion-B.Aman	395	0.09	6
17 Sesame-B.Aman	330	0.08	2
18 Garlic-B.Aman	220	0.05	4
19 Muskmelon-B.Aman	175	0.04	4
20 Blackgram-B.Aman	170	0.04	3
21 Potato+Maize-B.Aman	110	0.03	2
22-24 Other three patterns (in Table 8)	110	0.03	-
Total deep-water rice	70655	16.11	

cultivated in the smallest area. Eight cropping patterns of lentil jointly cover more than one-half of the total pulse area in the region (Tables 6 and 8). Grasspea holds the second position in pulse crop cultivation in Comilla region. There are five cropping patterns for grasspea which in-together occupy over one-fourth of total pulse crop cultivation area in the region. In the documentation of pulse cropping system it is observed that majority of pulse crop are is under deep-water rice ecosystem. Finally the aggregate area of the pulse cropping system stands for 1.93% of the NCA in Comilla region.

### Vegetables and spices crops

Table 7 presents 58 cropping patterns arranged in descending order according to area coverage. Potato and other vegetables of Rabi, Kharif-I and Kharif-II; spices (chilli, onion, garlic, coriander) are included in this list. The most contributing cropping pattern is Potato-Maize-Fallow covering 1.61% of NCA which is distributed over only five upazilas. The second one is Vegetable-Vegetable-Vegetable

covering 1.60% of NCA and it is the most available pattern recorded in 22 upazilas out of 33.

### Sporadic and distinct cropping patterns

There are some cropping patterns which are extremely location-specific, however, with a large area coverage. These are Single T. Aman (Table 2); Mustard-Aus-Fallow (Table 5) and Maize-Fallow-Fallow (Table 4). The single T. Aman is grown on 3,430 hectares in Chouddagram upazila of Comilla district. The area is situated on the foot hill border of India and the water holding capacity of its soil is low. Boro is not possible due the scarcity of irrigation water in dry season. Some non-rice crops viz maize might be grown after T. Aman. Sesame might be suggested in Kharif-I season. Mustard-Aus-Fallow is limited to two upazilas viz Muradnagar upazila of Comilla district (1,800 ha) and Chandpur sadar upazila (100 ha). Maize-Fallow-Fallow is available in Daudkandi upazila (1,200 ha) and Titas (300 ha) of Comilla district.

**Table 5. Cropping patterns for oil-seed crops in Comilla region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-B.Aman	9690	2.21	9
02 Mustard-Boro-Fallow	3810	0.87	12
03 Mustard-Boro-T. Aman	2100	0.48	6
04 Mustard-Aus-Fallow	1900	0.43	2
05 Mustard-Boro-Aus-T. Aman	1470	0.34	9
06 Mustard-Maize-T. Aman	1030	0.23	2
07 Mustard-Jute-Fallow	730	0.17	5
08 Soybean-Fallow-Fallow	700	0.16	2
09 Soybean-B.Aman	550	0.13	1
10 Mustard-Boro-B.Aman	500	0.11	4
11 Mustard-Sesame+B.Aman	500	0.11	1
12 Mustard-Fallow-T. Aman	400	0.09	1
13 Soybean-Fallow-T. Aman	400	0.09	1
14 Mustard-Boro-Aus	330	0.08	2
15 Sesame-B.Aman	330	0.08	2
16 Sesame-Fallow-T. Aman	300	0.07	1
17 Mustard-Aus-T. Aman	245	0.06	4
18 Lentil-Sesame-Fallow	170	0.04	3
19 Groundnut- Aus-T. Aman	160	0.04	2
20 Groundnut-Sesame-Fallow	150	0.03	1
21 Soybean-Jute-Fallow	130	0.03	1
22 Potato-Sesame-T. Aman	125	0.03	4
23-31 Other nine patterns (in Table 8)	530	0.12	-
Total oil-seed crops	26250	6.03	

**Table 6. Cropping patterns for pulse crops in Comilla region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Lentil-B.Aman	2970	0.68	10
02 Grasspea-B.Aman	1785	0.41	9
03 Boro-Fallow-Blackgram	880	0.20	2
04 Lentil-Jute-T. Aman	500	0.11	1
05 Grasspea-Jute-T. Aman	400	0.09	1
06 Lentil-Jute-Fallow	360	0.08	3
07 Lentil-Jute-Fallow	360	0.08	3
08 Fallow-Fallow-Blackgram	350	0.08	5
09 Blackgram-B.Aman	170	0.04	3
10 Lentil-Sesame-Fallow	170	0.04	3
11-22 Other 12 patterns (in Table 8)	495	0.11	-
Total pulse crops	8440	1.93	

### Rare cropping patterns

In the present investigation, 44 cropping patterns have been identified as rare cropping patterns with a negligible area coverage with seldom existence (Table 8). These are location specific system and are limited in one or two and in some cases three upazilas of the region. Total area coverage of the 44 patterns

is far less than 1% of NCA. Among these the highest area was allotted for Grasspea-Jute-Fallow, Groundnut-Aus-Fallow, Mungbean-Aus-T. Aman, Potato-Vegetab-T. Aman and Soybean-Aus-T. Aman (100 ha for each) and these are recoded dispersedly in Haimcharand Faridganj upazila of Chandpur district, Titas upazila of Comilla district and B. Baria sadar

**Table 7. Cropping patterns for vegetables and spices in Comilla region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Maize-Fallow	7050	1.61	5
02 Vegetab-Vegetab-Vegetab	7030	1.60	22
03 Vegetab-Vegetab-Fallow	6840	1.56	16
04 Potato-Boro-Fallow	4250	0.97	4
05 Potato-Jute-Fallow	3870	0.88	11
06 Potato-Aus-T. Aman	2500	0.57	8
07 Potato-Boro-T. Aman	2120	0.48	9
08 Vegetab-Aus-T. Aman	1775	0.40	7
09 Vegetab-Aus-Fallow	1640	0.37	7
10 Boro-Vegetab(Float/Norm)	1230	0.28	3
11 Vegetab-Fallow-Fallow	1180	0.27	6
12 Vegetab-Fallow-T. Aman	1160	0.26	6
13 Potato-Maize-T. Aman	930	0.21	4
14 Maize-Vegetab-Fallow	800	0.18	1
15 Potato+S.gourd-Aus-T. Aman	740	0.17	3
16 Chilli-Jute-Fallow	725	0.17	6
17 Chilli-Aus-T. Aman	710	0.16	3
18 Coriander-Fallow-Fallow	700	0.16	4
19 Potato-Boro-Aus-T. Aman	630	0.14	4
20 Chilli-Fallow-Fallow	600	0.14	3
21 Vegetab-Vegetab-T. Aman	580	0.13	3
22 Potato-Sesbania	550	0.13	2
23 Chilli-Fallow-T. Aman	425	0.10	7
24 Onion-Jute-Fallow	400	0.09	2
25 Garlic-Jute-Fallow	390	0.09	2
26 Vegetab-Boro-Aus-T. Aman	370	0.08	3
27 Vegetab-Jute-Fallow	335	0.08	6
28 Vegetab-Jute-T. Aman	310	0.07	5
29 Onion-Fallow-T. Aman	305	0.07	2
30 Coriander-Fallow-T. Aman	220	0.05	5
31 Chilli-Vegetab-Fallow	220	0.05	5
32 Potato-S.gourd-Aus	180	0.04	3
33 Garlic-Fallow-T. Aman	155	0.04	2
34 Chilli-Jute-T. Aman	150	0.03	1
35 Potato-Aus-Fallow	120	0.03	3
36 Potato+Maize-B.Aman	110	0.03	2
37-58 Other 22 patterns (in Table 8)	845	0.19	-
<b>Total for vegetables and spices</b>	<b>52145</b>	<b>11.90</b>	

upazila. The smallest area was recorded for three cropping patterns whose coverage was five hectares for each (Table 8).

### Most dominant cropping pattern

Single Boro was the most dominant cropping pattern in Comilla region. It covers 26.18% of NCA in the region and is available in 30 upazilas out of 33 (Table 9). The highest area 1,1650 ha under this cropping pattern was

recorded in Nasirnagar upazila of B. Baria district, which represents 10.15% of the total Boro-Fallow-Fallow area of the region. In consideration of individual upazila Hajiganj upazila of Chandpur district has allocated the highest area and it is 75% of its NCA for this pattern alone. This area covered by deepwater in wet season and is only cultivable in the dry season. Farmers are not interested to cultivate deepwater rice because of its low yield. If

**Table 8. Rare cropping patterns covering non-significant area in Comilla region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Grasspea-Jute-Fallow	100	0.02	1	Haimchar
02	Groundnut- Aus-Fallow	100	0.02	1	Titas
03	Mungbean-Aus-T. Aman	100	0.02	2	Faridganj+Haimchar
04	Potato-Vegetab-T. Aman	100	0.02	1	B.Baria sadar
05	Soybean-Aus-T. Aman	100	0.02	1	Haimchar
06	Onion-Sesame-Fallow	90	0.02	2	Bancharampur+Homna
07	Chilli-Aus-Fallow	80	0.02	1	Homna
08	Mustard-Jute-T. Aman	80	0.02	1	Brahmanpara
09	Soybean-Jute-T. Aman	70	0.02	1	Faridganj
10	Vegetab-Maize-Fallow	70	0.02	1	Faridganj
11	Garlic-Fallow-Fallow	60	0.01	1	Bancharampur
12	Lentil-Aus-T. Aman	60	0.01	1	Matlab North
13	Coriander-Vegetab-Fallow	55	0.01	3	Burichang+Laksam+Monoharganj
14	Mungbean-B.Aus+B.Aman	50	0.01	1	Matlab South
15	Onion-Vegetab-Vegetab	50	0.01	1	Brahmanpara
16	Potato-Fallow-T. Aman	50	0.01	2	Haimchar+Burichang
17	Vegetab-Fallow-Blackgram	50	0.01	2	Comilla South+Nangolkot
18	Onion-Aus-T. Aman	40	0.01	3	B.Baria sadar+Chandina+Debidwar
19	Pea-B.Aman	40	0.01	3	Homna+Meghna+Muradnagar
20	Groundnut-Fallow-Fallow	35	0.01	3	Bancharampur+Nasirnagar+Debidwar
21	Potato-Jute-T. Aman	30	0.01	1	Brahmanpara
22	Potato-Maize-Aus-Vegetab	30	0.01	1	Debidwar
23	Sesame-Fallow-Blackgram	30	0.01	1	Homna
24	S.Potato-Jute-Fallow	30	0.01	1	ComillaSouth
25	Vegetab-Boro-T. Aman	30	0.01	1	Kachua
26	Garlic-Vegetab-Vegetab	25	0.01	2	Brahmanpara+Debidwar
27	Fallow-B.Aman	20	0.00	1	Laksam
28	Lentil-Fallow-T. Aman	20	0.00	1	Chauddagram
29	Lentil-Maize-T. Aman	20	0.00	1	Matlab North
30	Muskmelon-F-T. Aman	20	0.00	1	Debidwar
31	Potato-Boro-Aus	20	0.00	1	Brahmanpara
32	Groundnut-Fallow-T. Aman	15	0.00	2	Chandina+Chouddagram
33	Blackgram-Jute-T. Aman	10	0.00	1	B.Baria sadar
34	Coriander-Jute-T. Aman	10	0.00	1	Kachua
35	Garlic-Aus-Fallow	10	0.00	1	Debidwar
36	Garlic-Aus-T. Aman	10	0.00	1	Chandina
37	Garlic-Jute-T. Aman	10	0.00	1	Nasirnagar
38	Grasspea-Fallow-Fallow	10	0.00	1	Titas
39	Mustard-Fallow-Fallow	10	0.00	1	Monoharganj
40	Onion-Jute-T. Aman	10	0.00	1	Nasirnagar
41	Wheat-Vegetab-Vegetab	10	0.00	1	Homna
42	Chilli-Vegetab-T. Aman	5	0.00	1	Monoharganj
43	Mungbean-Jute-T. Aman	5	0.00	1	Debidwar
44	W.Melon-Fallow-T. Aman	5	0.00	1	Debidwar
	Total	1775	0.40		

**Table 9. Distribution of the most dominant Boro–F–F cropping pattern in Comilla region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Nasirnagar	11650	44.72	10.15
02 Nabinagar	10600	40.15	9.24
03 Sarail	9500	57.58	8.28
04 Hajiganj	9000	75.00	7.84
05 Bijoy nagar	8500	58.22	7.41
06 Bancharampur	7500	54.55	6.53
07 Dauadkandi	7000	47.95	6.10
08 Monoharganj	6250	60.10	5.45
09 B.Baria	4800	31.79	4.18
10 Laksam	4250	41.67	3.70
11 Titas	4200	57.53	3.66
12 Kasba	3500	22.95	3.05
13 Chandpur	3000	25.86	2.61
14 Matlab sadar	2900	31.87	2.53
15 Faridganj	2800	23.93	2.44
16 Homna	2500	25.38	2.18
17 Muradnagar	2500	10.59	2.18
18 Meghna	2100	29.58	1.83
19 Nangolkot	1900	12.42	1.66
20 Brahmanpara	1870	19.58	1.63
21 Akhaura	1700	26.36	1.48
22 Sarail	1700	15.96	1.48
23 Kachua	1300	7.78	1.13
24 Matlab North	900	6.16	0.78
25 Chandina	760	6.23	0.66
26 Haimchar	500	10.53	0.44
27 Comilla South	500	2.96	0.44
28 Debidwar	500	3.25	0.44
29 Ashuganj	300	5.88	0.26
30 Chouddagram	300	1.63	0.26
Comilla region	114780	26.18	100.00

modern varieties of deepwater rice can be made available, hopefully farmers will cultivate the land in wet season also. Debidwar, Ashuganj and Chouddagram upazila had a negligible area coverage for this pattern. In the country-wide compilation of data, it was observed that the single Boro was the 2<sup>nd</sup> 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).

### Second dominant cropping pattern

The second dominant cropping pattern in Comilla region is Boro–Fallow–T. Aman. It belongs to 19.93% of NCA of the region

and spread out over 25 upazilas (Table 10). Chouddagram upazila of Comilla district holds the highest area (10,900 ha) under this double rice cropping system. This upazila contributes 12.47% share of Boro–Fallow–T. Aman cropping area in the region. Faridganj upazila of Chandpur district stands in the sixth position, however, this upazila has allocated 62.39% surface, the biggest share, of its NCA. In some portion of the double rice area some short duration Rabi crops can be grown before Boro transplanting if appropriate varieties and other related technologies are made available (FAO, 1988). In the country-wide compilation of data it was observed that Boro–F–T. Aman was the most dominant cropping pattern in

**Table 10. Distribution of the 2<sup>nd</sup> dominant Boro–F–T. Aman cropping pattern in Comilla region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Chouddagram	10900	59.08	12.47
02 Comilla sadar South	8000	47.34	9.15
03 B.Baria	7800	51.66	8.92
04 Faridganj	7300	62.39	8.35
05 Kasba	6700	43.93	7.67
06 Matlab North	5000	34.25	5.72
07 Bijoynagar	4700	32.19	5.38
08 Burichang	4600	40.00	5.26
09 Sarail	4400	26.67	5.03
10 Comilla Adorsho sadar	4400	59.86	5.03
11 Nangolkot	4400	28.76	5.03
12 Akhaura	3500	54.26	4.00
13 Nabinagar	2800	10.61	3.20
14 Ashuganj	2400	47.06	2.75
15 Chandpur	2300	19.83	2.63
16 Brahmanpara	2000	20.94	2.29
17 Debidwar	1600	10.39	1.83
18 Nasirnagar	1350	5.18	1.54
19 Barura	1110	6.81	1.27
20 Muradnagar	900	3.81	1.03
21 Chandina	500	4.10	0.57
22 Bancharampur	360	2.62	0.41
23 Laksam	300	2.94	0.34
24 Haimchar	50	1.05	0.06
25 Matlab South	40	0.44	0.05
Comilla region	87410	19.93	100.00

**Table 11. Distribution of the 3<sup>rd</sup> dominant Boro–Aus–T. Aman cropping pattern in Comilla region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Barura	11200	68.71	17.28
02 Debidwar	7500	48.70	11.57
03 Comilla sadar South	5700	33.73	8.79
04 Chandina	5000	40.98	7.71
05 Nangolkot	4900	32.03	7.56
06 Laksam	4700	46.08	7.25
07 Kachua	3900	23.35	6.02
08 Burichang	3700	32.17	5.71
09 Matlab North	3300	22.60	5.09
10 Brahmanpara	3160	33.09	4.87
11 Muradnagar	2000	8.47	3.08
12 Kasba	1700	11.15	2.62
13 Comilla Adarsha sadar	1500	20.41	2.31
14 Chouddagram	1300	7.05	2.01
15 Saharasti	1200	11.27	1.85
16 Ashuganj	900	17.65	1.39
17 Nabinagar	900	3.41	1.39
18 B.Baria	800	5.30	1.23
19 Haimchar	470	9.89	0.72
20 Chandpur sadar	400	3.45	0.62
21 Bijoynagar	200	1.37	0.31
22 Nasirnagar	200	0.77	0.31
23 Sarail	150	0.91	0.23
24 Akhaura	20	0.31	0.03
25 Monoharganj	20	0.19	0.03
26 Matlab South	10	0.11	0.02
Comilla region	64830	14.78	100.00

**Table 12. Distribution of the 4<sup>th</sup> dominant Boro-B. Aman cropping pattern in Comilla region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Shaharasti	6800	63.85	17.73
02 Kachua	6700	40.12	17.47
03 Nabinagar	5700	21.59	14.86
04 Muradnagar	4000	16.95	10.43
05 Monoharganj	3850	37.02	10.04
06 Homna	2900	29.44	7.56
07 Nasirnagar	2200	8.45	5.74
08 Bancharampur	1600	11.64	4.17
09 Meghna	1200	16.90	3.13
10 Chandina	750	6.15	1.96
11 Nangolkot	650	4.25	1.69
12 Debidwar	550	3.57	1.43
13 Laksam	500	4.90	1.30
14 Sarail	350	2.12	0.91
15 Brahmanpara	330	3.46	0.86
16 Hajiganj	100	0.83	0.26
17 Barura	100	0.61	0.26
18 Chandpur sadar	50	0.43	0.13
19 Bijoy nagar	30	0.21	0.08
Comilla region	38360	8.75	100.00

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

Triple rice cropping system, Boro-Aus-T. Aman cropping pattern holds the third largest area coverage 64,830 hectares in Comilla region. This area is an equivalent to 14.78% of NCA in the region. This three-rice pattern is widely distributed over 26 upazilas. Barura upazila of Comilla district has the highest area coverage of 11,200 ha for three-rice system which stands for 17.28% of the total area under this pattern in the region (Table 11). Debidwar upazila of the same district ranks in second position for three-rice (7,500 ha) which represents 48.70% of its NCA and this area is 11.57% of the total area for this particular pattern in the region. Though continuous rice cropping is not suggested by the researchers and extension personnel, however, this type of land is not suitable for cultivation of non-rice crops. In this context, to maintain the fertility of the soils and for better crop production suggestions should be recommended for proper dose of chemical fertilizer, application of organic manure and retention of sufficient rice straw in the field.

### Fourth dominant cropping pattern

Fourth dominant cropping pattern Boro-B. Aman has occupied 38,360 hectares representing 8.75% share of NCA in Comilla region (Table 12). This pattern is distributed over 19 upazilas where Shaharasti upazila of Chandpur district ranked in top position. This upazila has 6,800 ha area of Boro-B. Aman which alone represents 63.85% of upazila NCA. In consideration of the whole this area is equivalent to 17.73% of total area for this particular pattern in the region. Kachua upazila of the same district ranks in second position with 6,700 ha area for this pattern. In the same way this upazila has allotted the second biggest share (40.12%) of its NCA. The area normally belongs to medium high land-II and medium low land. Therefore, in wet season there is no scope of T. Aman cultivation. In some portion of this area mixed B. Aus+B. Aman cropping system might be introduced to boost up the productivity.

### Fifth dominant cropping pattern

Fifth dominant cropping pattern Mustard-B. Aman had been covering 9,690 hectares representing 2.21% share of NCA in Comilla region (Table 13). This pattern is distributed over only nine upazilas where Nasirnagar

**Table 13. Distribution of the 5<sup>th</sup> dominant Mustard–B.Aman cropping pattern in Comilla region, 2014-15.**

Upazila	Area (ha)	%of upazila NCA	% of the pattern in region
01 Nasirnagar	4880	18.73	50.36
02 Muradnagar	2600	10.95	26.83
03 Bancharampur	600	4.36	6.19
04 Nabinagar	440	1.67	4.54
05 Kasba	400	2.60	4.13
06 Meghna	270	3.80	2.79
07 Nangolkot	250	1.63	2.58
08 Brahmanpara	220	2.32	2.27
09 Shaharasti	30	0.28	0.31
Comilla region	9690	2.21	100.00

**Table 14. Crop diversity and cropping intensity in Comilla region, 2014-15.**

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Akhaura	07	07	0.624	0.776	174
02 Ashuganj	07	08	0.705	0.872	215
03 B.Barua	15	14	0.627	0.772	181
04 Bijoyagar	11	07	0.559	0.737	144
05 Bancharampur	24	20	0.682	0.829	141
06 Kasba	12	11	0.739	0.872	195
07 Nabinagar	16	15	0.774	0.898	170
08 Nasirnagar	24	20	0.751	0.877	156
09 Sarail	13	12	0.594	0.774	146
10 Chandpur	20	20	0.865	0.925	166
11 Faridganj	14	10	0.566	0.749	180
12 Haimchar	24	17	0.930	0.964	208
13 Hajiganj	13	11	0.433	0.637	126
14 Kachua	16	08	0.761	0.891	221
15 Matlab.N	20	17	0.822	0.925	236
16 Matlab.S	17	14	0.801	0.894	168
17 Shaharasti	11	09	0.558	0.773	197
18 Barua	15	13	0.522	0.832	292
19 Brahmanpara	20	17	0.800	0.903	221
20 Burichang	13	15	0.724	0.889	244
21 Chouddagram	18	17	0.605	0.785	188
22 Chandina	33	20	0.806	0.911	250
23 Com.Adarsha	07	08	0.590	0.481	129
24 Com.South	19	12	0.659	0.862	240
25 Daudkandi	12	07	0.668	0.791	144
26 Debidwar	36	21	0.739	0.891	265
27 Homna	27	16	0.832	0.891	176
28 Nangolkot	16	13	0.769	0.900	231
29 Laksam	14	10	0.612	0.806	205
30 Meghna	15	13	0.828	0.911	170
31 Monoharganj	13	13	0.504	0.677	140
32 Muradnagar	35	20	0.909	0.956	209
33 Titas	20	13	0.656	0.795	132
Comilla region	146	33	0.859	0.935	192

upazila of B.Barua district ranked in top position. This upazila had 4,880 ha area for Mustard-B.Aman pattern which alone represented 50.36% of the total area for this pattern in the region. Muradnagar upazila of Comilla district had the 2<sup>nd</sup> largest area 2,600 ha for this cropping. These two upazilas had contributed more than three-fourths share of the total Mustard-B. Aman area in the region. In this land type irrigation water might be less available. Boro cultivation is not possible in the dry season. In this situation other high yielding non-rice crop e.g. maize and mixed cropping of lentil+mustard might be suggested.

### **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 146 cropping patterns were identified in the whole area of Comilla region under this investigation. The highest number of cropping patterns was identified 36 in Debidwar upazila of Comilla district (Table 14). The lowest number of cropping patterns was identified seven in Akhura and Ashuganj upazila of B.Barua and Adarsha upazila of Comilla district followed by 11 in Shaharasti upazila of Chandpur and Bijoynagar upazila of B.Barua district. The higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were normally related to water logging. The lowest diversity index for cropping pattern was recorded 0.433 in Hajiganj upazila of Chandpur district followed by 0.504 in Monoharganj of Comilla district. In a study Shahidullah *et al.* (2006) also found lowest values for all the diversity and intensity parameters in water stagnant area of greater Noakhali. The highest value of diversity index for cropping pattern was found 0.930 in Haimchar upazila of Chandpur district and that was followed by 0.909 in Muradnagar upazila of Comilla district. The lowest crop diversity index (CDI) was reported 0.481 in Comilla Adarsha upazila followed by 0.637 in Hajiganj

upazila of Chandpur district. The highest value of CDI was observed 0.964 in Haimchar upazila of Chandpur followed by 0.956 in Muradnagar upazila of Comilla district. The range of cropping intensity (CI) value was recorded 126-292%. The maximum value was for Barura upazila of Comilla district and minimum for Hajiganj upazila of Chandpur district. As a whole the CDI for Comilla region was calculated 0.935 and the average cropping intensity at regional level was 192%. 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). The farmers of Kerala diversified their cropping pattern to minimize risk from due to crop failures and price fluctuations (Mahesh, 1999).

### **CONCLUSION**

The cropping intensity of the Comilla region was little bit lower than the national average. Single Boro, Boro-Fallow-T. Aman, Boro-T. Aus-T. Aman, Boro-B.Aman, Mustard-B. Aman were the major cropping patterns in the region. Exclusive rice area is about nine folds of exclusive non-rice area. The non-rice based cropping patterns were either few or area under those cropping patterns were much lower, which are the challenges to food and nutritional security for the people of the Comilla 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.
- The cropping patterns with minor area coverage but wider existence might be expanded in the same upazilas or other upazilas of the region.
- In the single Boro area suitable vegetables 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.

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- Blade, S F and A E Slinkard 2002. New Crop Development: The Canadian Experience. In: *Trends in New Crops and New Uses*. J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Jackson, B R, A Yantasast, C Prechachat, M A Chowdhury and S M H Zaman. 1972. Breeding rice for deep-water areas. Pages 517-528 In: *International Rice Research Institute, Rice Breeding*, Los Baños, Philippines.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapuram.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

Cropping pattern		Area(ha)	Cropping pattern		Area(ha)
001	Boro-Fallow-Fallow	114780	052	Vegetab-Vegetab-T. Aman	580
002	Boro-Fallow-T. Aman	87410	053	Potato-Sesbania	550
003	Boro-Aus-T. Aman	64830	054	Soybean-B.Aman	550
004	Boro-B.Aman	38360	055	S.Potato-Fallow-T. Aman	540
005	Mustard-B.Aman	9690	056	Lentil-Jute-T. Aman	500
006	Potato-Maize-Fallow	7050	057	Mustard-Boro-B.Aman	500
007	Vegetab-Vegetab-Vegetab	7030	058	Mustard-Sesame+B.Aman	500
008	Vegetab-Vegetab-Fallow	6840	059	Maize-B.Aman	450
009	Boro-Aus-Fallow	4670	060	S.Potato-B.Aman	440
010	Potato-Boro-Fallow	4250	061	Chilli-Fallow-T. Aman	425
011	Fallow-Aus-T. Aman	4160	062	Wheat-Fallow-T. Aman	405
012	Potato-Jute-Fallow	3870	063	Grasspea-Jute-T. Aman	400
013	Chilli-B.Aman	3820	064	Mustard-Fallow-T. Aman	400
014	Mustard-Boro-Fallow	3810	065	Onion-Jute-Fallow	400
015	Potato-B.Aman	3720	066	Soybean-Fallow-T. Aman	400
016	Fallow-Fallow-T. Aman	3430	067	Onion-B.Aman	395
017	Boro-Sesbania-T. Aman	3000	068	Garlic-Jute-Fallow	390
018	Lentil-B.Aman	2970	069	Vegetab-Boro-Aus-T. Aman	370
019	Potato-Aus-T. Aman	2500	070	Lentil-Jute-Fallow	360
020	Vegetab-B.Aman	2480	071	Fallow-Fallow-Blackgram	350
021	Wheat-B.Aman	2140	072	Vegetab-Jute-Fallow	335
022	Potato-Boro-T. Aman	2120	073	Mustard-Boro-Aus	330
023	Mustard-Boro-T. Aman	2100	074	Sesame-B.Aman	330
024	Boro-Sesbania-Fallow	1910	075	S.Potato-Vegetab-Fallow	330
025	Mustard-Aus-Fallow	1900	076	Vegetab-Jute-T. Aman	310
026	Grasspea-B.Aman	1785	077	Wheat-Jute-T. Aman	310
027	Vegetab-Aus-T. Aman	1775	078	Onion-Fallow-T. Aman	305
028	Vegetab-Aus-Fallow	1640	079	Sesame-Fallow-T. Aman	300
029	Maize-Fallow-Fallow	1500	080	Wheat-Aus-Fallow	300
030	Mustard-Boro-Aus-T. Aman	1470	081	Wheat-Aus-T. Aman	250
031	Boro-Vegetab(Float/Norm)	1230	082	Mustard-Aus-T. Aman	245
032	Vegetab-Fallow-Fallow	1180	083	Chilli-Vegetab-Fallow	220
033	Vegetab-Fallow-T. Aman	1160	084	Coriander-Fallow-T. Aman	220
034	S.Potato-Fallow-Fallow	1060	085	Garlic-B.Aman	220
035	Mustard-Maize-T. Aman	1030	086	Maize-Jute-Fallow	190
036	Fallow-Sesame+B.Aman	950	087	Boro-Jute-T. Aman	180
037	Potato-Maize-T. Aman	930	088	Potato-S.gourd-Aus	180
038	Boro-Fallow-Blackgram	880	089	Muskmelon-B.Aman	175
039	Maize-Aus-Fallow	800	090	Blackgram-B.Aman	170
040	Maize-Vegetab-Fallow	800	091	Lentil-Sesame-Fallow	170
041	Coriander-B.Aman	790	092	Groundnut- Aus-T. Aman	160
042	Wheat-Jute-Fallow	780	093	Garlic-Fallow-T. Aman	155
043	Potato+S.gourd-Aus-T. Aman	740	094	Chilli-Jute-T. Aman	150
044	Mustard-Jute-Fallow	730	095	Groundnut-Sesame-Fallow	150
045	Chilli-Jute-Fallow	725	096	Maize-Aus-T. Aman	150
046	Chilli-Aus-T. Aman	710	097	Maize-Fallow-T. Aman	140
047	Coriander-Fallow-Fallow	700	098	S.Potato-Jute-T. Aman	140
048	Fallow-Jute-T. Aman	700	099	Soybean-Jute-Fallow	130
049	Soybean-Fallow-Fallow	700	100	Potato-Sesame-T. Aman	125
050	Potato-Boro-Aus-T. Aman	630	101	Potato-Aus-Fallow	120
051	Chilli-Fallow-Fallow	600	102	Potato+Maize-B.Aman	110
			103-146	Other 44 patterns (Table 8)	1775



# Diversity of Cropping Systems in Chittagong Region

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## ABSTRACT

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

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

## INTRODUCTION

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

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

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

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

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

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

## METHODOLOGY

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

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

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

Where,  $CDI_i$  = Crop Diversity Index

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

$A_i$  = Total area planted under all crops

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

## RESULTS AND DISCUSSION

### Land use

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

### Cropping patterns of Chittagong

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

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

### Rice and non-rice crops at a glance

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

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

### Pulse crops

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

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

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

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

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

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

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

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

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

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

### **Oil-seed crops**

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

### **Vegetables and spices crops**

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

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

### **Sporadic and distinct cropping patterns**

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

### **Rare cropping patterns**

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

### **Most dominant cropping pattern**

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

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

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

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

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

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

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

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

### Second dominant cropping pattern

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

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

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

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

**Third dominant cropping pattern**

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

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

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

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

**Fourth dominant cropping pattern**

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

**Fifth dominant cropping pattern**

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

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

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

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

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

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

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

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

### Crop diversity and cropping intensity

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

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

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

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

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

## CONCLUSION

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

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

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

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.

- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2):213-238.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.
- Singh, J. and R S Sidhu. 2006. Accounting for impact of environmental degradation in agriculture of Indian Punjab. *Agric. Economics Res. Rev.* 19: 37-48.
- Tscharntke, T, R Bommarco, Y Clough, T O Crist, D Klein, T A Rand, J M Tylianakis, S vanNouhuys, and S Vidal. 2007. Conservation biological control and enemy diversity on a landscape scale. *Biol. Control.* 43: 294-309.
- Tscharntke, T., A M Klein, A Kruess, I S Dewenter, and C Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity-ecosystem service management. *Ecol. Lett.* 8: 857-874.

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

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

# Cropping Pattern, Intensity and Diversity in Dhaka Region

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## ABSTRACT

Sustainable crop production in Bangladesh through improvement of cropping intensity and crop diversity in rice based cropping system is regarded as increasingly important in national issues. Planning of agricultural development largely depends on the authentic, reliable and comprehensive statistics of the existing cropping patterns, cropping intensity and crop diversity of a particular area, which will provide guideline to our policy makers, researchers, extensionists and development workers. The study was conducted over all 46 upazilas of Dhaka agricultural region in 2015 using pretested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity in the region. From the present study, it was observed that about 48.27% net cropped area (NCA) is covered by exclusive rice cropping systems whereas deep water rice occupied about 16.57% of the regional NCA. The most dominant cropping pattern Boro–Fallow–T. Aman alone occupied about 22.59% of net cropped area (NCA) with its distribution over 32 upazilas out of 46. The second largest area was covered by single Boro cropping pattern, which was spread over 44 upazilas. Total number of cropping patterns was observed 164. The highest number of cropping pattern was identified 35 in Tangail sadar and Dhamrai upazila of Dhaka district and the lowest was seven in Bandar of Narayanganj and Palash of Narsingdi district. The lowest crop diversity index (CDI) was reported as 0.70 in Dhamrai followed by 0.72 in Monohardi of Narsingdi. The highest value of CDI was observed as 0.97 in Tangail sadar followed by 0.95 in Dhamrai of Dhaka and Bhuanpur of Tangail. The range of cropping intensity value was recorded 124-239%. The maximum CDI was observed in Saturia upazila of Manikganj district and minimum in Sreenagar upazila of Munsiganj district. The CDI value for Dhaka region was calculated 0.94 and the average cropping intensity at regional level was 191%.

**Key words:** Crop diversity index, land use, cropping intensity and deepwater ecosystem

## INTRODUCTION

Agriculture is the science and practice of producing crops; and cropping pattern expresses the shares of various crops in the farmers' total cultivated area in an agricultural year. Cropping pattern is an important indicator of a farmer's decision making ability and also influences the consumption pattern as well as health and nutritional status of the people. Cropping pattern vary from region to region, country to country and culture to culture. Cropping systems of a region are decided by and large, by a number of soil and climatic parameters which determine overall agro-ecological setting for nourishment and appropriateness of a crop or set of crops for cultivation.

Bangladesh agriculture involves food production for over 162 million people from merely 8.75 million hectares of agricultural land (Salam *et al.*, 2014) and it is shrinking day by day. The overall land area increased in the recent past is due to reclamation of char lands. The annual loss of agricultural land is about 0.73% per annum due to construction of houses, roads and industrial infrastructure (BBS, 2014). 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

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limited land resource. In order to produce more food within a limited area, the most important options are i) to increase the cropping intensity by producing three or more crops over the same piece of land in a year and ii) to increase the production efficiency of the individual crop by using optimum management practices (Salam *et al.*, 2014).

To meet the challenges of a globalizing market in agriculture as well as the growing and changing needs of the population, many countries in South East Asia have undertaken crop diversification to enhance productivity and cultivate high value crop with positive outcome. Diversification is taking place either through area augmentation or by crop substitution. If carried out appropriately, diversification can be used as a tool to augment farm income, generate employment, alleviate poverty and conserve precious soil and water resources (Pingali and Rosegrant, 1995; Chand, 1996). It can be said that present cropping pattern and crop diversification is a contemporary issue in the field of agriculture, especially in the context of Bangladesh. Therefore, it claims a comprehensive study for the betterment of the agriculture of the country. From the literature, it is found that there are a number of studies were carried out in different countries regarding this issue. However, a very few studies on this aspect was carried out in Bangladesh. In this study, the cropping pattern survey was carried out in Dhaka region to search the better opportunities for improvement of cropping intensity in this region through the cropping pattern analysis. In this backdrop, the present study is an attempt to analyze to the present scenario of cropping pattern and diversification of Dhaka region in Bangladesh. The present study was designed with the following specific objectives to:

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

## METHODOLOGY

Forty-six upazilas of Dhaka, Gazipur, Narsingdi, Manikganj, Munsiganj, Narayanganj and Tangail districts under Dhaka 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 46 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during July 2015 at upazila level. SAAOs were purposively selected by Agriculture Extension Officers (AEO), Additional Agriculture Officer (AAO) and Upazila Agriculture Officer (UAO). 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. The filled questionnaires were collected by the scientists of Rice Farming Systems 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 held on the 27 August in Munsiganj; 7 September in Gazipur; 17 September in Manikganj; 21 September in Narsingdi; 5 October in Dhaka 3 November in Tangail; and 25 November 2015 in Narayanganj district. 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), Deputy Director of Seed Certification Agency, District Training Officer and Additional Deputy Directors, one representative from Agricultural Training Institute (ATI) participated in the data validation workshop. The number participants of validation workshop ranged from 46 to 104 in each district. All the participants were divided into three to four groups for data validation.

Each group was facilitated by two 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 the collected data were done using Microsoft 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 in Dhaka region. The net cropped area of the region is 653,670 hectares. Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in the region were pineapple, sugarcane, banana papaya, betel leaf, ginger and turmeric. The annual cropped area in different upazilas ranged from 10 to 11,000 ha. The annual cropped area accounted only 5.21% of the net cropped area (NCA) in the region. At a glance, the region possesses 21.25% single cropped area (SCA), 55.37% double cropped area (DCA), 17.23% triple cropped area (TCA) and 0.04% quadruple cropped area (QCA). The SCA had the major share of NCA in Raipur upazila of Narsingdi district, Sreepur and Kaliganj upazilas of Gazipur district; Sreenagar upazila of Munsiganj district; Nawabganj and Savar upazilas of Dhaka district, Rupganj and Sonargaon upazila of Narayanganj district followed by corresponding double cropped area (DCA). Most of the upazilas were dominated by DCA (Table 1). The area which

could not defined under SCA, DCA, TCA or QCA was considered as others whose coverage is less than 1% of the NCA.

### Cropping patterns of Dhaka

In total, 164 cropping patterns were observed in Dhaka region of which eight cropping patterns with exclusive rice crop covers 48% of the NCA. There were 59 cropping patterns with exclusive non-rice crop covering about 16% of the NCA. Rest of the NCA i.e. around 25% area is covered by 97 rice - non-rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Table 2 presents eight cropping patterns where rice is the only crop round the year. It comprises 48.27% of the NCA in the region. Among them single, double and triple rice areas represent 18.88%, 29.20% and 0.19%, respectively. It reflects the unparallel dominance of rice in the cropping systems in Dhaka region. In case of individual pattern Boro-Fallow-T. Aman has the highest coverage (22.59%) and was recorded in 32 upazilas out of 46. The second dominant pattern as single Boro area occupied 16.74% of NCA which was distributed in most of the upazilas i.e. 44 upazilas. Boro-B.Aman covered 6.12% area with its considerable existence in 24 upazilas.

In the current investigation, 59 cropping patterns were identified that was free from rice. Among the 59 patterns first 47 have been arranged in descending order in Table 3. The rest 12 patterns with negligible area coverage can be found in Table 8 where they are arranged with other patterns of different categories. Aggregate of the 59 patterns have had approximately 16% of NCA. In critical comparison is clear that exclusive rice area is about three folds of exclusive non-rice area. In Dhaka region crop diversity is much wider than that of other regions like Sylhet and Chittagong where exclusive rice area covers 37 folds and 23 folds, respectively, of exclusive non-rice area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). Appropriate cropping patterns may facilitate maximum possible land utilization as well as efficient use of other scarce resources

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Dhamrai	30740	100	500	15580	5910	0	110	22200	224
02 Dohar	12169	30	3040	2130	770	0	160	6130	161
03 Keraniganj	16697	530	1200	4530	2900	0	170	9330	213
04 Nawabganj	24481	20	6830	6520	2840	0	110	16320	175
05 Savar	28013	60	6400	4230	3310	0	160	14160	178
06 Gazipur sadar	43363	2000	4900	8665	3170	0	165	18900	180
07 Kapasia	35698	3500	5700	9150	1140	0	110	19600	159
08 Kaliakair	31114	690	5285	5520	1680	0	165	13340	167
09 Kaliganj	2153	360	6950	3870	1150	0	130	12460	150
10 Sreepur	46294	970	10940	7890	1110	0	160	21070	148
11 Daulatpur	21031	40	2830	9340	1930	0	100	14240	193
12 Ghor	14601	520	1130	6820	1780	0	120	10370	201
13 Harirampur	24542	90	4590	7890	1600	0	110	14280	178
14 Manikganj sadar	21515	320	230	12790	3770	0	110	17220	219
15 Satura	14009	160	350	4670	4150	0	130	9460	239
16 Shibalaya	19910	100	1900	5000	4500	0	100	11600	222
17 Singair	21765	1120	470	7560	6950	0	120	16220	233
18 Gazaria	13092	40	2820	3170	0	0	110	6140	153
19 Lohajang	13012	10	3230	4790	150	0	120	8300	162
20 sadar	20719	30	920	9450	570	0	130	11100	197
21 Sreenagar	19239	30	9300	3000	0	0	100	12430	124
22 Serajdikhan	18000	30	1200	9550	2800	0	150	13730	212
23 Tungibari	15002	50	200	9320	350	0	180	10100	201
24 Arai hazar	18335	20	3350	8400	1460	0	140	13370	186
25 Bandar	5439	30	2120	950	300	0	80	3480	146
26 Nrayanganj sadar	10080	20	300	2710	550	0	40	3620	206
27 Rupganj	17908	100	6540	3470	100	0	90	10300	136
28 Sonargaon	17166	10	6470	2370	0	0	60	8910	127
29 Belabo	11800	250	500	4850	3050	0	100	8750	227
30 Monohardi	19260	1500	400	8400	1360	0	140	11800	195
31 Narsingdi sadar	21344	240	6000	4000	1360	0	140	11740	158
32 Palash	9013	430	800	3010	600	0	90	4930	187
33 Raipur	31255	10	12000	8670	2010	0	110	22800	156
34 Shibpur	20586	420	900	9290	1460	0	150	12220	201
35 Basail	15626	50	1600	6260	4750	0	190	12850	224
36 Bhuanpur	21638	300	3300	7750	4640	0	110	16100	207
37 Delduar	18400	150	0	9820	2900	0	130	13000	221
38 Dhanbari	13020	500	530	8900	1300	20	150	11400	203
39 Ghatail	45171	4500	1300	20930	2650	0	170	29550	189
40 Gopalpur	19337	10	1625	9645	3345	100	85	14810	213
41 Kalihati	30100	260	3600	11100	5560	80	160	20760	209
42 Madhupur	37047	11000	100	11590	1370	0	140	24200	160
43 Mirzapur	37400	740	3035	17740	5220	0	155	26890	205
44 Nagarpur	26720	560	70	14280	6400	0	150	21460	227
45 Shakhipur	43000	1500	500	15300	4535	0	115	21950	212
46 Tangail sadar	30197	680	2980	11070	5150	50	150	20080	208
Dhaka region	-	34080	138935	361940	112600	250	5865	653670	191

**Table 2. Cropping patterns with exclusive rice in Dhaka region, 3014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Boro-Fallow-T. Aman	147820	22.61	32
02	Boro-Fallow-Fallow	109530	16.76	44
03	Boro-B.Aman	40050	6.13	24
04	Fallow-Fallow-T. Aman	9650	1.48	5
05	Boro-Sesbania-Fallow	4410	0.67	7
06	Boro-Sesbania-T. Aman	2440	0.37	6
07	Boro-Aus-T. Aman	1215	0.19	7
08	Boro-Aus-Fallow	780	0.12	6
	Total	315895	48.33	

in a sustainable manner. Diversified cropping pattern may be option for the farmers as a coping strategy against risks (Mandal and Bezbaruah, 2013). Typology of different cropping systems is the base for the managers of these systems to intensify production (Shriar, 2000).

### Deep water rice ecosystem

Deep water is a special type of ecosystem in the country. In context of Dhaka region this ecosystem represents a large portion. The cropping patterns under deep water ecosystem are listed in the Table 4. Among the listed 20 patterns Boro-B.Aman cropping pattern covers the highest area coverage of 40,050 hectares which represents 6.12% of the region's NCA. This pattern is distributed over 24 upazilas out of 46. The second highest Mustard-Boro-B. Aman cropping pattern covers 26,600 hectares and distributed over 21 upazilas. The first two patterns jointly covered 10.18% NCA which is more than three-fifths of total deep-water rice area in the region. The water level of this ecosystem ranges between 150 and 400 cm, and water usually remains 3-4 months. Special rice varieties known as 'floating rice' are planted in these areas. In the past, Bangladesh had a land coverage of 3 million hectares for deepwater rice (Jackson *et al.*, 1972). In course of time the continuous effort on modern agriculture shifted DWR area mainly to modern Boro. Now, the area under deep water rice in Bangladesh is reduced to 0.4 million hectares (Nasim *et al.*, 2017). Though this cropping system is less productive than other modern cropping systems, the specific fragile ecosystem still struggling because of no other alternatives.

### Vegetables and spices crops

Seventy-six cropping patterns have been arranged in descending order according to area coverage in Table 5. Potato, sweet potato, vegetables of Rabi, Kharif-I and Kharif-II; spices viz chilli, onion, garlic are included in this list. A row is included at the end of the Table 5 representing an aggregate of 19 patterns of vegetables and spices, which is elaborately presented in the Table 8 with other patterns of different categories. The most contributing cropping pattern is year-round vegetables covering 3.98% of NCA, which distributed over 36 upazilas. Potato-B.Aman was the second dominant cropping pattern which possessed 19,960 ha covering 3.05% of NCA and recorded in 15 upazilas. Potao-Sesbania is the third dominant pattern exists in 13 upazilas. Among the vegetables potato alone is leading in 20 cropping patterns covering 49,550 hectares of land, which is equivalent to 7.57% of NCA. 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 vegetables, good communication and marketing facilities enhanced the extensive production of various types of vegetables in Dhaka region (FAO, 1988). Vegetables like *Colocasia esculenta*, okra (*Abelmoschus esculentus*), amaranth (*Amaranthus* spp.), brinjal (*Solanum melongena*), cucurbits, etc are grown in medium upland adjacent to rice fields during rainy season and potato, sweet gourd, cole crops, leafy vegetables etc are grown during winter season in Tripura (Das *et.al.*, 2015).

**Table 3. Cropping patterns of non-rice exclusive in Dhaka region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	26050	3.99	36
02 Potato-Sesbania	10220	1.56	13
03 Vegetab-Vegetab-Fallow	8750	1.34	17
04 Vegetab-Fallow-Fallow	6980	1.07	9
05 Potato-Jute-Fallow	4360	0.67	15
06 Groundnut-Fallow-Fallow	3620	0.55	8
07 Fallow-Fallow-Blackgram	3415	0.52	10
08 Maize-Maize-Fallow	3280	0.50	3
09 Maize-Jute-Fallow	2790	0.43	6
10 Maize-Fallow-Fallow	2265	0.35	6
11 Vegetab-Jute-Fallow	2170	0.33	10
12 Sesame-Fallow-Blackgram	1850	0.28	4
13 Maize-Vegetab-Fallow	1700	0.26	5
14 Wheat-Jute-Fallow	1560	0.24	10
15 Chilli-Fallow-Fallow	1490	0.23	6
16 S.Potato-Fallow-Fallow	1430	0.22	9
17 Potato-Sesame-Fallow	1390	0.21	8
18 Grasspea-Sesbania-Fallow	1350	0.21	2
19 Onion-Jute-Fallow	1350	0.21	11
20 S.Potato-Jute-Fallow	1230	0.19	7
21 Vegetab-Maize-Fallow	1170	0.18	3
22 Grasspea-Fallow-Fallow	1060	0.16	3
23 Chilli-Jute-Fallow	1050	0.16	11
24 Lentil-Jute-Fallow	1040	0.16	8
25 Maize-Sesbania-Fallow	1000	0.15	1
26 Grasspea-Sesame-Fallow	920	0.14	6
27 Onion-Vegetab-Vegetab	800	0.12	9
28 Vegetab-Fallow-Blackgram	790	0.12	4
29 Maize-Sesame-Fallow	690	0.11	2
30 Blackgram-Jute-Fallow	660	0.10	2
31 Potato-Maize-Fallow	610	0.09	4
32 Coriander-Vegetab-Fallow	580	0.09	3
33 Chilli-Vegetab-Fallow	570	0.09	7
34 Mustard-Jute-Fallow	560	0.09	4
35 Garlic-Jute-Fallow	530	0.08	9
36 Grasspea-Jute-Fallow	420	0.06	3
37 Coriander-Fallow-Fallow	390	0.06	6
38 Lentil-Sesame-Fallow	355	0.05	3
39 Pea-Vegetab-Fallow	350	0.05	1
40 Coriander-Jute-Fallow	330	0.05	6
41 Potato-Chilli-Fallow	330	0.05	3
42 Lentil-Vegetab-Vegetab	320	0.05	4
43 Potato-Groundnut	170	0.03	1
44 Garlic-Fallow-Fallow	150	0.02	3
45 Maize-Fallow-Blackgram	150	0.02	1
46 Garlic-Vegetab-Vegetab	135	0.02	5
47 Wheat-Chilli-Fallow	110	0.02	1
48-59 Other 12 patterns (in Table 8)	575	0.09	-
Total area for exclusive non-rice	103065	15.77	

**Table 4. Cropping patterns under deep water rice ecosystem in Dhaka region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-B.Aman	40050	6.13	24
02 Mustard-Boro-B.Aman	26600	4.07	21
03 Potato-B.Aman	19960	3.05	15
04 Onion-B.Aman	5230	0.80	8
05 Blackgram-B.Aman	3090	0.47	8
06 Grasspea-B.Aman	2970	0.45	11
07 Maize-B.Aman	1920	0.29	7
08 Vegetab-B.Aman	1690	0.26	6
09 Mustard-B.Aman	1340	0.20	4
10 Chilli-B.Aman	820	0.13	6
11 Mustard-Sesame+B.Aman	800	0.12	2
12 Wheat-B.Aman	690	0.11	7
13 Garlic-B.Aman	640	0.10	5
14 Sesame+B.Aman-Blackgram	600	0.09	1
15 Coriander-B.Aman	550	0.08	6
16 Groundnut-B.Aman	420	0.06	4
17 Lentil-B.Aman	330	0.05	5
18 Grasspea-B.Aus+B.Aman	300	0.05	1
19 Potato+Maize-B.Aman	300	0.05	1
20 Fallow-Sesame+B.Aman	200	0.03	2
21 Pea-B.Aman	170	0.03	4
22-24 Other three patterns (in Table 8)	280	0.04	
Total deep-water rice	108950	16.67	

### Oil-seed crops

Mustard is the most important one among the oil-seed crops in Dhaka region. There are 32 cropping patterns for oil-seeds among which 15 patterns had been led by mustard alone (Tables 6 and 8). The total share of oil-seed cropping patterns is 17.71% of NCA in the region whereas mustard absolutely occupies 16.11%. The second prevailing sesame covers over 1%. The most dominant Mustard-Boro-Fallow pattern is distributed over 31 upazilas out of 46.

### Pulse crops

Thirty-four cropping patterns are holding different pulse crops (Tables 7 and 8). Among them blackgram is covering the largest area whereas pea is cultivated in the smallest area. Twelve cropping patterns of blackgram jointly cover 2.42% of NCA. Grasspea (*Lathyrus sativus*) holds the second position in pulse crop cultivation in Dhaka region. There are nine cropping patterns for grasspea, which in-together occupy about 1% of NCA. In the

documentation of pulse cropping systems grasspea has the widest spreading in the region. The third ranking pattern Grasspea-B. Aman is available in 11 upazilas. Finally the aggregate area of the pulse cropping system stands for 4.26% of the NCA in Dhaka region. 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 (FAO, 1988).

### Sporadic and distinct cropping patterns

Some cropping patterns are extremely location-specific, however, with a large area coverage. These are Maize-Maize-Fallow (Table 3) and Vegetable-Boro-Fallow (Table 5). The Maize-Maize-Fallow is grown in Ghior (430 ha), Satoria (1,700 ha) and Singair (1,150 ha) upazila in Manikganj district. Vegetable-Boro-Fallow is limited to only Dhamrai upazila (1,590 ha)

**Table 5. Area for vegetables and spices under different cropping patterns in Dhaka region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	26050	3.98	36
02 Potato-B.Aman	19960	3.05	15
03 Potato-Sesbania	10220	1.56	13
04 Vegetab-Vegetab-Fallow	8750	1.34	17
05 Vegetab-Fallow-Fallow	6980	1.07	9
06 Onion-B.Aman	5230	0.80	8
07 Potato-Jute-Fallow	4360	0.67	15
08 Potato-Boro-Fallow	4050	0.62	5
09 Potato-Jute-T. Aman	3360	0.51	14
10 Potato-Boro-T. Aman	3090	0.47	11
11 Vegetab-Boro-Fallow	2590	0.40	2
12 Boro-Vegetab(Float/Norm)	2360	0.36	5
13 Vegetab-Jute-Fallow	2170	0.33	10
14 Maize-Vegetab-Fallow	1700	0.26	5
15 Vegetab-B.Aman	1690	0.26	6
16 Vegetab-Vegetab-T. Aman	1660	0.25	6
17 Chilli-Fallow-Fallow	1490	0.23	6
18 S.Potato-Fallow-Fallow	1430	0.22	9
19 Potato-Sesame-Fallow	1390	0.21	8
20 Onion-Jute-Fallow	1350	0.21	11
21 S.Potato-Jute-Fallow	1230	0.19	7
22 Boro-Vegetab-T. Aman	1200	0.18	1
23 Vegetab-Maize-Fallow	1170	0.18	3
24 Vegetab-Jute-T. Aman	1120	0.17	7
25 Chilli-Jute-Fallow	1050	0.16	11
26 Chilli-B.Aman	820	0.13	6
27 Vegetab-Boro-T. Aman	820	0.13	5
28 Onion-Vegetab-Vegetab	800	0.12	9
29 Vegetab-Fallow-Blackgram	790	0.12	4
30 Fallow-Vegetab-T. Aman	720	0.11	1
31 Vegetab-Aus-T. Aman	680	0.10	3
32 Garlic-B.Aman	640	0.10	5
33 Potato-Maize-Fallow	610	0.09	4
34 Coriander-Vegetab-Fallow	580	0.09	3
35 Chilli-Vegetab-Fallow	570	0.09	7
36 Coriander-B.Aman	550	0.08	6
37 Garlic-Jute-Fallow	530	0.08	9
38 Onion-Jute-T. Aman	530	0.08	5
39 Potato-Vegetab-T. Aman	440	0.07	5
40 Chilli-Fallow-T. Aman	400	0.06	2
41 Potato-Fallow-T. Aman	400	0.06	1
42 Potato-Maize-T. Aman	400	0.06	2
43 Coriander-Fallow-Fallow	390	0.06	6
44 Vegetab-Fallow-T. Aman	360	0.06	4
45 Pea-Vegetab-Fallow	350	0.05	1
46 Coriander-Jute-Fallow	330	0.05	6
47 Potato-Chilli-Fallow	330	0.05	3
48 Lentil-Vegetab-Vegetab	320	0.05	4
49 Potato+Maize-B.Aman	300	0.05	1
50 Potato-Sesame-Aus	200	0.03	1
51 Potato-Groundnut	170	0.03	1
52 Chilli-Vegetab-T. Aman	150	0.02	1
53 Garlic-Fallow-Fallow	150	0.02	3
54 Garlic-Vegetab-Vegetab	135	0.02	5
55 Garlic-Jute-T. Aman	110	0.02	4
56 Potato-Aus-Fallow	110	0.02	2
57 Wheat-Chilli-Fallow	110	0.02	1
58-76 Other 19 patterns (in Table 8)	1030	0.16	-
Total vegetab. and spices	130475	19.94	

**Table 6. Area coverage for oil-seed crops under different cropping patterns in Dhaka region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-Fallow	51300	7.84	31
02 Mustard-Boro-B.Aman	26600	4.06	21
03 Mustard-Boro-T. Aman	22400	3.42	26
04 Groundnut-Fallow-Fallow	3620	0.55	8
05 Sesame-Fallow-Blackgram	1850	0.28	4
06 Potato-Sesame-Fallow	1390	0.21	8
07 Mustard-B.Aman	1340	0.20	4
08 Mustard-Boro-Jute	1100	0.17	5
09 Grasspea-Sesame-Fallow	920	0.14	6
10 Mustard-Sesame+B.Aman	800	0.12	2
11 Mustard-Boro-Sesbania	700	0.11	2
12 Maize-Sesame-Fallow	690	0.11	2
13 Sesame+B.Aman-Blackgram	600	0.09	1
14 Mustard-Jute-Fallow	560	0.09	4
15 Groundnut-B.Aman	420	0.06	4
16 Lentil-Sesame-Fallow	355	0.05	3
17 Mustard-Boro-Jute-T. Aman	240	0.04	4
18 Mustard-Jute-T. Aman	220	0.03	3
19 Fallow-Sesame+B.Aman	200	0.03	2
20 Potato-Sesame-Aus	200	0.03	1
21 Potato-Groundnut	170	0.03	1
22-32 Other 11 patterns (in Table 8)	490	0.07	
Total oil-seed crops	116165	17.77	

in Dhaka and Singair (1,000 ha) upazila in Manikganj district.

### Rare cropping patterns

In the present investigation, 45 cropping patterns have been identified as rare cropping patterns with a negligible area coverage with seldom existence (Table 8). These are location specific system and are limited in one or two upazilas of the region. Total area coverage of the 45 patterns is only 0.35% of NCA. Among these the top nine patterns are holding the same area i.e. 100 ha for each. The smallest area was recorded for Millet (*cheena*)-Fallow-Fallow cropping pattern whose coverage was only 5 hectares (Table 7) and is available only in Mirzapur upazila of Tangail district.

### Most dominant cropping pattern

Boro-Fallow-T. Aman was the most dominant cropping pattern in Dhaka region. It covers 22.59% of NCA in the region and is available in 32 upazilas out of 46 (Table 9). The highest

area under this cropping was recorded 18,000 hectares in Ghatail upazila of Tangail district, which represents 12.18% of the total Boro-Fallow-T. Aman area of the region. In consideration of individual upazila Dhanbari stands on the sixth position for area coverage of the pattern, however, this upazila has allocated highest area and it is 79.16% of its NCA for this pattern alone. Keraniganj and Dohar upazila of Dhaka district and Narayanganj sadar upazila had a negligible area coverage for this pattern. In the country-wide compilation of data it was observed that Boro-F-T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### Second dominant cropping pattern

The second dominant cropping pattern in Dhaka region is the single Boro. It belongs to 16.74% NCA of the region and spread out over most of the upazilas i.e. 44 upazilas (Table 10).

**Table 7. Area coverage for pulse crops under different cropping systems in Dhaka region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-Blackgram	3955	0.60	9
02 Fallow-Fallow-Blackgram	3415	0.52	10
03 Blackgram-B.Aman	3090	0.47	8
04 Grasspea-B.Aman	2970	0.45	11
05 Sesame-Fallow-Blackgram	1850	0.28	4
06 Grasspea-Sesbania-Fallow	1350	0.21	2
07 Grasspea-Jute-T. Aman	1150	0.18	2
08 Lentil-Jute-T. Aman	1120	0.17	4
09 Grasspea-Fallow-Fallow	1060	0.16	3
10 Lentil-Jute-Fallow	1040	0.16	8
11 Grasspea-Sesame-Fallow	920	0.14	6
12 Blackgram-Aus-T. Aman	850	0.13	2
13 Vegetab-Fallow-Blackgram	790	0.12	4
14 Blackgram-Jute-Fallow	660	0.10	2
15 Sesame+B.Aman-Blackgram	600	0.09	1
16 Grasspea-Jute-Fallow	420	0.06	3
17 Lentil-Sesame-Fallow	355	0.05	3
18 Blackgram-Jute-T. Aman	350	0.05	2
19 Pea-Vegetab-Fallow	350	0.05	1
20 Lentil-B.Aman	330	0.05	5
21 Lentil-Vegetab-Vegetab	320	0.05	4
22 Grasspea-B.Aus+B.Aman	300	0.05	1
23 Pea-B.Aman	170	0.03	4
24 Maize-Fallow-Blackgram	150	0.02	1
25-34 Other 10 patterns (in Table 8)	570	0.09	
Total pulse crops	28135	4.30	

Sreenagar upazila of Munsiganj district holding the highest is (9,300 ha) under this single Boro cropping. This upazila alone contribute 8.49% share of single Boro cropping area in the region. This upazila has allotted its largest share (74.82%) of NCA. Sonargaon upazila of Narayanganj has maintained the 8<sup>th</sup> position for single Boro area coverage (5,400 ha) in the region. However, this area represents 60.61% of its own NCA. This pattern is frequent and concurrently experienced by early flash flood in April and cold injury at 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). 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-Fallow cropping pattern holds the third largest area coverage 51,300 hectares in Dhaka region. This area is an equivalent to 7.84% of NCA in the region. This pattern Mustard-Boro-Fallow is widely distributed over 31 upazilas. Manikganj sadar upazila has an area of 6,100 ha for this pattern which stands for 11.89% of the total area under this pattern in the region (Table 11). Ghior upazila of Manikganj district ranks in third position for Mustard-Boro-Fallow, however, this upazila has allotted the largest share (41.44%) of NCA.

### Fourth dominant cropping pattern

Fourth dominant cropping pattern Boro-B. Aman has occupied 40,050 hectares representing 6.12% share of NCA in Dhaka region (Table 12).

**Table 8. Rare cropping patterns covering non-significant area in Dhaka region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Tobacco-Jute-Fallow	100	0.02	2	Daulatpur+Ghior
02	Vegetab-Aus-Blackgram	100	0.02	2	Saturia+Shibpur
03	Wheat-Vegetab-T. Aman	100	0.02	2	Madhupur+Nagarpur
04	Garlic-Fallow-T. Aman	100	0.02	1	Belabo
05	Grasspea-Boro-B.Aman	100	0.02	1	Dohar
06	Grasspea-Sesame+B.Aman	100	0.02	1	Singair
07	Maize-Aus-T. Aman	100	0.02	1	Dhamrai
08	Potato-Boro-Vegetab	100	0.02	1	Saturia
09	Wheat-Sesame-Fallow	100	0.02	1	Delduar
10	Coriander-Jute-T. Aman	90	0.01	1	Dhamrai
11	Mungbean-Fallow-T. Aman	80	0.01	3	Sreepur+Belabo+Shibpur
12	Mustard-Aus-T. Aman	80	0.01	1	Dhamrai
13	S.Potato-B.Aman	80	0.01	1	Araihazar
14	Tobacco-Fallow-Fallow	80	0.01	1	Daulatpur
15	Coriander-Fallow-T. Aman	70	0.01	1	Belabo
16	Wheat-Aus-T. Aman	65	0.01	4	Sreepur+Raipur+Araihazar
17	Mustard-Aus-Fallow	50	0.01	2	Dohar+Keraniganj
18	Wheat-Sesame-T. Aman	50	0.01	2	Kalihati+Tangail
19	Boro-Aus-Blackgram	50	0.01	1	Basail
20	Onion-Sesame-Fallow	50	0.01	1	Kalihati
21	Vegetab-Jute-Vegetab	50	0.01	1	Madhupur
22	Wheat-Aus-Fallow	50	0.01	1	Tangail
23	Grasspea-Boro-Fallow	40	0.01	2	Dhamrai+Keraniganj
24	S.Potato-Jute-T. Aman	40	0.01	2	Belabo+Kalihati
25	Chilli-Aus-Fallow	40	0.01	1	Tungibari
26	Onion-Maize-Fallow	40	0.01	1	Ghior
27	Potato-Maize-Vegetab	40	0.01	1	Ghior
28	Vegetab-Aus-Fallow	40	0.01	1	Keraniganj
29	Wheat-Jute-Blackgram	40	0.01	1	Singair
30	Lentil-Aus-Fallow	30	0.00	2	Dhamrai+Tungibari
31	Wheat-Vegetab-Vegetab	30	0.00	1	Singair
32	Wheat-Jute-Vegetab	20	0.00	2	Savar+Narsingdi
33	Lentil-Fallow-T. Aman	20	0.00	1	Kaliganj
34	Mustard-Fallow-T. Aman	20	0.00	1	Gazipur
35	Onion-Aus-Fallow	20	0.00	1	Lohajang
36	Wheat-Fallow-Fallow	20	0.00	1	Gopalpur
37	Grasspea-Fallow-T. Aman	10	0.00	1	Kaliganj
38	Groundnut-Jute-T. Aman	10	0.00	1	Belabo
39	Mustard-Boro-Aus-T. Aman	10	0.00	1	Tangail
40	Mustard-Sesame-T. Aman	10	0.00	1	Belabo
41	Potato-Sesame-T. Aman	10	0.00	1	Belabo
42	Potato+S.gourd-Aus-T. Aman	10	0.00	1	Gopalpur
43	Tobacco-Jute-T. Aman	10	0.00	1	Daulatpur
44	Wheat-Fallow-T. Aman	10	0.00	1	Sreepur
45	Millet ( <i>cheena</i> )-Fallow-Fallow	5	0.00	1	Mirzapur
	Total	2270	0.35		-

**Table 9. Distribution of the most dominant Boro–F–T. Aman cropping patterns in the region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Ghatail	18000	60.91	12.18
02	Shakhipur	14000	63.78	9.47
03	Madhupur	11500	45.73	7.78
04	Gopalpur	9400	63.26	6.36
05	Shibpur	8800	72.01	5.95
06	Dhanbari	8700	79.16	5.89
07	Monohardi	8400	71.19	5.68
08	Kapasias	8200	41.71	5.55
09	Sreeppur	6500	30.85	4.40
10	Kalihati	6500	31.31	4.40
11	Gazipur	6100	32.28	4.13
12	Raipur	5000	21.92	3.38
13	Mirzapur	4500	16.73	3.04
14	Belabo	4400	50.25	2.98
15	Bhuanpur	3900	24.53	2.64
16	Kaliakair	3800	28.48	2.57
17	Delduar	3500	26.66	2.37
18	Palash	3000	60.85	2.03
19	Kaliganj	2500	20.06	1.69
20	Narsingdi	1900	16.18	1.29
21	Rupganj	1800	17.48	1.22
22	Nagarpur	1800	8.39	1.22
23	Tangail	1700	8.47	1.15
24	Savar	1400	9.88	0.95
25	Dhamrai	530	2.38	0.36
26	Saturia	530	5.60	0.36
27	Bsail	500	3.89	0.34
28	Manikganj	450	2.61	0.30
29	Araihazar	300	2.24	0.20
30	Keraniganj	100	1.07	0.07
31	Narayanganj	100	2.76	0.07
32	Dohar	10	0.16	0.01
	Dhaka region	147820	22.59	100.00

This pattern is distributed over 24 upazilas where Mirzapur upazila of Tangail district ranked in top position. This upazila has 6,000 ha area for Boro–B. Aman which is only 22.31% of upazila NCA. Nagarpur upazila of the same district ranks in third position with 5,500 ha area for this pattern, however, this upazila has allotted the biggest share (25.63%) of its NCA.

#### **Fifth dominant cropping pattern**

Fifth dominant cropping pattern Mustard–Boro–B.Aman has occupied 26,600 hectares representing 4.06% share of NCA in Dhaka region (Table 13). This pattern is distributed over 21 upazilas where Shibalaya upazila of

Manikganj district ranked in top position. This upazila has 4,300 ha area Mustard–Boro–B. Aman, which is 37.07% of upazila NCA and it is 16.17% of the total pattern area in the region. The second ranking upazila is Singair of Manikganj district where area coverage for this pattern is 23.41% of upazila NCA and it is 14.29% of total pattern area in the region.

#### **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 164 cropping patterns were identified in the whole

**Table 10. Distribution of the second dominant Boro–F–F cropping pattern in Dhaka region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Sreenagar	9300	74.82	8.49
02	Raipur	8400	36.82	7.67
03	Kaliganj	6950	55.76	6.35
04	Nawabganj	6800	41.67	6.21
05	Savar	6400	45.18	5.84
06	Sreepur	5800	27.53	5.30
07	Rupganj	5500	53.40	5.02
08	Sonargaon	5400	60.61	4.93
09	Kaliakair	5200	38.97	4.75
10	Narsingdi	5100	43.44	4.66
11	Kapasia	3700	18.82	3.38
12	Kalihati	3600	17.34	3.29
13	Gazipur	3500	18.52	3.20
14	Araihazar	3100	23.18	2.83
15	Dohar	2900	47.29	2.65
16	Lohajang	2700	32.49	2.47
17	Tangail	2500	12.45	2.28
18	Gazaria	2400	39.09	2.19
19	Bandar	2100	60.34	1.92
20	Shibalaya	1900	16.38	1.73
21	Gopalpur	1600	10.77	1.46
22	Daulatpur	1450	10.18	1.32
23	Mirzapur	1300	4.83	1.19
24	Serajdikhan	1200	8.74	1.10
25	Bsail	1200	9.35	1.10
26	Keraniganj	1150	12.33	1.05
27	Shibpur	900	7.36	0.82
28	Palash	800	16.23	0.73
29	Bhuanpur	800	5.03	0.73
30	Harirampur	600	4.20	0.55
31	Munsiganj	600	5.39	0.55
32	Ghior	550	5.30	0.50
33	Dhamrai	500	2.25	0.46
34	Belabo	500	5.71	0.46
35	Dhanbari	500	4.55	0.46
36	Ghatail	500	1.69	0.46
37	Shakhipur	500	2.28	0.46
38	Monohardi	400	3.39	0.37
39	Saturia	350	3.70	0.32
40	Narayanganj	300	8.29	0.27
41	Manikganj	230	1.34	0.21
42	Tungbari	200	1.98	0.18
43	Singair	100	0.62	0.09
44	Madhupur	50	0.20	0.05
	Dhaka region	109530	16.74	100.00

**Table 11. Distribution of the third dominant Mustard–Boro–Fallow cropping pattern in Dhaka region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Manikganj	6100	35.42	11.89
02	Mirzapur	5100	18.97	9.94
03	Ghior	4300	41.44	8.38
04	Nagarpur	4300	20.04	8.38
05	Dhamrai	3700	16.65	7.21
06	Singair	3350	20.64	6.53
07	Daulatpur	3000	21.07	5.85
08	Harirampur	2900	20.29	5.65
09	Bsail	2800	21.81	5.46
10	Nawabganj	2700	16.54	5.26
11	Tangail	2600	12.95	5.07
12	Serajdikhan	1500	10.92	2.92
13	Keraniganj	1400	15.01	2.73
14	Kaliakair	1400	10.49	2.73
15	Shibalaya	800	6.90	1.56
16	Savar	700	4.94	1.36
17	Delduar	700	5.33	1.36
18	Bandar	500	14.37	0.97
19	Sonargaon	500	5.61	0.97
20	Narsingdi	500	4.26	0.97
21	Kalihati	450	2.17	0.88
22	Sreenagar	350	2.82	0.68
23	Gazaria	300	4.89	0.58
24	Araihazar	300	2.24	0.58
25	Rupganj	300	2.91	0.58
26	Shakhipur	300	1.37	0.58
27	Dohar	150	2.45	0.29
28	Lohajang	150	1.81	0.29
29	Tungibari	70	0.69	0.14
30	Kapasias	50	0.25	0.10
31	Shibpur	30	0.25	0.06
	Dhaka region	51300	7.84	100.00

area of Dhaka region under this investigation. The highest number of cropping patterns was identified 35 in Tangail sadar upazila and Dhamrai upazila of Dhaka district followed by 31 in Daulatpur upazila in Manikganj district (Table 14). The lowest number of cropping patterns was identified seven in Bandar of Narayanganj district and Palash of Narsingdi district followed by eight in Sreenagar and sadar upazila of Munsiganj district. Higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were related to water logging. The lowest diversity index for

cropping pattern was recorded 0.37 in Dhanbari of Tangail district followed by 0.47 in Shibpur of Narsingdi. In a study Shahidullah *et al.* (2006) also found lowest values for all the diversity and intensity parameters in salt affected and water-stagnant area of greater Noakhali. The highest value of diversity index for cropping pattern was found 0.93 in Tangail sadar upazila and that was followed by 0.90 in Bhuanpur upazila of the same district. The lowest CDI was reported 0.70 in Dhanbari of Tangail followed by 0.72 in Monohardi of Narsingdi district. The highest value of CDI was observed 0.97 in Tangail sadar upazila followed by 0.95

**Table 12. Distribution of the fourth dominant Boro-B. Aman cropping pattern in Dhaka region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region	
01	Mirzapur	6000	22.31	14.98
02	Dhamrai	5600	25.20	13.98
03	Nagarpur	5500	25.63	13.73
04	Kalihati	4000	19.27	9.99
05	Delduar	3600	27.42	8.99
06	Araihazar	3100	23.18	7.74
07	Bsail	2500	19.47	6.24
08	Tangail	1600	7.97	4.00
09	Ghatail	1500	5.08	3.75
10	Saturia	1400	14.80	3.50
11	Bhuanpur	1150	7.23	2.87
12	Kapasia	700	3.56	1.75
13	Manikganj	500	2.90	1.25
14	Raipur	500	2.19	1.25
15	Shakhipur	500	2.28	1.25
16	Keraniganj	470	5.04	1.17
17	Serajdikhan	400	2.91	1.00
18	Sonargaon	400	4.49	1.00
19	Nawabganj	200	1.23	0.50
20	Kaliakair	100	0.75	0.25
21	Bandar	100	2.87	0.25
22	Rupganj	100	0.97	0.25
23	Kaliganj	80	0.64	0.20
24	Gopalpur	50	0.34	0.12
	Dhaka region	40050	6.12	100.00

**Table 13. Distribution of the fifth dominant Mustard-Boro-B. Aman cropping pattern in Dhaka region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region	
01	Shibalaya	4300	37.07	16.17
02	Singair	3800	23.41	14.29
03	Bsail	2900	22.59	10.9
04	Nagarpur	2400	11.18	9.02
05	Daulatpur	1900	13.34	7.14
06	Mirzapur	1900	7.07	7.14
07	Ghior	1300	12.53	4.89
08	Manikganj	1300	7.55	4.89
09	Narsingdi	1000	8.52	3.76
10	Nawabganj	800	4.90	3.01
11	Delduar	800	6.09	3.01
12	Tangail	750	3.74	2.82
13	Harirampur	700	4.90	2.63
14	Araihazar	700	5.23	2.63
15	Kalihati	600	2.89	2.26
16	Gopalpur	500	3.36	1.88
17	Keraniganj	400	4.29	1.50
18	Serajdikhan	300	2.18	1.13
19	Dohar	100	1.63	0.38
20	Kaliakair	100	0.75	0.38
21	Savar	50	0.35	0.19
	Dhaka region	26600	4.06	100.00

**Table 14. Crop diversity and cropping intensity in Dhaka region , 2014-15.**

	Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01	Dhamrai	35	20	0.88	0.95	224
02	Dohar	30	20	0.76	0.84	161
03	Keraniganj	22	21	0.89	0.94	213
04	Nawabganj	18	19	0.77	0.90	175
05	Savar	14	13	0.72	0.91	177
06	Gazipur sadar	19	12	0.84	0.91	180
07	Kapasia	14	12	0.78	0.84	158
08	Kaliakair	17	13	0.75	0.87	167
09	Kaliganj	15	16	0.64	0.83	150
10	Sreepur	18	11	0.77	0.85	148
11	Daulatpur	31	23	0.90	0.94	193
12	Ghior	21	16	0.80	0.89	201
13	Harirampur	21	21	0.90	0.94	178
14	Manikganj sadar	29	21	0.85	0.93	219
15	Saturia	16	14	0.84	0.93	239
16	Shibalaya	10	10	0.79	0.89	222
17	Singair	25	16	0.87	0.94	233
18	Gazaria	12	11	0.79	0.89	153
19	Lohaganj	15	18	0.79	0.90	162
20	Munsiganj sadar	18	17	0.66	0.82	197
21	Sreenagar	8	9	0.66	0.82	124
22	Serajdikhan	17	12	0.89	0.95	212
23	Tungibari	14	14	0.73	0.86	201
24	Araihazar	25	17	0.83	0.92	186
25	Bandar	7	7	0.60	0.85	146
26	Nrayanganj sadar	8	8	0.76	0.88	206
27	Rupganj	20	17	0.67	0.80	136
28	Sonargaon	22	18	0.61	0.75	127
29	Belabo	19	17	0.61	0.75	226
30	Monohardi	11	11	0.49	0.72	195
31	Narsingdi sadar	14	14	0.76	0.88	158
32	Palash	7	6	0.60	0.77	187
33	Raipur	20	17	0.79	0.89	156
34	Shibpur	19	17	0.47	0.73	201
35	Basail	18	15	0.85	0.93	225
36	Bhuanpur	25	24	0.90	0.95	208
37	Delduar	22	18	0.84	0.93	220
38	Dhanbari	12	11	0.37	0.70	207
39	Ghatail	14	13	0.62	0.79	189
40	Gopalpur	24	18	0.57	0.81	213
41	Kalihati	24	16	0.82	0.92	209
42	Madhupur	16	13	0.79	0.83	157
43	Mirzapur	26	21	0.87	0.94	205
44	Nagarpur	19	15	0.85	0.94	227
45	Shakhipur	13	13	0.58	0.80	212
46	Tangail sadar	35	26	0.93	0.97	208
	Dhaka region	164	36	0.90	0.94	191

in Dhanbari and Bhuanpur of Tangail and Serajdikhan upazila of Munsiganj district.

The range of cropping intensity values was recorded 124-239%. The maximum value was for Saturia upazila of Manikganj district and minimum for Sreenagar upazila of Munsiganj district. As a whole the CDI of Dhaka region was calculated 0.94 and the average cropping intensity at regional level was 191%. In a simultaneous study, the investigators identified 316 cropping patterns for whole Bangladesh; where the CDI value was 0.95 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 the other. (Blade and Slinkard, 2002). The farmers of Kerala diversified their cropping pattern to minimize risk from due to crop failures and price fluctuations (Mahesh, 1999).

## CONCLUSION

In total, the highest cropping intensity was observed in Saturia upazila and lowest was in Sreenagar upazila under Dhaka region. The cropping intensity of the Dhaka region was little bit lower than the national average. Boro-Fallow-T. Aman, Single Boro, Mustard-Boro-Fallow, Boro-B. Aman were the dominant cropping patterns in the region. Exclusive rice area is about three folds of exclusive non-rice area. In Dhaka region, crop diversity is much wider than that of other regions. However, pulse crops and oil-seed crops are not sufficient in the crop distributions and cropping sequences. Based on the findings of the study, the following recommendations were made.

- Initiative should to be taken to increase productivity of exclusive rice based cropping patterns with high yielding varieties of rice along with recommended crop management packages.
- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.

- A portion of single T. Aman area could be bought under double rice area with inclusion of Aus.
- Emphasis should be given so that a portion of double-rice area could be brought under Mustard-Boro-T. Aman cropping system or other three cropping systems.
- Area under deepwater rice might be intensified by relay cropping.

## REFERENCES

- BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- Blade, S F and A E Slinkard 2002. New Crop Development: The Canadian Experience. *In: Trends in New Crops and New Uses.* J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- Chand, R. 1996. Diversification through high value crops in western Himalayan region: evidence from Himachal Pradesh. *Indian J. Agric. Econ.* 51(4): 652-663.
- Das, Anup, G I Ramkrushna, G S Yadav, J Layek, C Debnath, B U Choudhury, K P Mohaptara, S V Ngachan and S Das. 2015. Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India. *Applied Ecology and Environmental Sciences.* 3(4): 100-107.
- FAO. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy. 570p.
- Jackson, B R, A Yantasast, C Prechachat, M A Chowdhury and S M H Zaman. 1972. Breeding rice for deep-water areas. International Rice Research Institute, Rice Breeding, Los Baños, Philippines. 517-528.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines. 5(97).
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 273-288.

- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Pingali, P I and M W Rosegrant. 1995. Agricultural commercialization and diversification: process and policies, *Food Policy.* 20(3): 171-186.
- Salam, M U, S M A Hossain, J K Biswas and A J Mridha. 2014. Managing the unmanageable: rice variety technology for future challenging food security in Bangladesh. Extended abstract in the 'Agronomic visions in challenging future', the proceedings of the 13<sup>th</sup> conference of the Bangladesh Society of Agronomy, 20 September 2014, Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-122.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)		
001	Boro-Fallow-T. Aman	147820	061	Maize-Sesbania-Fallow	1000
002	Boro-Fallow-Fallow	109530	062	Grasspea-Sesame-Fallow	920
003	Mustard-Boro-Fallow	51300	063	Blackgram-Aus-T. Aman	850
004	Boro-B.Aman	40050	064	Chilli-B.Aman	820
005	Mustard-Boro-B.Aman	26600	065	Vegetab-Boro-T. Aman	820
006	Vegetab-Vegetab-Vegetab	26050	066	Mustard-Sesame+B.Aman	800
007	Mustard-Boro-T. Aman	22400	067	Onion-Vegetab-Vegetab	800
008	Potato-B.Aman	19960	068	Vegetab-Fallow-Blackgram	790
009	Potato-Sesbania	10220	069	Boro-Aus-Fallow	780
010	Fallow-Fallow-T. Aman	9650	070	Fallow-Vegetab-T. Aman	720
011	Vegetab-Vegetab-Fallow	8750	071	Cotton-Aus-Fallow	700
012	Vegetab-Fallow-Fallow	6980	072	Mustard-Boro-Sesbania	700
013	Onion-B.Aman	5230	073	Maize-Sesame-Fallow	690
014	Boro-Jute-T. Aman	4780	074	Wheat-B.Aman	690
015	Boro-Sesbania-Fallow	4410	075	Vegetab-Aus-T. Aman	680
016	Potato-Jute-Fallow	4360	076	Blackgram-Jute-Fallow	660
017	Potato-Boro-Fallow	4050	077	Garlic-B.Aman	640
018	Boro-Fallow-Blackgram	3955	078	Potato-Maize-Fallow	610
019	Groundnut-Fallow-Fallow	3620	079	Sesame+B.Aman-Blackgram	600
020	Fallow-Fallow-Blackgram	3415	080	Coriander-Vegetab-Fallow	580
021	Potato-Jute-T. Aman	3360	081	Chilli-Vegetab-Fallow	570
022	Maize-Maize-Fallow	3280	082	Mustard-Jute-Fallow	560
023	Wheat-Jute-T. Aman	3245	083	Coriander-B.Aman	550
024	Blackgram-B.Aman	3090	084	Garlic-Jute-Fallow	530
025	Potato-Boro-T. Aman	3090	085	Onion-Jute-T. Aman	530
026	Grasspea-B.Aman	2970	086	Tobacco-Boro-T. Aman	450
027	Maize-Jute-Fallow	2790	087	Potato-Vegetab-T. Aman	440
028	Vegetab-Boro-Fallow	2590	088	Grasspea-Jute-Fallow	420
029	Boro-Sesbania-T. Aman	2440	089	Groundnut-B.Aman	420
030	Boro-Vegetab(Float/Norm)	2360	090	Chilli-Fallow-T. Aman	400
031	Maize-Fallow-Fallow	2265	091	Potato-Fallow-T. Aman	400
032	Vegetab-Jute-Fallow	2170	092	Potato-Maize-T. Aman	400
033	Maize-B.Aman	1920	093	Tobacco-Maize-T. Aman	400
034	Sesame-Fallow-Blackgram	1850	094	Coriander-Fallow-Fallow	390
035	Fallow-Jute-T. Aman	1770	095	Vegetab-Fallow-T. Aman	360

**Appendix 1. Continued.**

Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
036	Maize-Vegetab-Fallow	1700	096	Lentil-Sesame-Fallow	355
037	Vegetab-B.Aman	1690	097	Blackgram-Jute-T. Aman	350
038	Vegetab-Vegetab-T. Aman	1660	098	Pea-Vegetab-Fallow	350
039	Wheat-Jute-Fallow	1560	099	Coriander-Jute-Fallow	330
040	Chilli-Fallow-Fallow	1490	100	Lentil-B.Aman	330
041	S.Potato-Fallow-Fallow	1430	101	Potato-Chilli-Fallow	330
042	Maize-Fallow-T. Aman	1390	102	Lentil-Vegetab-Vegetab	320
043	Potato-Sesame-Fallow	1390	103	Grasspea-B.Aus+B.Aman	300
044	Grasspea-Sesbania-Fallow	1350	104	Potato+Maize-B.Aman	300
045	Onion-Jute-Fallow	1350	105	Boro-Jute-Fallow	280
046	Mustard-B.Aman	1340	106	Mustard-Boro-Jute-T. Aman	240
047	S.Potato-Jute-Fallow	1230	107	Mustard-Jute-T. Aman	220
048	Boro-Aus-T. Aman	1215	108	Fallow-Sesame+B.Aman	200
049	Boro-Vegetab-T. Aman	1200	109	Potato-Sesame-Aus	200
050	Vegetab-Maize-Fallow	1170	110	Pea-B.Aman	170
051	Grasspea-Jute-T. Aman	1150	111	Potato-Groundnut	170
052	Lentil-Jute-T. Aman	1120	112	Chilli-Vegetab-T. Aman	150
053	Vegetab-Jute-T. Aman	1120	113	Fallow-Aus-T. Aman	150
054	Mustard-Boro-Jute	1100	114	Garlic-Fallow-Fallow	150
055	Wheat-Maize-T. Aman	1100	115	Maize-Fallow-Blackgram	150
056	Grasspea-Fallow-Fallow	1060	116	Garlic-Vegetab-Vegetab	135
057	Chilli-Jute-Fallow	1050	117	Garlic-Jute-T. Aman	110
058	Maize-Jute-T. Aman	1050	118	Potato-Aus-Fallow	110
059	Lentil-Jute-Fallow	1040	119	Wheat-Chilli-Fallow	110
060	Maize-Maize-T. Aman	1000	120-164	Other 45 patterns (Table 8)	3045



# Crops and Cropping Systems in Dinajpur Region

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## ABSTRACT

The development of agricultural planning largely depends on the reliable and comprehensive statistics of the existing cropping patterns, cropping intensity and crop diversity of a particular area, which will provide a guideline to the policy makers, researchers, extensionists and development workers. A study was undertaken over all the upazilas of Dinajpur region during 2016 using pre-tested semi-structured questionnaire with a view to document of the existing cropping patterns, intensity and diversity for the region. The most important cropping pattern Boro-Fallow-T. Aman occupied about 41% of net cropped area (NCA) of the region with its distribution over all the upazilas. The second largest area, 9% of NCA, was covered by Wheat-Fallow-T. Aman, which was spread over 18 upazilas. A total of 112 cropping patterns were identified in the whole region. The highest number of cropping patterns was identified 30 in Boda upazila of Panchagarh district while the lowest was 11 in Kaharol upazila of Dinajpur district. The lowest crop diversity index (CDI) was reported 0.708 in Birampur followed by 0.753 in Ghoraghat of Dinajpur. The highest CDI was reported 0.955 in Ranisonkail followed by 0.952 in Baliadangi of Thakurgaon. The range of cropping intensity was recorded 206-249% whereas the maximum value was found for Khansama of Dinajpur and minimum for Boda of Panchagarh district. As a whole, CDI and cropping intensity for Dinajpur region were calculated 0.924 and 229% respectively, which indicates that the land use and crop diversification is not quite enough for the national demand.

**Key words:** Cropping patterns, land use, diversity, wheat, rice and cropping intensity

## INTRODUCTION

The agricultural sector plays a vital role in the economy of Bangladesh in terms of its contribution to GDP 15.59%, employment generation, livelihoods and poverty alleviation (BBS, 2015). Bangladesh has very fertile land for crop production though some natural calamities occur frequently. It has 30 agro-ecological zones (AEZ) in terms of different soil and climatic condition. That is why diversified cropping pattern exists in the country. A cropping pattern is defined as yearly sequences of crop production in a piece of land grown in the course of a year (Alam, 1994). The cropping patterns of a region are closely influenced by the geo-climatic, socio-economic, historical and political factors (Hossain, 1996). It is also dependent on physical, historical, social, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The cropping pattern and the changes

therein depend on a large number of factors like climate, soil type, rainfall, agricultural technology, availability of irrigation facilities and other inputs, marketing and transport facilities and growth of agro-industries (Neena, 1998; Gadge, 2003; Rashid *et al.*, 2005). Rice-based cropping pattern shows dominancy in Bangladesh for the highest demand of rice as staple food and suitable condition for rice production (Shirazy *et al.*, 2016). Dinajpur agricultural region comprises three districts viz Dinajpur, Thakurgaon and Panchagarh. A unique character of this region is its extra-long winter season, which favors the successful production of numerous winter crops. Soils are mainly non-calcareous light-textured with less fertility. Occasional flash floods are prevailing in some specific locations. Short duration of rainy season and less availability of irrigation water are the limiting factors for production of diversified crops (FAO, 1988).

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Cultivable land is declining day by day so that escalating cropping intensity with more production and bringing the barren land under cultivation is the pre-requisite for sustainable food security of Bangladesh. Although the country is nearly self-sufficient in rice production, other foods such as vegetables, pulses, oil crops etc. are still deficit to a large extent. Even rice food security has not been achieved at the household level in many poor and extreme poor farm families (Shopan *et al.*, 2012). Therefore, crop diversification will increase cropping intensity, raising the productivity of land and labor, generate income and employment which in turn will eliminate food and nutritional insecurity and poverty of farming community of the Dinajpur region. From the above circumstances, the present study was undertaken for satisfying the following objectives to:

- Find out the existing cropping patterns scenario for Dinajpur region
- Understand the current land use pattern at upazila and regional level
- Visualize the cropping intensity and diversity at local and regional level.

## METHODOLOGY

Twenty-three upazilas of Dinajpur, Thakurgaon and Panchagarh districts under Dinajpur 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 23 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during July 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. The second stage of data collection was daylong data validation workshop at district level. The workshop dates were 1 September for Dinajpur; 4 October for Panchagarh; and 6 October 2016 for Thakurgaon. 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, Rangpur participated in the data validation workshop. The number of participants of validation workshop ranged from 43 to 98 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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

Net cropped area of Dinajpur agricultural region is 527,440 (Table 1). The cropping intensity (CI) of the region is 229% which is much higher than the national average. 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, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 30 to 1,700 ha. The annual crops area accounted for only 1.79% of the net cropped area (NCA) in the region. At a glance, the region possesses 1.25% single cropped area (SCA), 64.66% double cropped area (DCA), 31.68% triple cropped area (TCA) and a very little amount (0.04%) of quadruple cropped area (QCA) which exists only in Bochaganj and Hakimpur upazila. The DCA had the major share of NCA in all the upazilas of Dinajpur, Thakurgaon and Panchagarh district except Khansama of Dinajpur district, Baliadangi and Haripur of Thakurgaon district where triple cropped area is the dominant one (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.

### Cropping patterns of Dinajpur

In total 112 cropping patterns were observed in Dinajpur region of which only four cropping patterns with exclusive rice crop covers over 41% of the NCA. There were 32 cropping patterns with exclusive non-rice crop covering about 5% of the NCA. Rest of the NCA i.e. around 54% areas is covered by 74 rice non-rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

In Dinajpur region, 41.40% of NCA was covered by exclusively rice-based cropping patterns (Table 2). The highest area coverage (40.92%) was recorded by double rice, Boro-Fallow-T. Aman cropping pattern which was found in all the upazilas. Altogether, single and triple rice based pattern occupied less than 1% of NCA. Triple rice based pattern Boro-Aus-T. Aman

was reported in seven upazilas while single rice pattern was reported only in five upazilas.

In the current investigation, 32 cropping patterns were identified that were free from rice. Among these 32 patterns first 18 have been arranged in descending order in Table 3. The rest 14 patterns with negligible area coverage (Table 7) are arranged with other patterns of different categories. Aggregate of the 32 patterns have had approximately 5% of NCA. In critical comparison it is clear that exclusive rice area is about nine folds of exclusive non-rice area. Among these 32 patterns, year-round vegetable production system has the highest area coverage that practiced on or around the homestead area. Appropriate cropping patterns may facilitate maximum possible land use 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).

### Non-rice cereal crops

Thirty-five cropping patterns are holding different non-rice cereal crops (Table 4). Among them wheat, with the largest area, is leading 14 patterns cultivated on 111,220 hectares that is equivalent to 21.08% of NCA. Maize holds the second position in non-rice cereal crop cultivation in Dinajpur region. There are 23 cropping patterns for maize, which in-together occupy 19.28% of NCA. In the documentation of non-rice cereal cropping systems wheat reported widest spreading e.g. Wheat-Jute-T. Aman is distributed over 20 upazilas out of 23. Overall, the aggregate area of the non-rice rice-cereal cropping system stands for 37.23% of the NCA in Dinajpur region. In Bangladesh there is a vast market of maize seeds for feed industries. Loam and sandy-loam soil of the comparative dry area is very suitable for maize cultivation. Wheat cultivation with its better yield in this region is specially favoured by long winter season that is normally unavailable in southern parts of the country. Light textured soil with

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Birampur	21283	50	200	14450	2760	0	140	17600	214
02 Birganj	41312	300	0	17510	13110	0	130	31050	241
03 Biral	35358	120	150	15700	14060	0	190	30220	246
04 Bochaganj	22489	530	40	11730	7450	200	180	20130	236
05 Chirirbandar	31285	360	0	18370	4910	0	120	23760	219
06 Dinajpur	35447	1200	0	14590	11510	0	150	27450	238
07 Phulbari	22851	50	20	13800	4730	0	150	18750	225
08 Ghoraghat	14874	65	50	10245	1490	0	110	11960	212
09 Hakimpur	9993	30	0	6110	2015	10	115	8280	225
10 Kaharol	20555	600	0	13400	3800	0	100	17900	218
11 Khansama	17972	320	150	6710	7915	0	125	15220	249
12 Nawabganj	31754	360	190	22450	2800	0	160	25960	209
13 Parbatipur	39510	160	0	23440	4800	0	160	28560	216
14 Atwari	21002	400	30	11680	4070	0	120	16300	222
15 Boda	34998	340	250	20750	1980	0	120	23440	206
16 Debiganj	30905	690	1450	14690	7210	0	150	24190	221
17 Panchagarh	33844	640	1950	18360	3420	0	170	24540	203
18 Tetulia	18909	240	450	6720	6180	0	150	13740	240
19 Baliadangi	28425	80	1100	11120	11250	0	130	23680	243
20 Haripur	20115	160	240	8470	8680	0	110	17660	247
21 Pirganj	35414	550	300	19470	9190	0	140	29650	228
22 Ranisonkail	28748	300	30	12270	11450	0	150	24200	246
23 Thakurgaon	68375	1700	40	29030	22320	0	110	53200	239
Dinajpur region	-	9245	6640	341065	167100	210	3180	527440	229

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-T. Aman	215850	40.92	23
02 Boro-Aus-T. Aman	1575	0.30	7
03 Boro-Fallow-Fallow	650	0.12	3
04 Fallow-Fallow-T. Aman	300	0.06	2
Total	218375	41.40	

low water-holding capacity as well as less availability of irrigation water is driving forces that discourage the farmers for modern Boro cultivation. During the harvesting period of wheat, the crop is privileged by clear sun-shine and low humidity. All these are the factors this area is dominated by wheat-based cropping systems (FAO, 1988).

### Pulses and oil-seed crops

There were 34 cropping patterns of pulse and oil-seed crops where eight patterns had been led by mustard alone (Table 5). Mustard is the most important among all the oil-seed

crops in the region. The total share of pulses and oil-seed crops is 8.16% of NCA whereas mustard absolutely occupies about 5%. Along with its widest coverage Mustard-Boro-T. Aman pattern was reported from 21 upazilas out of 23. On the other hand, the total pulse crops occupied only around 1% of NCA where mungbean was dominant.

### Vegetables and spices crops

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

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	5070	0.96	18
02 Wheat-Fallow-Fallow	3250	0.62	3
03 Wheat-Maize-Fallow	3050	0.58	3
04 Wheat-Maize-Vegetab	2000	0.38	2
05 Maize-Vegetab-Fallow	1700	0.32	3
06 Potato-Maize-Fallow	1600	0.30	1
07 Wheat-Vegetab-Vegetab	1400	0.27	2
08 Groundnut-Fallow-Fallow	1330	0.25	2
09 Onion-Vegetab-Vegetab	850	0.16	8
10 Garlic-Vegetab-Vegetab	710	0.13	7
11 Vegetab-Jute-Fallow	520	0.10	2
12 Vegetab-Fallow-Fallow	470	0.09	2
13 Vegetab-Fallow-Blackgram	405	0.08	5
14 Potato-Maize-Vegetab	350	0.07	1
15 Vegetab-Vegetab-Fallow	310	0.06	3
16 Chilli-Fallow-Fallow	240	0.05	3
17 Potato-Jute-Fallow	200	0.04	1
18 Chilli-Vegetab-Fallow	160	0.03	3
19-32 Other 14 patterns (in table 7)	980	0.19	
Total	24595	4.66	

**Table 4. Non-rice cereal crops under different cropping systems in Dinajpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Fallow-T. Aman	46660	8.84	18
02 Maize-Fallow-T. Aman	45980	8.71	18
03 Potato-Maize-T. Aman	26330	4.99	18
04 Wheat-Jute-T. Aman	23960	4.54	20
05 Wheat-Maize-T. Aman	11520	2.18	7
06 Wheat-Aus-T. Aman	9990	1.89	13
07 Wheat-Mungbean-T. Aman	6280	1.19	14
08 Mustard-Maize-T. Aman	3590	0.68	10
09 Wheat-Fallow-Fallow	3250	0.62	3
10 Wheat-Maize-Fallow	3050	0.58	3
11 Wheat-Vegetab-T. Aman	2920	0.55	8
12 Wheat-Maize-Vegetab	2000	0.38	2
13 Maize-Maize-T. Aman	1700	0.32	1
14 Maize-Vegetab-Fallow	1700	0.32	3
15 Potato-Maize-Fallow	1600	0.30	1
16 Wheat-Vegetab-Vegetab	1400	0.27	2
17 Maize-Boro-T. Aman	1200	0.23	1
18 Vegetab-Maize-T. Aman	1020	0.19	6
19 Maize-Jute-T. Aman	440	0.08	2
20 Potato-Maize-Vegetab	350	0.07	1
21 Maize-Aus-Fallow	300	0.06	2
22 Maize-Vegetab-T. Aman	300	0.06	2
23 Maize-Aus-T. Aman	250	0.05	1
24 Millet( <i>kaon</i> )-Fallow-T. Aman	10	0.00	1
25-35 Other 11 patterns (in table 7)	665	0.13	-
Total non-rice cereal crops	196465	37.23	

**Table 5. Cropping patterns with pulses and oil-seed crops in Dinajpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-T. Aman	18720	3.55	21
02 Wheat-Mungbean-T. Aman	6280	1.19	14
03 Groundnut-Fallow-T. Aman	3700	0.70	5
04 Mustard-Maize-T. Aman	3590	0.68	10
05 Potato-Groundnut-T. Aman	2700	0.51	3
06 Sesame-Fallow-T. Aman	2010	0.38	2
07 Mustard-Boro-Fallow	1490	0.28	3
08 Groundnut-Fallow-Fallow	1330	0.25	2
09 Fallow-Sesame-T. Aman	700	0.13	1
10 Vegetab-Fallow-Blackgram	405	0.08	5
11 Mustard-Jute-T. Aman	380	0.07	3
12 Mustard-Fallow-T. Aman	360	0.07	2
13 Groundnut-Jute-T. Aman	300	0.06	1
14 Vegetab-Groundnut-T. Aman	300	0.06	1
15 Mustard-Aus-T. Aman	160	0.03	2
16-34 Other 19 patterns (in Table 7)	630	0.12	-
Total pulses and oil-seed crops	43055	8.16	

garlic are included in this list. Here, potato based pattern is the most contributing cropping pattern that covers more than 12% of NCA. In addition, Potato-Boro-T. Aman and Potato-Maize- T. Aman pattern occupies the largest area than the other patterns. In total the area for vegetables and spices covered one-fifth of NCA in the Dinajpur region

### Sporadic and distinct cropping patterns

There are some cropping patterns, which are extremely location-specific, however, with a large area coverage. These are Maize-Maize-T. Aman, Maize-Boro-T. Aman (Table 4) and Potato-Maize-Fallow (Table 6). Maize-Maize-T. Aman is grown on 1,700 hectares of land in Birol upazila of Dinajpur district. The Maize-Boro-T. Aman is limited to Dinajpur sadar upazila covering 1,200 hectares of area. Potato-Maize-Fallow is limited to only Ranisonkail upazila of Thakurgaon district with area coverage of 1,600 hectares.

### Rare cropping patterns

In the present investigation, 40 cropping patterns have been identified as rare cropping patterns with negligible area coverage with seldom existence (Table 7). These are location specific system and are limited in one or two or

in some cases three upazilas of the region. Total area coverage of the 40 patterns is far below than 1% of NCA. Among them, top three patterns viz Chilli-Vegetab-T. Aman (150 ha), Maize-Jute-Fallow (150 ha) and Vegetab-Jute-T. Aman (150 ha) were recorded separately in one upazila of the region. The smallest area was recorded for Maize-Sesame-T. Aman cropping patterns whose coverage was five hectares for each (Table 7).

### Most dominant cropping pattern

Boro-Fallow-T. Aman was the most dominant cropping pattern in Dinajpur region. It covers 40.91% of NCA in the region and is available in all upazilas of the region (Table 8). The highest area under this cropping was recorded 20,800 hectares in Parbatipur upazila which represents 9.64% of the total Boro-Fallow-T. Aman area of the region. In consideration of individual upazila Birampur has allocated the highest area and it is over 80% of its NCA for this pattern alone. Atwari upazila had the lowest area coverage for this pattern, which was 14.11% of NCA and 1.07% of the pattern in that region. In the country-wide compilation of data it was observed that Boro-F- T. Aman was the most dominant

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Boro-T. Aman	26590	5.04	16
02 Potato-Maize-T. Aman	26330	4.99	18
03 Chilli-Fallow-T. Aman	7560	1.43	10
04 Vegetab-Vegetab-Vegetab	5070	0.96	18
05 Vegetab-Fallow-T. Aman	4460	0.85	8
06 Potato-Jute-T. Aman	3515	0.67	7
07 Wheat-Vegetab-T. Aman	2920	0.55	8
08 Potato-Groundnut-T. Aman	2700	0.51	3
09 Vegetab-Vegetab-T. Aman	2650	0.50	8
10 Potato-Vegetab-T. Aman	2460	0.47	8
11 Potato-Aus-T. Aman	2020	0.38	4
12 Wheat-Maize-Vegetab	2000	0.38	2
13 Maize-Vegetab-Fallow	1700	0.32	3
14 Potato-Maize-Fallow	1600	0.30	1
15 Potato-Fallow-T. Aman	1440	0.27	4
16 Wheat-Vegetab-Vegetab	1400	0.27	2
17 Vegetab-Maize-T. Aman	1020	0.19	6
18 Garlic-Jute-T. Aman	980	0.19	8
19 Onion-Vegetab-Vegetab	850	0.16	8
20 Onion-Jute-T. Aman	740	0.14	6
21 Garlic-Vegetab-Vegetab	710	0.13	7
22 Chilli-Jute-T. Aman	670	0.13	5
23 Garlic-Fallow-T. Aman	570	0.11	6
24 Onion-Fallow-T. Aman	560	0.11	5
25 Vegetab-Jute-Fallow	520	0.10	2
26 Potato-Boro-Fallow	500	0.09	1
27 Potato-Onion-T. Aman	500	0.09	1
28 Vegetab-Fallow-Fallow	470	0.09	2
29 Vegetab-Fallow-Blackgram	405	0.08	5
30 Garlic-Aus-T. Aman	350	0.07	3
31 Potato-Maize-Vegetab	350	0.07	1
32 Onion-Aus-T. Aman	300	0.06	2
33 Chilli-Fallow-Fallow	240	0.05	3
34 Potato-Jute-Fallow	200	0.04	1
35 Chilli-Vegetab-Fallow	160	0.03	3
36-52 Other 17 patterns (in Table 7)	1030	0.20	
Total veg and spices crops	105540	20.01	

cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### Second dominant cropping pattern

The second dominant cropping pattern in Dinajpur region is Wheat-Fallow-T. Aman. It belongs to 8.84% of NCA of the region

and spread out over 18 upazilas (Table 9). Thakurgaon sadar upazila hold the highest area (7,500 ha) under this cropping pattern with 16% share of the region alone. Regarding NCA percentage Pirganj upazila occupied over 22% of NCA, which was the highest of that region. The four upazila namely Debiganj, Nawabganj, Parbatipur and Hakimpur shared very little area as less than 1% of NCA.

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

	Cropping pattern	Area (ha)	% of NCA	Freq.	Upazila
01	Chilli-Vegetab-T. Aman	150	0.03	1	Dinajpur
02	Maize-Jute-Fallow	150	0.03	1	Tetulia
03	Vegetab-Jute-T. Aman	150	0.03	1	Boda
04	W.Melon-Fallow-Fallow	140	0.03	3	Bochaganj+Boda+Debiganj
05	Onion-Maize-T. Aman	130	0.02	2	Debiganj+Baliadangi
06	S.Potato-Vegetab-Fallow	120	0.02	2	Parbatipur+Chirirbandar
07	S.Potato-Fallow-T. Aman	110	0.02	3	Pirganj+Debiganj+Ghoraghat
08	Maize-Fallow-Fallow	100	0.02	1	Debiganj
09	Onion-Jute-Fallow	90	0.02	1	Khansama
10	Fallow-Fallow-Blackgram	80	0.02	3	Phulbari+Tetulia+Haripur
11	Wheat-Sesame-T. Aman	80	0.02	3	Atwari+Ranisonkail+Thakurgaon
12	Chilli-Aus-T. Aman	70	0.01	1	Pirganj
13	Maize-Aus-Blackgram	70	0.01	1	Chirirbandar
14	Wheat-Jute-Fallow	60	0.01	1	Khansama
15	Coriander-Fallow-Fallow	50	0.01	1	Tetulia
16	Mustard-Mung-T. Aman	50	0.01	1	Atwari
17	Potato-Mungbean-T. Aman	50	0.01	1	Panchagarh
18	Coriander-Vegetab-Fallow	40	0.01	1	Debiganj
19	Mungbean-Aus-T. Aman	40	0.01	1	Birganj
20	Potato-Chilli-Fallow	40	0.01	1	Tetulia
21	Lentil-Jute-T. Aman	35	0.01	3	Ranisonkail+Parbatipur+Hakimpur
22	Blackgram-Jute-T. Aman	30	0.01	1	Boda
23	Lentil-Vegetab-Vegetab	30	0.01	2	Tetulia+Bochaganj
24	Mustard-Sesame-T. Aman	30	0.01	1	Boda
25	S.Potato-Fallow-Fallow	30	0.01	1	Ranisonkail
26	S.Potato-Jute-T. Aman	30	0.01	1	Boda
27	Wheat-Chilli-Fallow	30	0.01	1	Thakurgaon
28	Coriander-Fallow-T. Aman	20	0.00	2	Pirganj+Boda
29	Coriander-Jute-T. Aman	20	0.00	2	Nawabganj+Parbatipur
30	Groundnut-F-Blackgram	20	0.00	1	Debiganj
31	Lentil-Aus-T. Aman	20	0.00	1	Pirganj
32	Lentil-Fallow-T. Aman	20	0.00	2	Dinajpur+Hakimpur
33	Lentil-Vegetab-T. Aman	20	0.00	1	Boda
34	Wheat-Aus-Blackgram	20	0.00	1	Ghoraghat
35	Chickpea-Aus-T. Aman	10	0.00	1	Pirganj
36	Lentil-Maize-T. Aman	10	0.00	1	Haripur
37	Millet( <i>kaon</i> )-F-T. Aman	10	0.00	1	Boda
38	Potato+Maize-Veg-T. Aman	10	0.00	1	Hakimpur
39	Vegetab-Aus-Blackgram	10	0.00	1	Hakimpur
40	Maize-Sesame-T. Aman	5	0.00	1	Ghoraghat
	Total	2180	0.41		

**Third dominant cropping pattern**

Maize-Fallow-T. Aman cropping pattern holds the third largest area coverage 45,980 hectares in Dinajpur region. This area is an equivalent to 8.71% of NCA in the region. This pattern is distributed over 18 upazilas as same as Wheat-Fallow-T. Aman cropping pattern. Birol upazila has an area of 5,800 ha which stands for 12.61% of the total area under this pattern in the region

(Table 10). Ranisonkail has the lowest area compared to other upazila and it is just 20 ha.

**Fourth dominant cropping pattern**

Fourth dominant cropping pattern Potato-Boro-T. Aman has occupied 26,590 hectares representing 5.04% share of NCA in Dinajpur region (Table 11). This pattern is distributed over 16 upazilas where Dinajpur sadar ranked

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

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Parbatipur	20800	72.83	9.64
02	Thakurgaon	17500	32.84	8.11
03	Chirirbandar	17100	71.97	7.92
04	Nawabganj	15900	61.23	7.37
05	Birampur	14200	80.66	6.58
06	Phulbari	11500	61.33	5.33
07	Boda	11000	46.92	5.10
08	Debiganj	11000	45.46	5.10
09	Dinajpur	10400	37.86	4.82
10	Pirganj	9800	33.05	4.54
11	Ghoraghat	8700	72.71	4.03
12	Birol	8200	27.13	3.80
13	Birganj	8000	25.76	3.71
14	Bochaganj	7800	38.75	3.61
15	Haripur	6750	38.21	3.13
16	Baliadangi	6600	27.87	3.06
17	Hakimpur	6000	72.41	2.78
18	Khansama	5100	33.49	2.36
19	Panchagarh	4900	19.96	2.27
20	Kaharol	4700	26.20	2.18
21	Ranisonkail	4400	18.17	2.04
22	Tetulia	3200	23.29	1.48
23	Atwari	2300	14.11	1.07
	Dinajpur region	215850	40.91	100.00

**Table 9. Distribution of the 2<sup>nd</sup> dominant Wheat–Fallow–T. Aman cropping pattern in Dinajpur region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Thakurgaon	7500	14.07	16.07
02	Pirganj	6600	22.26	14.14
03	Ranisonkail	5000	20.64	10.72
04	Birganj	4850	15.62	10.39
05	Baliadangi	3700	15.63	7.93
06	Kaharol	3150	17.56	6.75
07	Boda	3100	13.22	6.64
08	Atwari	3000	18.4	6.43
09	Tetulia	3000	21.83	6.43
10	Birol	1700	5.63	3.64
11	Bochaganj	1600	7.95	3.43
12	Haripur	1600	9.06	3.43
13	Chirirbandar	1000	4.21	2.14
14	Dinajpur sadar	400	1.52	0.86
15	Debiganj	200	0.85	0.43
16	Nawabganj	120	0.47	0.26
17	Parbatipur	100	0.35	0.21
18	Hakimpur	40	0.48	0.09
	Dinajpur region	46660	8.84	100.00

in top position. This upazila has 4,530 ha area which is only 16.49% of upazila NCA. Birganj upazila ranked in second position with 4,500 ha area for this pattern, while Pirganj holds the lowest position with just 500 hectares area. In the country-wide data compilation it was observed that Potato–Boro–T. Aman was the 8<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.80 lac ha (2.11% of NCA in the country) with its distribution in 115 upazilas of 33 districts (Nasim *et al.*, 2017).

#### Fifth dominant cropping pattern

Fifth dominant cropping pattern Potato–Maize–T. Aman had been covering 26,330 hectares representing 4.99% share of NCA in Dinajpur region (Table 12). This pattern is distributed over 18 upazilas where Thakurgaon sadar ranked in top position. This upazila had 6,500 ha area for Potato–Maize–T. Aman pattern which is only 12.2% of upazila NCA and 24.69% contributor for the region. Birampur and Debiganj occupied the lowest area, which was only 100 ha for each upazila under this cropping pattern.

#### 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 110 cropping patterns were identified in the whole area of Dinajpur region under this investigation. The highest number of cropping patterns was identified 30 in Boda upazila and that was 26 in Khansama; and 25 in Dinajpur sadar, Debiganj, Tetulia (Table 13). The lowest number of cropping patterns was identified 11 in Kaharol followed by 15 in Birampur. Higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The highest diversity index for cropping pattern was recorded 0.883 in Ranisonkail followed by 0.874 in Panchagarh. The lowest value of diversity index for cropping pattern was found 0.343 in Birampur upazila that was followed by 0.451 in Parbatipur upazila. The highest CDI was reported 0.955 in Ranisonkail followed by 0.952 in Baliadangi. The lowest value of CDI was observed 0.708 in Birampur followed by 0.753 in Ghoraghat upazila. The range of cropping intensity values was recorded 206-249%. The maximum value

**Table 10. Distribution of the 3<sup>rd</sup> dominant Maize–Fallow–T. Aman cropping patterns in Dinajpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Birol	5800	19.19	12.61
02 Nowabganj	5500	21.18	11.96
03 Panchagarh	5500	22.41	11.96
04 Kaharol	5400	30.10	11.74
05 Birganj	4300	13.85	9.35
06 Dinajpur	3000	10.92	6.52
07 Atwari	2500	15.33	5.44
08 Thakurgaon	2400	4.50	5.22
09 Phulbari	2200	11.73	4.78
10 Bochaganj	2000	9.93	4.35
11 Parbatipur	1900	6.65	4.13
12 Boda	1550	6.61	3.37
13 Debiganj	1500	6.20	3.26
14 Khansama	1300	8.54	2.83
15 Ghoraghat	800	6.72	1.73
16 Birampur	200	1.14	0.43
17 Chirirbandar	110	0.47	0.24
18 Ranisonkail	20	0.08	0.04
Dinajpur region	45980	8.71	100.00

**Table 11. Distribution of the 4<sup>th</sup> dominant Potato–Boro–T. Aman cropping pattern in Dinajpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Dinajpur	4530	16.49	17.04
02 Birganj	4500	14.49	16.92
03 Parbatipur	3300	11.55	12.41
04 Thakurgaon	3200	6.00	12.03
05 Birol	1800	5.96	6.77
06 Bochaganj	1300	6.46	4.89
07 Birampur	1200	6.82	4.51
08 Phulbari	1000	5.33	3.76
09 Debiganj	1000	4.13	3.76
10 Hakimpur	800	9.65	3.01
11 Ranisonkail	800	3.30	3.01
12 Khansama	760	4.99	2.86
13 Chirirbandar	700	2.95	2.63
14 Ghoraghat	600	5.01	2.26
15 Nawabganj	600	2.34	2.26
16 Pirganj	500	1.72	1.88
Dinajpur region	26590	5.04	100.00

**Table 12. Distribution of the 5<sup>th</sup> dominant Potato–Maize–T. Aman cropping patterns in Dinajpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Thakurgaon	6500	12.20	24.69
02 Birganj	3550	11.43	13.48
03 Birol	3000	9.93	11.39
04 Haripur	2500	14.15	9.49
05 Khansama	2300	15.10	8.74
06 Kaharol	2100	11.71	7.98
07 Baliadangi	1550	6.55	5.89
08 Pirganj	1000	3.37	3.80
09 Dinajpur	600	2.18	2.28
10 Phulbari	600	3.20	2.28
11 Ghoraghat	600	5.01	2.28
12 Chirirbandar	500	2.14	1.90
13 Parbatipur	500	1.76	1.90
14 Nawabganj	380	1.48	1.44
15 Atwari	300	1.89	1.14
16 Hakimpur	150	1.82	0.57
17 Birampur	100	0.57	0.40
18 Debiganj	100	0.43	0.40
Dinajpur region	26330	4.99	100.00

was for Khansama upazila of Dinajpur district and minimum for Boda upazila of Panchagarh district. As a whole, crop diversity index (CDI) for Dinajpur region was calculated 0.924. 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 the other. (Blade and Slinkard, 2002). The farmers of Kerala diversified their cropping pattern to minimize risk from due to crop failures and price fluctuations (Mahesh, 1999).

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

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Birampur	15	14	0.343	0.708	214
02 Birganj	19	16	0.849	0.941	241
03 Birol	16	15	0.856	0.947	246
04 Bochaganj	17	14	0.811	0.927	236
05 Chirirbandar	22	16	0.473	0.777	219
06 Dinajpur	25	16	0.809	0.925	238
07 Phulbari	19	15	0.600	0.837	225
08 Ghoraghat	17	19	0.458	0.753	212
09 Hakimpur	20	19	0.456	0.774	225
10 Kaharol	11	13	0.794	0.909	218
11 Khansama	26	15	0.831	0.937	249
12 Nawabganj	18	18	0.578	0.803	209
13 Parbatipur	16	16	0.451	0.760	216
14 Atwari	20	19	0.852	0.935	222
15 Boda	30	22	0.746	0.879	206
16 Debiganj	25	21	0.863	0.902	221
17 Panchagarh	20	19	0.874	0.938	203
18 Tetulia	25	19	0.855	0.941	240
19 Baliadangi	18	14	0.859	0.952	243
20 Haripur	18	15	0.792	0.931	247
21 Pirganj	22	18	0.811	0.922	228
22 Ranisonkail	24	18	0.883	0.955	246
23 Thakurgaon	19	16	0.839	0.938	239
Dinajpur region	112	25	0.807	0.924	229

## CONCLUSION

The cropping intensity, diversity and land use of the Dinajpur region is little bit higher than the national average but it is not yet enough as we have a vast population and need a huge amount of food everyday. Exclusive rice area is about nine folds of exclusive non-rice area. Abundance of non-rice cereal crops is extraordinary characteristic of the region. Therefore, Dinajpur region can play a vital role through abundant crop production for maintaining the food security of the country. 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. As rice is the synonym of the primary food security, the high yielding varieties of rice along with recommended crop management packages to be adopted.

- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.
- Devotion might be invested so that a portion of double-rice area could be brought under Potato-Boro-T. Aman cropping system or other three cropping systems.
- Scope might be explored for the establishment of agro-based food and feed industry for the best use of potato as well as maize.

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- Alam, M S. 1994. Optimum cropping patterns of the small farmers under risk: a micro level study in Bangladesh.

- Ph D thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.
- BBS (Bangladesh Bureau of Statistics). 2015. Yearbook of Agriculture Statistics of Bangladesh. Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.
- Blade, S F and A E Slinkard. 2002. New Crop Development: The Canadian Experience. *In: Trends in New Crops and New Uses*. J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Hossain, D. 1996. Relative profitability from alternative cropping patterns under irrigated conditions in selected areas of Bogra district. M. S. Ag. Econ. Thesis. Bangladesh Agricultural University, Mymensingh.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location-specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapuram.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rashid M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2):213-238.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shirazy, B J, M H Rashid, M M Mahbub, T A Somee and P C Goswami. 2016. Farmers' participatory demonstration of salt tolerant T. Aman rice varieties in saline soils. *Academic Journal of Plant Sciences*, 9 (1): 01-04.
- Shopan, J, M S U Bhuiya, M A Kader and M K Hasan. 2012. The feasibility of crop diversification in rice based cropping systems in *haor* ecosystem. *J. Bangladesh Agril. Univ.* 10(2): 211-216.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

	Cropping pattern	Area (ha)	Cropping pattern	Area (ha)	
01	Boro-Fallow-T. Aman	215850	36	Garlic-Jute-T. Aman	980
02	Wheat-Fallow-T. Aman	46660	37	W.Melon-Fallow-T. Aman	970
03	Maize-Fallow-T. Aman	45980	38	Onion-Vegetab-Vegetab	850
04	Potato-Boro-T. Aman	26590	39	Onion-Jute-T. Aman	740
05	Potato-Maize-T. Aman	26330	40	Garlic-Vegetab-Vegetab	710
06	Wheat-Jute-T. Aman	23960	41	Fallow-Sesame-T. Aman	700
07	Mustard-Boro-T. Aman	18720	42	Chilli-Jute-T. Aman	670
08	Wheat-Maize-T. Aman	11520	43	Boro-Fallow-Fallow	650
09	Wheat-Aus-T. Aman	9990	44	Garlic-Fallow-T. Aman	570
10	Chilli-Fallow-T. Aman	7560	45	Onion-Fallow-T. Aman	560
11	Wheat-Mungbean-T. Aman	6280	46	Vegetab-Jute-Fallow	520
12	Vegetab-Vegetab-Vegetab	5070	47	Potato-Boro-Fallow	500
13	Vegetab-Fallow-T. Aman	4460	48	Potato-Onion-T. Aman	500
14	Groundnut-Fallow-T. Aman	3700	49	Vegetab-Fallow-Fallow	470
15	Mustard-Maize-T. Aman	3590	50	Maize-Jute-T. Aman	440
16	Potato-Jute-T. Aman	3515	51	Vegetab-Fallow-Blackgram	405
17	Wheat-Fallow-Fallow	3250	52	Mustard-Jute-T. Aman	380
18	Wheat-Maize-Fallow	3050	53	Mustard-Fallow-T. Aman	360
19	Wheat-Vegetab-T. Aman	2920	54	Garlic-Aus-T. Aman	350
20	Potato-Groundnut-T. Aman	2700	55	Potato-Maize-Vegetab	350
21	Vegetab-Vegetab-T. Aman	2650	56	Vegetab-Boro-T. Aman	310
22	Potato-Vegetab-T. Aman	2460	57	Vegetab-Vegetab-Fallow	310
23	Potato-Aus-T. Aman	2020	58	Fallow-Fallow-T. Aman	300
24	Sesame-Fallow-T. Aman	2010	59	Groundnut-Jute-T. Aman	300
25	Wheat-Maize-Vegetab	2000	60	Maize-Aus-Fallow	300
26	Maize-Maize-T. Aman	1700	61	Maize-Vegetab-T. Aman	300
27	Maize-Vegetab-Fallow	1700	62	Onion-Aus-T. Aman	300
28	Potato-Maize-Fallow	1600	63	Vegetab-Groundnut-T. Aman	300
29	Boro-Aus-T. Aman	1575	64	Maize-Aus-T. Aman	250
30	Mustard-Boro-Fallow	1490	65	Chilli-Fallow-Fallow	240
31	Potato-Fallow-T. Aman	1440	66	Vegetab-Aus-T. Aman	240
32	Wheat-Vegetab-Vegetab	1400	67	Potato-Jute-Fallow	200
33	Groundnut-Fallow-Fallow	1330	68	Vegetab-Boro-Aus-T. Aman	200
34	Maize-Boro-T. Aman	1200	69	Chilli-Vegetab-Fallow	160
35	Vegetab-Maize-T. Aman	1020	70	Mustard-Aus-T. Aman	160
			71-110	Other 40 patterns (Table 7)	2180

# Diversity of Cropping Patterns and Land Use Practices in Faridpur Region

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## ABSTRACT

The development of agriculture sector largely depends on the reliable and comprehensive statistics of the existing cropping patterns, cropping intensity and crop diversity of a particular area, which will provide guideline to policy makers, researchers, extensionists and development workers. The study was conducted over all 29 upazilas of Faridpur region during 2015-16 using pre-tested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity of this area. From the present study it was observed that about 43.23% net cropped area (NCA) was covered by only jute based cropping patterns on the other hand deep water ecosystem occupied about 36.72% of the regional NCA. The most dominant cropping pattern Boro-Fallow-Fallow occupied about 24.40% of NCA with its distribution over 28 out of 29. The second largest area, 6.94% of NCA, was covered by Boro-B. Aman cropping pattern, which was spread out over 23 upazilas. In total 141 cropping patterns were identified under this investigation. The highest number of cropping patterns was identified 44 in Faridpur sadar and the lowest was 12 in Kashiani of Gopalganj and Pangsa of Rajbari. The lowest crop diversity index (CDI) was reported 0.448 in Kotalipara followed by 0.606 in Tungipara of Gopalganj. The highest value of CDI was observed 0.981 in Faridpur sadar followed by 0.977 in Madhukhali of Faridpur. The range of cropping intensity value was recorded 113-262%. The maximum value was for Saltha of Faridpur and minimum for Kotalipara of Gopalganj. As a whole the CDI of Faridpur region was calculated 0.971 and the average cropping intensity at regional level was 197%.

**Key words:** Cropping system, jute, diversity index and deep-water ecosystem

## INTRODUCTION

The term cropping system refers to the crops, cropping patterns and the management techniques used on a particular field over the period of a year. This term is not a new one, but it has been used more often in recent years in discussions about sustainability of our agricultural production systems. Cropping pattern is the yearly sequence and spatial arrangement of crops or of crops and fallow on a given area (Chandrasekaran *et al.*, 2010). The cropping patterns of a region are closely influenced by the geo-climatic, socio-economic, historical and political factors (Hussain, 1996). It also depends on topography, slope, soils and availability of water for irrigation, use of pesticides, fertilizers and mechanization.

Weather plays a decisive role in determining the existing cropping pattern. Faridpur region is a low lying area of the country.

Faridpur municipality was established in 1869, which is divided into five districts in modern days. These are Faridpur, Rajbari, Gopalganj, Madaripur and Shariatpur. Collectively all these districts are known as Faridpur region. It is mostly a riverine area of the country belongs to Active Ganges River Floodplain (AEZ-10), Low Ganges River Floodplain (AEZ-12), Gopalganj-Khulna Bils (AEZ-14) and Old Meghna Estuarine Floodplain (AEZ-19) (FAO, 1988). Most of the soils of this region are floodplain and basin type, which are formed from the river deposits. Sedimentation occurs in every year in this region due to the regular flooding. As a result soils of this region

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are very fertile and diversified crops can be grown there during the rainy season as well as in winter. This region is well known for jute and rice cultivation. Several adverse situations e.g. deep flood, flash flood, peat soils, heavy basin clays, noxious perennial weeds, slow drainage affect the cultivation of different crops. As a result the cropping intensity in this region is much lower than the other region like Bogra, Dinajpur, Jessore. 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). There is a strong need for judicious and appropriate use limited resources in case of intervention selection that does not lead to increased mal adaption or inequity in the society over long term. Existing trends of available agricultural lands is most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these contexts, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The present study was designed with the following specific objectives to:

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

## METHODOLOGY

Twenty-nine upazilas of Faridpur, Goplaganj, Shariatpur, Madaripur and Rajbari districts under Faridpur 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 29 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during July 2015 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 based on day-long data validation workshop at district level. The workshop dates were 18 August 2015 for Rajbari; 30 May 2016 for Faridpur; 31 May 2016 for Shariatpur; 25 July 2016 for Goplaganj and 26 July 2016 for Madaripur. Four field-workers i.e. one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRI regional station, Bhanga and Kushtia participated in the data validation workshop. The number of participants of validation workshop ranged from 40 to 69 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 the collected data were done using Microsoft 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 Faridpur region is 490,490 hectares. Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in the region were pineapple, sugarcane, banana papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 10 to 2,000 ha. The annual crops area accounted only 2.45% of the net cropped area (NCA) in the region. At a glance the region possesses 25% single cropped area (SCA), 47% double cropped area (DCA), 24.6% triple cropped area (TCA). The quadruple cropped area is absent in this region. The SCA had the major share of NCA in Kotalipara, and Tungipara upazilas of Gopalganj district; Kalkini upazila of Madaripur district; Damudya and Naria upazilas of Shariatpur district followed by corresponding double cropped area (DCA). Most of the upazilas were dominated by DCA. The exceptions are Madhukhali and Saltha of Faridpur district and Baliakandi, Kalukhali, Pangsa and Rajbari sadar of Rajbari district where triple cropped area is the dominating one (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.

### Cropping patterns of Faridpur

In total 141 cropping patterns were observed in Faridpur region of which six cropping patterns with exclusive rice crop covers over 35% of the NCA. There were 46 cropping patterns with exclusive non-rice crop covering over 28% of the NCA. Rest of the NCA i.e. about 37% area is covered by 89 rice-non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Table 2 presents six cropping patterns where rice is the only crop round the year. It comprises about 35.23% of the NCA in the region. Among them single rice, double rice and triple rice areas represent around 24.44%, 10.69% and 0.03% respectively. It reflects the unparallel dominance of rice in the cropping systems in Faridpur region. In case of individual pattern Boro-Fallow-Fallow has the highest coverage (24.41%) and was recorded in 28 upazilas out of 29. The second dominant cropping pattern Boro- B. Aman occupied 6.94% of NCA which was reported in 23 upazilas. Boro-Fallow- T. Aman covered 3.6% area with its existence in 22 upazilas.

In the current investigation, 46 cropping patterns were identified that was free from rice. Among the 46 patterns, first 32 have been arranged in descending order (Table 3). The rest 14 patterns with negligible area coverage (Table 8) were arranged with other patterns of different categories. Aggregate of the 46 patterns have had 28.45% of NCA. In critical comparison it is clear that exclusive rice area is more or less same as exclusive non-rice area. In Faridpur region crop diversity is much wider than that of other regions like Sylhet and Chittagong where exclusive rice area covers 37 folds and 23 folds respectively, of exclusive non-rice area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). Appropriate cropping patterns may facilitate maximum possible land use 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

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)	
01	Alfadanga	12803	90	700	7310	1300	0	140	9540	205
02	Bhanga	21640	200	850	8760	4480	0	110	14400	224
03	Boalmari	27203	900	0	12360	8100	0	140	21500	234
04	Charbhadrasan	17377	200	1460	6250	260	0	130	8300	183
05	Faridpur sadar	39623	900	2620	13300	7330	0	150	24300	216
06	Madhukhali	23018	2000	845	4265	8890	0	100	16100	237
07	Nagarkanda	19314	390	1700	7600	3970	0	130	13790	214
08	Sadarpur	28579	890	100	11920	6390	0	140	19440	228
09	Saltha	18512	20	255	4225	8030	0	90	12620	262
10	Gopalganj sadar	41375	1300	17650	7460	3960	0	130	30500	151
11	Kasiani	28600	300	11000	8010	1500	0	190	21000	153
12	Kotalipara	36793	50	24050	3330	120	0	150	27700	113
13	Muksudpur	30850	100	7000	12640	3390	0	120	23250	184
14	Tungipara	12724	40	8500	1335	695	0	120	10690	126
15	Kalkini	28011	490	8100	7330	4400	0	170	20490	179
16	Madaripur sadar	31382	410	0	15670	5550	0	130	21760	224
17	Rajoir	23108	130	2800	11590	3070	0	140	17730	201
18	Shibchar	33288	10	5200	10300	7750	0	150	23410	211
19	Baliakandi	22900	450	720	5780	8420	0	180	15550	247
20	Goalanda	14987	10	550	7410	1000	0	140	9110	205
21	Kalukhali	17066	300	1500	4870	5570	0	160	12400	231
22	Pangsa	24902	1050	700	6190	9400	0	110	17450	244
23	Rajbari sadar	31300	550	3200	7550	10000	0	150	21450	229
24	Bhedarganj	26728	70	3290	12790	1770	0	150	18070	191
25	Damudya	9176	160	3800	1450	1430	0	120	6960	163
26	Goshairhat	16867	670	4600	5190	2110	0	150	12720	175
27	Naria	23206	120	6650	4910	1130	0	110	12920	156
28	Shariatpur sadar	17508	160	4200	8345	235	0	120	13060	168
29	Janjira	25274	80	645	12855	575	0	125	14280	199
Faridpur region			12040	122685	230995	120825	0	3945	490490	197

the base for the managers of these systems to intensify production (Shriar, 2000). Light textured soil with low-water holding capacity are discouraging factors for modern rice cultivation specially in dry season. Moreover, supply of modern varieties of various crops, knowledge of modern crop management practices, good communication facilities, skilled technology transfer channel help crop diversification in a given area (FAO, 1988).

### Pulse crops

Thirty-eight cropping patterns are holding different pulse crops (Table 4). Among them lentil is covering the largest area whereas mungbean is cultivated in the smallest area.

The cropping patterns of only lentil altogether cover more than one-half of pulse growing area in the region. Grasspea holds the second position in pulse crop cultivation in Faridpur region. There are 11 cropping patterns for grasspea, which occupy over 2% of NCA. In the documentation of pulse cropping, Lentil-Jute-Fallow reported its widest spreading over 22 upazilas in the region. The aggregate area of the pulse cropping systems stands for 14.68% of the NCA in Faridpur region.

### Spices crops

Spices crops play an important role in the economy of Faridpur region. Twenty-seven cropping patterns are holding different spices

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

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Boro-Fallow-Fallow	119750	24.41	28
02	Boro-B. Aman	34060	6.94	23
03	Boro-Fallow-T. Aman	17685	3.61	22
04	Boro-Aus-Fallow	685	0.14	6
05	Fallow-B. Aman	500	0.10	1
06	Boro-Aus-T. Aman	150	0.03	2
	Total	172830	35.23	

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

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Onion-Jute-Fallow	25960	5.29	23
02	Wheat-Jute-Fallow	23210	4.73	25
03	Lentil-Jute-Fallow	15330	3.12	22
04	Mustard-Jute-Fallow	13880	2.83	18
05	Grasspea-Jute-Fallow	12680	2.58	18
06	Vegetab-Vegetab-Vegetab	8420	1.72	16
07	Coriander-Jute-Fallow	6510	1.33	12
08	Garlic-Jute-Fallow	6020	1.23	16
09	Vegetab-Vegetab-Fallow	4255	0.87	13
10	Vegetab-Jute-Fallow	3820	0.78	6
11	Chilli-Jute-Fallow	2045	0.42	9
12	Lentil-Vegetab-Vegetab	1910	0.39	2
13	Blackcumin-Jute-Fallow	1780	0.36	10
14	Potato-Jute-Fallow	1735	0.35	10
15	Groundnut-Fallow-Fallow	1480	0.30	4
16	Chilli-Fallow-Fallow	1360	0.28	5
17	Lentil-Sesame-Fallow	1125	0.23	5
18	Pea-Jute-Fallow	910	0.19	8
19	Chilli-Vegetab-Fallow	810	0.17	6
20	Blackgram-Jute-Fallow	735	0.15	6
21	Sesame-Fallow-Blackgram	680	0.14	4
22	W.Melon-Fallow-Fallow	510	0.10	2
23	Groundnut-Fallow-Blackgram	500	0.10	1
24	Onion-Sesame-Fallow	500	0.10	3
25	S.Potato-Fallow-Fallow	495	0.10	5
26	Vegetab-Fallow-Fallow	450	0.09	3
27	Onion-Vegetab-Vegetab	400	0.08	1
28	Fallow-Fallow-Blackgram	370	0.08	4
29	Wheat-Ginger/Turmeric	350	0.07	1
30	S.Potato-Jute-Fallow	230	0.05	4
31	Wheat-Sesame-Fallow	230	0.05	2
32	Grasspea-Sesame-Fallow	210	0.04	2
33-46	Other 14 patterns (in Table 8)	740	0.15	
	Total	139640	28.45	

**Table 4. Area covered by pulse crops under cropping system in Faridpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Lentil-Jute-Fallow	15330	3.13	22
02 Lentil-Jute-T. Aman	13230	2.70	21
03 Grasspea-Jute-Fallow	12680	2.59	18
04 Grasspea-B. Aman	4140	0.84	9
05 Lentil-Sesame-T. Aman	3280	0.67	5
06 Grasspea-Jute-T. Aman	2460	0.50	11
07 Lentil-B. Aman	2130	0.43	7
08 Lentil-Vegetab-Vegetab	1910	0.39	2
09 Pea-B. Aman	1730	0.35	4
10 Grasspea-Fallow-T. Aman	1510	0.31	2
11 Grasspea-Boro-Fallow	1430	0.29	2
12 Blackgram-B. Aman	1300	0.27	4
13 Boro-Fallow-Blackgram	1250	0.25	4
14 Lentil-Sesame-Fallow	1125	0.23	5
15 Pea-Jute-Fallow	910	0.19	8
16 Lentil-Fallow-T. Aman	830	0.17	2
17 Grasspea-B.Aus+B. Aman	770	0.16	3
18 Blackgram-Jute-Fallow	735	0.15	6
19 Grasspea-Sesame-T. Aman	700	0.14	1
20 Sesame-Fallow-Blackgram	680	0.14	4
21 Lentil-Aus-Fallow	670	0.14	4
22 Wheat-Aus-Blackgram	550	0.11	1
23 Groundnut-Fallow-Blackgram	500	0.10	1
24 Fallow-Fallow-Blackgram	370	0.08	4
25 Lentil-Aus-T. Aman	350	0.07	2
26 Grasspea-Aus-T. Aman	330	0.07	1
27 Pea-Fallow-T. Aman	290	0.06	3
28 Grasspea-Sesame-Fallow	210	0.04	2
29-38 Other 10 patterns (in Table 8)	585	0.12	
Total pulse crops	71985	14.68	

crops (Table 5). Among them onion alone is leading nine cropping patterns covering the largest area of 56,450 hectares which is equivalent to 11.50% of NCA in the region. Garlic holds the second position in spices crops leading five cropping patterns covering 13,210 hectares (2.69% of NCA). Blackcumin is a special crop with multidimensional uses. For its medicinal use it is a high value commodity in the market. Faridpur agricultural region is specially famous for the production of blackcumin. This crop is leading two patterns covering 3,000 hectares. Light textured soil and siltation by flood water are encouraging factors for spices. Moreover, extensive jute cultivation enriches soil organic matter, makes the soil

friable and free from weed. All the aforesaid determinants along with marketing facilities are helping spices crop production. Favourable climate, supply of modern varieties, knowledge of modern crop management practices, good communication facilities, skilled technology transfer channel help extensive production of demanded crop (FAO, 1988).

### Fibre crops

Socially and economically jute is an important crop in the Faridpur region. Thirty-six cropping patterns were identified based on jute (Table 6). It is observed that the jute based cropping patterns covered 43.49% of NCA of the Faridpur region. Among them Wheat-Jute-T. Aman cropping pattern alone occupied

**Table 5. Cropping patterns with spices crops in Faridpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Onion-Jute-Fallow	25960	5.29	23
02 Onion-Jute-T. Aman	24510	4.99	14
03 Coriander-Jute-Fallow	6510	1.33	12
04 Garlic-Jute-Fallow	6020	1.23	16
05 Chilli-B. Aman	4370	0.89	6
06 Garlic-Jute-T. Aman	3570	0.73	8
07 Coriander-Jute-T. Aman	3380	0.69	11
08 Onion-Aus-Fallow	2860	0.58	5
09 Chilli-Jute-Fallow	2045	0.42	9
10 Blackcumin-Jute-Fallow	1780	0.36	10
11 Onion-B. Aman	1620	0.33	5
12 Chilli-Aus-Fallow	1570	0.32	3
13 Chilli-Fallow-Fallow	1360	0.28	5
14 Blackcumin-Jute-T. Aman	1220	0.25	9
15 Chilli-Vegetab-Fallow	810	0.17	6
16 Coriander-Sesame-T. Aman	700	0.14	1
17 Chilli-Fallow-T. Aman	620	0.13	3
18 Onion-Sesame-Fallow	500	0.10	3
19 Garlic-B. Aman	480	0.10	3
20 Onion-Vegetab-Vegetab	400	0.08	1
21 Onion-Sesame+B. Aman	300	0.06	1
22 Garlic-Aus-Fallow	280	0.06	3
23-27 Other five patterns (in Table 8)	490	0.10	-
Total spices crops	58305	11.89	

6.74% of the NCA which is distributed over 26 upazilas out of 29 covering 33,045 hectares of land area. The second prevailing Onion-Jute-Fallow covers about 25,960 hectare area which is 5.29% of the NCA. Wheat-Jute-Fallow stands in fourth position in terms of area coverage but it is widely distributed over 25 upazilas out of 29 which is the second highest position in respect to distribution of the pattern in the region. Well-drained light-textured soil makes the friendly situation for early growth stages of jute. High temperature, high humidity and satisfactory rainfall are the pre-requisites for cultivation of the crop. Plenty of flood water is on time available in the region for jute retting. Clear sun-shine during the harvesting period is an extra facility for post-harvest management of fibre and stick. Now-a-days jute-stick also has a good market value with export potential. All these make a favourable package, which encourages the farmers for extensive jute cultivation in the region (FAO, 1988).

### Deep-water rice ecosystem

Deep water is a special type of ecosystem in the country. In context of Faridpur region this ecosystem is very important. Table 7 presents the cropping patterns under deep water ecosystem. Among the listed 25 patterns Boro-B. Aman cropping pattern covers the highest area of 34,060 hectares which represents 6.94% of the region's NCA. This pattern is distributed over 23 upazilas out of 29. The second highest Chilli-B. Aman cropping pattern covers 4,370 hectares and distributed over six upazilas. In total the area allocated for deep water rice cultivation is 61,725 hectares, which is equivalent to 12.58% of NCA in Faridpur region. The water level of this ecosystem ranges between 150 and 400 cm, and water usually remains 3-4 months. Special rice varieties known as 'floating rice' are planted in these areas. In the past Bangladesh had a land coverage of three million hectares for deepwater rice (Jackson *et al.*, 1972). In course of time the continuous effort on modern agriculture shifted DWR area mainly to modern

**Table 6. Cropping patterns with jute crops in Faridpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Jute-T. Aman	33045	6.74	26
02 Onion-Jute-Fallow	25960	5.29	23
03 Onion-Jute-T. Aman	24510	5.00	14
04 Wheat-Jute-Fallow	23210	4.73	25
05 Lentil-Jute-Fallow	15330	3.13	22
06 Mustard-Jute-Fallow	13880	2.83	18
07 Lentil-Jute-T. Aman	13230	2.70	21
08 Grasspea-Jute-Fallow	12680	2.59	18
09 Mustard-Jute-T. Aman	10580	2.16	17
10 Coriander-Jute-Fallow	6510	1.33	12
11 Garlic-Jute-Fallow	6020	1.23	16
12 Vegetab-Jute-Fallow	3820	0.78	6
13 Garlic-Jute-T. Aman	3570	0.73	8
14 Coriander-Jute-T. Aman	3380	0.69	11
15 Grasspea-Jute-T. Aman	2460	0.50	11
16 Vegetab-Jute-T. Aman	2290	0.47	6
17 Chilli-Jute-Fallow	2045	0.42	9
18 Blackcumin-Jute-Fallow	1780	0.36	10
19 Potato-Jute-Fallow	1735	0.35	10
20 Blackcumin-Jute-T. Aman	1220	0.25	9
21 Fallow-Jute-T. Aman	1200	0.24	1
22 Boro-Jute-Fallow	1150	0.23	3
23 Pea-Jute-Fallow	910	0.19	8
24 Blackgram-Jute-Fallow	735	0.15	6
25 Potato-Jute-T. Aman	485	0.10	7
26 Boro-Jute-T. Aman	400	0.08	1
27 Sesame-Jute-T. Aman	260	0.05	1
28 S.Potato-Jute-Fallow	230	0.05	4
29-36 Other eight patterns (in Table 8)	710	0.14	
Total area for jute	213335	43.49	

**Table 7. Cropping patterns under deep water rice ecosystem in Faridpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-B. Aman	34060	6.94	23
02 Chilli-B. Aman	4370	0.89	6
03 Grasspea-B. Aman	4140	0.84	9
04 Mustard-Boro-B. Aman	2620	0.53	2
05 Groundnut-B. Aman	2400	0.49	3
06 Lentil-B. Aman	2130	0.43	7
07 Pea-B. Aman	1730	0.35	4
08 Onion-B. Aman	1620	0.33	5
09 Wheat-B. Aman	1500	0.31	5
10 Blackgram-B. Aman	1300	0.27	4
11 Mustard-B. Aman	990	0.20	3
12 Mustard-B.Aus+B. Aman	980	0.20	3
13 Grasspea-B.Aus+B. Aman	770	0.16	3
14 W.Melon-B. Aman	505	0.10	2
15 Fallow-B. Aman	500	0.10	1
16 Garlic-B. Aman	480	0.10	3
17 Vegetab-B. Aman	430	0.09	2
18 Mustard-Sesame+B. Aman	350	0.07	1
19 Onion-Sesame+B. Aman	300	0.06	1
20-25 Other six patterns (in Table 8)	550	0.11	
Total deep-water rice area	61725	12.58	

Boro. Now the area under deep water rice in Bangladesh is reduced to 0.4 million hectares (Nasim *et al.*, 2017). Though this cropping system is less productive than other modern cropping systems, however, the specific fragile ecosystem still struggling because of no other alternatives.

### **Sporadic and distinct cropping patterns**

There are some cropping patterns which are extremely location-specific, however, with large area coverage. These are Fallow–Jute–T. Aman (Table 6), Lentil–Vegetables–Vegetables (Table 4) and Mustard–Boro–B. Aman (Table 7). The Fallow–Jute–T. Aman is grown only in Goplaganj sadar upazila (1,200 ha). Lentil–Vegetables–Vegetables is cultivated only in Madhukhali upazila on 1,900 ha of land. Mustard–Boro–B. Aman is limited to two upazilas viz Kalkini (720 ha) and sadar upazila (1,900) in Madaripur district.

### **Rare cropping patterns**

In the present investigation, 42 cropping patterns have been identified as rare cropping patterns with negligible area coverage and seldom existence (Table 8). These are location specific system and are limited in one or two or in some cases three upazilas of the region. Total area coverage of the 42 patterns is far less than 1% of NCA. Among these, the highest area was allotted for Fallow–Sesame+B. Aman and Onion–Sesame–T. Aman (200 ha for each). These are recorded in Madhukhali upazila of Faridpur and Kalukhali upazila of Rajbari district. The smallest area was recorded for two cropping patterns whose coverage was five hectares for each (Table 8).

### **Most dominant cropping pattern**

Boro–Fallow–Fallow was the most dominant cropping pattern in Faridpur region. It covers 24.41% of NCA in the region and is available in 28 upazilas out of 29 (Table 9). The highest area under this cropping pattern was recorded 23,000 hectares in Kotalipara upazila which represents 19.21% of the total single Boro area of the region. In respect to individual upazila the highest area is also covered by the Kotalipara

upazila and it is 83% of its NCA for this pattern alone. Saltha, Janjira and Sadarpur upazila had negligible area coverage for this pattern. This pattern is frequent and concurrently experienced by early flash flood in April and cold injury at 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). In the country-wide data compilation it was observed that the single Boro was the 2<sup>nd</sup> 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).

### **Second dominant cropping pattern**

The second dominant cropping pattern in Faridpur region is Boro–B. Aman. It belongs to 6.94% of NCA of the region and spread out over 23 upazilas (Table 10). Muksudpur upazila of Gopalganj district holds the highest area (6,300 ha) under this cropping pattern. It contributes 18.5% share of the Boro–B. Aman cropping area in the region. Rajoir stands in the second position, however, this upazila of Madaripur district has allocated biggest share 34.09% surface of its NCA. In the country-wide compilation of data it was observed that Boro–B. Aman was the 7<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.83 lac ha (2.14% of NCA in the country) with its distribution in 113 upazilas of 32 districts (Nasim *et al.*, 2017).

### **Third dominant cropping pattern**

Wheat–Jute–T. Aman cropping pattern holds the third largest area coverage 33,045 hectares in Faridpur region. This area is an equivalent to 6.73% of NCA in the region. This pattern Wheat–Jute–T. Aman is distributed over 26 upazilas. Pangsa upazila has an area of 5,200 ha for Wheat–Jute–T. Aman which stands for 15.74% of the total area under this pattern in the region (Table 11). It also covers the biggest share of upazila NCA (31.71%) allotted over different upazilas. In the country-wide compilation of data it was observed that Wheat–Jute–T.

**Table 8. Rare cropping patterns covering non-significant area in Faridpur region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Fallow-Sesame+B. Aman	200	0.04	1	Madhukhali
02	Onion-Sesame-T. Aman	200	0.04	1	Kalukhali
03	Vegetab-Vegetab-T. Aman	160	0.03	2	Madhukhali+Gosahirhat
04	Boro-Aus-T. Aman	150	0.03	2	Goalanda+Bhedarganj
05	Chickpea-Jute-T. Aman	150	0.03	3	Kalkini+Rajoir+Madaripur
06	Potato-B. Aman	150	0.03	1	Boalmari
07	Boro-Sesbania-T. Aman	120	0.03	2	Boalmari+Charbhadrasan
08	Vegetab-Jute-Vegetab	120	0.03	1	Rajoir
09	Sunflower-Jute-Fallow	105	0.02	2	Tungipara+Shariatpur
10	Mungbean-Jute-Fallow	100	0.02	3	Faridpur+Gopalganj+Kalkini
11	Vegetab-Onion-Aus	100	0.02	1	Madaripur
12	Wheat-Aus-T. Aman	100	0.02	1	Boalmari
13	Wheat-Vegetab-Vegetab	100	0.02	1	Baliakandi
14	Chilli-Jute-T. Aman	90	0.02	3	Bhanga+Saltha+Tungipara
15	S.Potato-B. Aman	90	0.02	1	Kalkini
16	Boro-Aus-Blackgram	80	0.02	1	Janjira
17	Mungbean-Jute-T. Aman	80	0.02	3	Gopalganj+Tungipara+Kalkini
18	Vegetab-Aus-Fallow	80	0.02	1	Janjira
19	Mustard-Sesame-T. Aman	70	0.01	2	Faridpur+Rajoir
20	Potato-Vegetab-T. Aman	70	0.01	1	Baliakandi
21	Mungbean-B.Aus+B. Aman	60	0.01	2	Faridpur+Tungipara
22	Maize-Jute-Fallow	55	0.01	2	Faridpur +Shariatpur
23	Coriander-Fallow-Fallow	50	0.01	2	Charbhadrasan+Janjira
24	Coriander-Vegetab-Fallow	50	0.01	1	Goalanda
25	Grasspea-Fallow-Fallow	50	0.01	1	Saltha
26	Maize-Fallow-Fallow	45	0.01	2	Charbhadrasan+Janjira
27	Muskmelon-B. Aman	40	0.01	1	Rajoir
28	Boro-Sesbania-Fallow	30	0.01	1	Charbhadrasan
29	Grasspea-Sesbania-Fallow	30	0.01	1	Bhedarganj
30	Lentil-Mungbean-T. Aman	20	0.00	1	Rajoir
31	Potato-Aus-Fallow	20	0.00	1	Charbhadrasan
32	Potato-Aus-T. Aman	20	0.00	1	Gosahirhat
33	Sesame-Fallow-T. Aman	20	0.00	1	Kotalipara
34	Maize-B. Aman	10	0.00	1	Charbhadrasan
35	Muskmelon-Fallow-Fallow	10	0.00	1	Baliakandi
36	Muskmelon-Fallow-T. Amn	10	0.00	1	Madhukhali
37	S.Potato-Fallow-T. Aman	10	0.00	1	Tungipara
38	Soybean-Fallow-Fallow	10	0.00	1	Bhedarganj
39	Soybean-Jute-Fallow	10	0.00	1	Bhedarganj
40	Wheat-Mungbean-T. Aman	10	0.00	1	Tungipara
41	Mustard-Mungbean-T. Amn	5	0.00	1	Madhukhali
42	Tobacco-Fallow-Fallow	5	0.00	1	Saltha
	Total	2885	0.59	-	

**Table 9. Distribution of the most dominant Boro–F–F cropping pattern in Faridpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Kotalipara	23000	83.18	19.21
02 Gopalganj	17000	58.22	14.2
03 Kasiani	11000	53.14	9.19
04 Tungipara	8300	77.93	6.93
05 Kalkini	8100	40.50	6.76
06 Muksudpur	7000	30.24	5.85
07 Naria	5700	44.53	4.76
08 Shibchar	5200	22.22	4.34
09 Goshairhat	4600	38.17	3.84
10 Shariatpur	4200	32.56	3.51
11 Damudya	3800	55.88	3.17
12 Rajbari	3200	15.31	2.67
13 Bhedarganj	3000	16.67	2.51
14 Rajoir	2800	15.91	2.34
15 Madaripur	2600	12.18	2.17
16 Nagarkanda	1700	12.69	1.42
17 Faridpur	1500	6.41	1.25
18 Kalukhali	1500	12.40	1.25
19 Charbhadrasan	1200	14.81	1.00
20 Bhanga	850	5.99	0.71
21 Baliakandi	700	4.64	0.58
22 Pangsa	700	4.27	0.58
23 Madhukhali	600	4.26	0.50
24 Alfadanga	550	5.82	0.46
25 Goalanda	450	4.95	0.38
26 Saltha	200	1.59	0.17
27 Janjira	200	1.41	0.17
28 Sadarpur	100	0.54	0.08
Faridpur region	119750	24.40	100.00

Aman was the 9<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.47 lac ha (1.72% of NCA in the country) with its distribution in 216 upazilas of 43 districts (Nasim *et al.*, 2017).

#### Fourth dominant cropping pattern

Fourth dominant cropping pattern Onion-Jute-Fallow has occupied 25,960 ha representing 5.29% share of NCA in Faridpur region (Table 12). This pattern is distributed over 23 upazilas where Nagarkanda ranked in top position. This upazila has 5,800 ha area Onion-Jute-Fallow, which is over 43% of upazila NCA. Boalmari upazila ranks in second position with 5,350 ha area for this pattern; which is also stands in second position in terms of percentage of upazila NCA as well as distribution of the patterns in the region.

#### Fifth dominant cropping pattern

The fifth dominant cropping pattern of the region is Onion-Jute-T. Aman. It had been covering 24,510 hectares representing 4.99% share of NCA in Faridpur region (Table 13). This pattern is distributed over 14 upazilas where Saltha ranked in top position. This upazila had 7,000 ha area for Onion-Jute-T. Aman pattern which is 55.56% of its upazila NCA. This is also the highest area coverage (28.56%) in respect of this pattern in the region.

#### Crop diversity and cropping intensity

The level of crop diversification largely depends on the geo-climatic or socio-economic conditions and technological development in a region (Bhatia, 1965). Higher number of available crops under cultivation in an

**Table 10. Distribution of the 2<sup>nd</sup> dominant Boro-B. Aman cropping pattern in Faridpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Muksudpur	6300	27.21	18.50
02 Rajoir	6000	34.09	17.62
03 Madaripur	5000	23.42	14.68
04 Bhangra	2100	14.79	6.17
05 Sadarpur	2000	10.78	5.87
06 Kasiani	1500	7.25	4.40
07 Kotalipara	1300	4.70	3.82
08 Shariatpur	1300	10.08	3.82
09 Faridpur	1000	4.27	2.94
10 Rajbari	1000	4.78	2.94
11 Bhedarganj	900	5.00	2.64
12 Naria	900	7.03	2.64
13 Kalkini	850	4.25	2.50
14 Nagarkanda	800	5.97	2.35
15 Gopalganj	800	2.74	2.35
16 Alfadanga	700	7.41	2.06
17 Damudya	400	5.88	1.17
18 Goshairhat	400	3.32	1.17
19 Madhukhali	280	1.99	0.82
20 Saltha	200	1.59	0.59
21 Kalukhali	200	1.65	0.59
22 Tungipara	80	0.75	0.23
23 Boalmari	50	0.24	0.15
Faridpur region	34060	6.94	100.00

area dictates its higher diversity. Number of cropping patterns is also a gross indicator of crop diversity. A total of 141 cropping patterns were identified in the whole area of Faridpur region under this investigation. The highest number of cropping patterns was identified 44 in Faridpur sadar upazila and that was 42 in Janjira and 40 in Charbhadrasan (Table 14). The lowest number of cropping patterns was identified 12 in Kasiani and Pangsa. The higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were due to flooding and/or water logging. The lowest diversity index for cropping pattern was recorded 0.307 in Kotalipara followed by 0.394 in Tungipara upazila. The highest value of diversity index for cropping pattern was found 0.957 in Faridpur sadar that was followed by 0.949 in Janjira upazila. The lowest CDI was reported 0.448 in Kotalipara followed by 0.606 in Tungipara.

The highest value of CDI was observed 0.981 in Faridpur sadar followed by 0.977 in Madhukhali upazila. The range of cropping intensity values was recorded 113-262%. The maximum value was for Saltha upazila of Faridpur district and minimum for Kotalipara upazila of Gopalganj district. As a whole the CDI of Faridpur region was calculated 0.971 and the average cropping intensity at regional level was 197%. 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). The farmers of Kerala diversified their cropping pattern to minimize risk from crop failures and price fluctuations (Mahesh, 1999).

**Table 11. Distribution of the 3<sup>rd</sup> dominant Wheat-Jute-T. Aman cropping pattern in Faridpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Pangsa	5200	31.71	15.74
02 Faridpur	4000	17.09	12.1
03 Boalmari	3300	16.02	9.99
04 Sadarpur	3000	16.17	9.08
05 Bhanga	2500	17.61	7.57
06 Nagarkanda	2000	14.93	6.05
07 Rajbari	2000	9.57	6.05
08 Madhukhali	1900	13.48	5.75
09 Baliakandi	1600	10.60	4.84
10 Kalukhali	1400	11.57	4.24
11 Alfadanga	900	9.52	2.72
12 Muksudpur	800	3.46	2.42
13 Shibchar	700	2.99	2.12
14 Goalanda	600	6.59	1.82
15 Madaripur	500	2.34	1.51
16 Saltha	400	3.17	1.21
17 Naria	350	2.73	1.06
18 Gopalganj	300	1.03	0.91
19 Kasiani	300	1.45	0.91
20 Bhedarganj	250	1.39	0.76
21 Tungipara	230	2.16	0.70
22 Damudya	220	3.24	0.67
23 Goshairhat	220	1.83	0.67
24 Kalkini	200	1.00	0.61
25 Shariatpur	100	0.78	0.30
26 Janjira	75	0.53	0.23
Faridpur region	33045	6.73	100.00

**Table 12. Distribution of the 4<sup>th</sup> dominant Onion-Jute-Fallow cropping pattern in Faridpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Nagarkanda	5800	43.28	22.34
02 Boalmari	5350	25.97	20.61
03 Saltha	2300	18.25	8.86
04 Kalukhali	1800	14.88	6.93
05 Faridpur	1500	6.41	5.78
06 Baliakandi	1500	9.93	5.78
07 Sadarpur	1300	7.01	5.01
08 Janjira	1080	7.61	4.16
09 Goalanda	850	9.34	3.27
10 Bhanga	800	5.63	3.08
11 Shibchar	800	3.42	3.08
12 Rajbari	550	2.63	2.12
13 Kasiani	500	2.42	1.93
14 Alfadanga	470	4.97	1.81
15 Muksudpur	400	1.73	1.54
16 Charbhadrasan	250	3.09	0.96
17 Tungipara	200	1.88	0.77
18 Kalkini	120	0.60	0.46
19 Madaripur	100	0.47	0.39
20 Bhedarganj	100	0.56	0.39
21 Shariatpur	70	0.54	0.27
22 Madhukhali	60	0.43	0.23
23 Rajoir	60	0.34	0.23
24 Faridpur region	25960	5.29	100.00

**Table 13. Distribution of the 5<sup>th</sup> dominant Onion-Jute-T. Aman cropping pattern in Faridpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Saltha	7000	55.56	28.56
02 Pangsa	3400	20.73	13.87
03 Baliakandi	2800	18.54	11.42
04 Kalukhali	2800	23.14	11.42
05 Madhukhali	2000	14.18	8.16
06 Shibchar	1800	7.69	7.34
07 Faridpur	1000	4.27	4.08
08 Bhanga	900	6.34	3.67
09 Sadarpur	900	4.85	3.67
10 Rajbari	600	2.87	2.45
11 Nagarkanda	500	3.73	2.04
12 Muksudpur	400	1.73	1.63
13 Naria	360	2.81	1.47
14 Damudya	50	0.74	0.20
Faridpur region	24510	4.99	100.00

**Table 14. Crop diversity and cropping intensity in Faridpur region, 2014-15.**

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Alfadanga	18	15	0.917	0.957	205
02 Bhanga	16	16	0.887	0.947	224
03 Boalmari	21	19	0.861	0.948	234
04 Charbhadrasan	40	22	0.942	0.970	183
05 Faridpur sadar	44	25	0.957	0.981	216
06 Madhukhali	39	22	0.937	0.977	237
07 Nagarkanda	17	14	0.779	0.901	214
08 Sadarpur	21	22	0.909	0.959	228
09 Saltha	23	16	0.649	0.850	262
10 Gopalganj sadar	25	18	0.675	0.848	151
11 Kasiani	12	10	0.692	0.732	153
12 Kotalipara	16	14	0.307	0.448	113
13 Muksudpur	17	15	0.810	0.912	184
14 Tungipara	28	22	0.394	0.606	126
15 Kalkini	30	19	0.822	0.935	179
16 Madaripur sadar	23	17	0.883	0.952	224
17 Rajoir	29	21	0.837	0.922	201
18 Shibchar	18	14	0.908	0.966	211
19 Baliakandi	24	21	0.924	0.965	247
20 Goalanda	22	17	0.931	0.966	205
21 Kalukhali	16	13	0.885	0.943	231
22 Pangsa	12	12	0.852	0.928	244
23 Rajbari sadar	18	15	0.928	0.971	229
24 Bhedarganj	33	21	0.935	0.970	191
25 Damudya	22	17	0.689	0.871	163
26 Goshairhat	22	13	0.843	0.938	175
27 Naria	22	13	0.783	0.902	156
28 Shariatpur sadar	30	22	0.851	0.930	168
29 Janjira	42	21	0.949	0.974	199
Faridpur region	141	34	0.918	0.971	197

## CONCLUSION

Faridpur region holds a wide range of cropping patterns with diversified crops. The intensity of cropping in the region is more or less similar to the national average but the country demands more to cope with its huge population within its limited resources. The less intensified area of the region is under deep water ecosystem which covers a major share of the regional NCA. Single Boro and Boro-B. Aman cropping patterns are the dominant patterns in this ecosystem. Based on the findings of the study, the following recommendations were made.

- Necessary steps need to be taken to increase the productivity of exclusive rice based cropping patterns. As rice is the major component of the food security in context of our country, we need to explore some high yielding rice varieties along with the recommended crop management practices for deep water ecosystem.
- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.
- Scope might be explored for the establishment of agro-industry on the basis of jute crop.
- Research and development activities can be taken in hand to diversify the single and double cropped area with the inclusion of new crops and crop varieties.
- In the single Boro area suitable vegetables might be grown on floating bed system in wet season.

## REFERENCES

Bhatia, S S. 1965. Patterns of crop concentration and diversification in India, *Economic Geography*, 41: 40-55.

- Blade, S F and A E Slinkard. 2002. New Crop Development: The Canadian Experience. *In: Trends in New Crops and New Uses*. J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- Chandrasekaran B, K Annadurai and E Somasundaram. 2010. *A Textbook of Agronomy*, New Delhi, New Age International (P) Limited, 182p.
- FAO. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agro-ecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Hossain, D. 1996. Relative profitability from alternative cropping patterns under irrigated conditions in selected areas of Bogra district. M. S. Ag. Econ. Thesis. Bangladesh Agricultural University, Mymensingh.
- Jackson, B R, A Yantasast, C Prechachat, M A Chowdhury and S M H Zaman. 1972. Breeding rice for deep-water areas. Pages 517-528 *In: International Rice Research Institute, Rice Breeding*, Los Baños, Philippines.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapuram.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 273-288.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-122.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

	Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
01	Boro-Fallow-Fallow	119750	51 Groundnut- Aus-Fallow	1150
02	Boro-B. Aman	34060	52 Lentil-Sesame-Fallow	1125
03	Wheat-Jute-T. Aman	33045	53 Mustard-B. Aman	990
04	Onion-Jute-Fallow	25960	54 Mustard-B.Aus+B. Aman	980
05	Onion-Jute-T. Aman	24510	55 Sesame-Aus-Fallow	950
06	Wheat-Jute-Fallow	23210	56 Pea-Jute-Fallow	910
07	Boro-Fallow-T. Aman	17685	57 Lentil-Fallow-T. Aman	830
08	Lentil-Jute-Fallow	15330	58 Chilli-Vegetab-Fallow	810
09	Mustard-Jute-Fallow	13880	59 Wheat-Fallow-T. Aman	780
10	Lentil-Jute-T. Aman	13230	60 Grasspea-B.Aus+B. Aman	770
11	Grasspea-Jute-Fallow	12680	61 Blackgram-Jute-Fallow	735
12	Mustard-Jute-T. Aman	10580	62 Coriander-Sesame-T. Aman	700
13	Vegetab-Vegetab-Vegetab	8420	63 Grasspea-Sesame-T. Aman	700
14	Coriander-Jute-Fallow	6510	64 Boro-Aus-Fallow	685
15	Mustard-Boro-Fallow	6170	65 Sesame-Fallow-Blackgram	680
16	Garlic-Jute-Fallow	6020	66 Lentil-Aus-Fallow	670
17	Chilli-B. Aman	4370	67 Chilli-Fallow-T. Aman	620
18	Vegetab-Vegetab-Fallow	4255	68 Wheat-Aus-Blackgram	550
19	Grasspea-B. Aman	4140	69 W.Melon-Fallow-Fallow	510
20	Vegetab-Jute-Fallow	3820	70 W.Melon-B. Aman	505
21	Garlic-Jute-T. Aman	3570	71 Fallow-B. Aman	500
22	Coriander-Jute-T. Aman	3380	72 Groundnut-Fallow-Blackgram	500
23	Lentil-Sesame-T. Aman	3280	73 Mustard-Fallow-T. Aman	500
24	Onion-Aus-Fallow	2860	74 Onion-Sesame-Fallow	500
25	Mustard-Boro-B. Aman	2620	75 S.Potato-Fallow-Fallow	495
26	Grasspea-Jute-T. Aman	2460	76 Potato-Jute-T. Aman	485
27	Groundnut-B. Aman	2400	77 Garlic-B. Aman	480
28	Vegetab-Jute-T. Aman	2290	78 Sesame-Aus-T. Aman	460
29	Wheat-Sesame-T. Aman	2170	79 Vegetab-Fallow-Fallow	450
30	Lentil-B. Aman	2130	80 Vegetab-B. Aman	430
31	Mustard-Aus-Fallow	2090	81 Boro-Jute-T. Aman	400
32	Chilli-Jute-Fallow	2045	82 Onion-Vegetab-Vegetab	400
33	Lentil-Vegetab-Vegetab	1910	83 Fallow-Fallow-Blackgram	370
34	Blackcumin-Jute-Fallow	1780	84 Lentil-Aus-T. Aman	350
35	Potato-Jute-Fallow	1735	85 Mustard-Sesame+B. Aman	350
36	Pea-B. Aman	1730	86 Wheat-Ginger/Turmeric	350
37	Onion-B. Aman	1620	87 Grasspea-Aus-T. Aman	330
38	Mustard-Boro-T. Aman	1590	88 Mustard-Aus-T. Aman	320
39	Chilli-Aus-Fallow	1570	89 Groundnut-Fallow-T. Aman	310
40	Grasspea-Fallow-T. Aman	1510	90 Onion-Sesame+B. Aman	300
41	Wheat-B. Aman	1500	91 Pea-Fallow-T. Aman	290
42	Groundnut-Fallow-Fallow	1480	92 Garlic-Aus-Fallow	280
43	Grasspea-Boro-Fallow	1430	93 Vegetab-Fallow-T. Aman	280
44	Chilli-Fallow-Fallow	1360	94 Sesame-Jute-T. Aman	260
45	Blackgram-B. Aman	1300	95 Boro-Vegetab(Float/Norm)	245
46	Boro-Fallow-Blackgram	1250	96 S.Potato-Jute-Fallow	230
47	Blackcumin-Jute-T. Aman	1220	97 Wheat-Sesame-Fallow	230
48	Fallow-Jute-T. Aman	1200	98 Fallow-Sesame-T. Aman	210
49	Wheat-Aus-Fallow	1200	99 Grasspea-Sesame-Fallow	210
50	Boro-Jute-Fallow	1150	100-141 Other 42 patterns (Table 8)	910

# Crops and Cropping Sequences in Chittagong Hill Tracts

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## ABSTRACT

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

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

## INTRODUCTION

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

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

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

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

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

## METHODOLOGY

Twenty-five upazilas of Bandarban, Rangamati and Khagrachhari districts under Chittagong Hill Tracts agricultural region were the locale of this study. Data were collected using double stage procedure. At initial stage,

data were collected through pre-tested, semi-structured questionnaire from 25 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during March 2016 at upazila level. The SAAOs were purposively preselected by Agriculture Extension Officers (AEO), Additional Agriculture Officer (AAO) and Upazila Agriculture Officer (UAO) or altogether. Prior to data collection, the pre-tested questionnaire was explained along with proper guidelines to the AEOs or UAOs or both and handed over to them at each Deputy Director's office of Department of Agricultural Extension (DAE) during monthly meeting for the sake of accurate data collection. The filled questionnaires were collected by the scientists of RFS Division, checked and analyzed to find the inconsistencies of the supplied data before validation workshop. All the inconsistencies among the information were documented. The collected data along with documented inconsistencies were discussed in district level workshop to for necessary correction and validation. Second stage of data collection was daylong data validation workshop at district level during 16 to 18 May 2016. Four field-workers i.e. one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRI regional station, Satkhira, Bhanga and Rajshahi participated in the data validation workshop. The number participants of validation workshop ranged from 48 to 63 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  location

$A_i$  = Total area planted under all crops

The index is zero for a land area growing only one crop approaches unity as the level of diversity increase. Data were compiled and processed using Micro Soft Excel programme. Descriptive statistics were used to facilitate the presentation of the findings.

## RESULTS AND DISCUSSION

### Land use

Crops occupied the particular land for round the year were considered under annual crops. The major annual crops reported in Chittagong hill tracts were banana, turmeric, ginger, pineapple, papaya and sugarcane (Table 1). The area under annual crops in different upazilas

ranged from 480 to 4,550 ha. The annual crops area accounted about 30% of the net cropped area (NCA) in the region. Among the annual crops, banana was widely distributed with higher area coverage. Ginger was distributed in 23 upazilas ranged 120 to 520 ha. Turmeric was reported in all upazilas except Naikhongchhari with a range of 130 to 980 ha. Pineapple was found in 19 upazilas with a major contribution from Ruma, Nannerchar, and Rowangchhari. Papaya was reported in 17 upazilas with an area coverage of five to 300 ha. Sugarcane was also reported in all upazilas except Barkal with a narrow area coverage (5-85 ha).

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

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

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

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

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

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

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

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

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

### Cropping patterns of Chittagong Hill Tracts

In total 72 cropping patterns were observed in Chittagong hill tract of which six cropping patterns with exclusive rice crop covers about 35% of the NCA. There were 20 cropping

patterns with exclusive non-rice crop covering 11% of the NCA. Rest of the NCA i.e. about 54% area is covered by 46 rice - non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

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

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

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

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

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

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

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

comparison it is clear that exclusive rice area is three folds of exclusive non-rice area.

### **Pulses and oil-seed crops**

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

### **Vegetables and spices crops**

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

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

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

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

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

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

### **Sporadic and distinct cropping patterns**

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

### **Most dominant cropping pattern**

Boro-Fallow-T. Aman cropping pattern was the most dominant one in Chittagong Hill Tracts existed in all upazilas except Ruma. The contribution of these upazilas in the existence of the cropping pattern ranged from 0.05 to 10.31% of the total Boro-Fallow-T. Aman cropping pattern. The largest area coverage under this cropping pattern was in Naikhongchhari (10.31% of the total) followed by Nannerchar, Dighinala and Khagrachhari sadar upazila. The potentiality of the intensification might be explored consulting other determinants with the stakeholders. The least area coverage was reported in Barkal, Thanchi and Belaichhari (Table 8). In the country-wide compilation of data it was observed that Boro-F-T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### **Second dominant cropping pattern**

Fallow-Fallow-T. Aman cropping pattern ranked the second position in the region distributed to 21 out of 25 upazilas. However,

their magnitude of contribution to the region was different, ranging 0.45 (Rowangchhari) to 11.36% (Dighinala and Naikhongchhari) of the cropping pattern in the region. The major shares from other upazilas were Matiranga, Mohalchhari, Lama, Bandarban, Ramgarh and Manikchhari upazilas (Table 9). In the country-wide data compilation it was observed that the single T. Aman was the 3<sup>rd</sup> dominant cropping pattern in Bangladesh covering 5.09 lac ha (6% of NCA in the country) with its distribution in 162 upazilas of 36 districts (Nasim *et al.*, 2017).

### **Third dominant cropping pattern**

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

### **Fourth dominant cropping pattern**

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

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

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

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

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

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

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

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

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

### Fifth dominant cropping pattern

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

### Crop diversity and cropping intensity

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

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

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

15, and 15, respectively. The lowest number of cropping patterns(8) was reported in Ruma. Higher number of cropping pattern is generally related to higher level of diversity indices for cropping pattern. The upazilas having lower number of cropping patterns were related to hill slope, lack of irrigation water and remoteness. Table 13 presents the calculated diversity indices (CDI) for cropping pattern. The overall crop diversity index for the region was 0.96. The highest CDI was in Rowangchhari (0.99) followed by Lama, Kaptai, Langadu and Rangamati sadar with same CDI, 0.96 and the lowest CDI was in Thanchi (0.76). Average CI for the Chittagong Hill Tracts was 139%. The lowest CI was recorded in Ruma (100%) and the highest was in Manikchhari and Panchhari (164%). Diversified cropping pattern may be resort for the farmer as a coping strategy with flood related risk (Mandal and Bezbaruah, 2013) but scope of diversification is limited due to environmental and climatic condition (FAO, 1988).

## CONCLUSION

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

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

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

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

- Short duration high yielding potential Aus rice varieties in suitable for *zhum* cultivation along with other species of crops for mixed and relay cropping with improved production practices to be extensively adopted for increasing system productivity.
- Initiatives to be taken to expand area under fruit crops in the hilly slope and the demand driven varieties to be adopted considering organic principles.
- The cropping patterns with major area coverage and narrow existence and minor area coverage with minor existence might be sustained for diversified food demand and adaptation to climatic hazard.
- The upazilas having higher cropping pattern index might be studied in depth to

extrapolate potential cropping patterns to other upazilas of similar environments.

- Research and development activities can be taken in hand to diversify the single and double cropped cropping pattern with the inclusion of new crops and crop varieties.
- Coordinated programme needs to be taken to conserve the biodiversity and natural resources.

#### REFERENCES

- Alam, M S. 1994. Optimum cropping patterns of the small farmers under risk: a micro level study in Bangladesh. Ph.D. thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.
- Barua, J L, N I Khan, S Barua, S M Mohsin and M R Islam. 2015. Cropping pattern and socio-economic study of

ethnic people in the hilly areas of Bangladesh. *The Agriculturists*. 13(1): 119-126.

FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.

Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.

GED (General Economics Division). 2015. 7<sup>th</sup> Five Year Plan. Bangladesh Planning Commission, Government of the People's Republic of Bangladesh, Sher-e-Bangla Nagar, Dhaka 1207. 666p.

Khisa, 1998. Ethnobotanical and cultural background of ethnic communities of forest resource management in Cittagong Hill Tracts. *In: Banik, R L, K Alam, S J Pel and A Rastogi (eds.), Applied Ethnobotany, Proceedings of Sub regional Training Workshop on Applied Ethnobotany, Bangladesh Forest Research Institute, Chittagong, pp. 56-63.*

Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.

Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.

Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.

Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.

Rashid M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.

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

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

# Diversity of Crops and Cropping Systems in Jessore Region

M M R Dewan<sup>1</sup>, M Harun Ar Rashid<sup>2</sup>, M Nasim<sup>3</sup> and S M Shahidullah<sup>3</sup>

## ABSTRACT

Thorough understanding and a reliable database on existing cropping patterns, cropping intensity and crop diversity of a particular area are needed for guiding policy makers, researchers, extensionists and development workers for the planning of future research and development. During 2016 a study was accomplished over all 34 upazilas of Jessore region using pre-tested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity in the region. The most dominant cropping pattern Boro-Fallow-T. Aman occupied 32.28% of net cropped area (NCA) of the region with its distribution in all upazilas. The second largest area, 5.29% of NCA, was covered by single Boro, which was spread over 24 upazilas. A total of 176 cropping patterns were identified in the whole region under the current investigation. The highest number of cropping patterns was identified 58 in Kushtia sadar upazila and the lowest was 11 in Damurhuda upazila of Chuadanga district. The lowest crop diversity index (CDI) was reported 0.852 in Narail sadar upazila followed by 0.863 in Jessore sadar upazila. The highest value of CDI was observed 0.981 in Daulatpur followed by 0.978 in Bheramara upazila of Kushtia district. The range of cropping intensity values was recorded 175–286%. The maximum value was for Sreepur of Magura district and minimum for Abhaynagar of Jessore district. As a whole the CDI of Jessore region was calculated 0.955 and the average cropping intensity at regional level was 229%.

**Key words:** Cropping pattern, diversity index, favourable environment and non-rice cereal

## INTRODUCTION

Cropping system is the crop production activity of a farm, which includes all cropping patterns grown on the farm resources, other household enterprises and the physical, biological, technological and socioeconomic factors or environments. A cropping pattern is the yearly sequence, temporal and partial arrangement of crops in a given land area. It is dependent on physical, historical, social, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The cropping pattern and the changes therein depend on a large number of factors like climate, soil type, rainfall, agricultural technology, availability of irrigation facilities and other inputs, marketing and transport facilities and growth of agro-industries (Neena, 1998; Gadge, 2003).

The Jessore region includes the western part of the Ganges river floodplain which is predominantly highland and medium highland and it consists of 34 upazilas under seven districts. General soil types predominantly include calcareous dark grey floodplain soils and calcareous brown floodplain soils. Organic matter content in the brown ridge soils is low but higher in the dark grey soils. Soils are slightly alkaline in reaction. General fertility level is low. This region is suitable for agricultural crop production especially in cereals and vegetables. The cropping intensity is much higher than the other region of the country. The whole area holds comparatively dry weather than the other parts of the country. Low water holding capacity is an overall limitation for modern Boro rice cultivation in the region. Water stagnation is also a problem in some specific locations.

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The overall agricultural development in Bangladesh conceals considerable regional differences because of farming practices, techniques, availability of irrigation facilities, attitude of the farmer etc in different parts of the country. The differences in agricultural productivity among the regions to some natural phenomena, such as, rainfall, temperature, humidity and some other agro-ecological features which are relatively less favourable in the lagging regions. Jessore region plays a vital role of Agriculture in Bangladesh. The region produces a variety of crops year-round.

The yields of cereal crops are tending to stagnation, even in favourable environments. Moreover, cultivable land area is decreasing day by day in the country. 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 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). 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. Existing trends of available agricultural lands is most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The present study was designed with the following specific objectives to:

- Understand the existing cropping patterns scenario in Jessore 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

Thirty-four upazilas of Jessore, Jhenaidaha, Magura, Narail, Kushtia, Meherpur and Chuadanga districts under Jessore 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 34 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during January 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. The workshop dates were 14 March for Narail and Magura; 15 March for Jhenaidaha; 12 April for Jessore; 13 April for Kushtia and 28 April 2016 for Chuadanga and Meherpur. 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, Kushtia and Satkhira participated in the data validation workshop. The number of participants of validation workshop ranged from 26 to 73 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 Jessore region is 736,920 ha. 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, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 100 to 2,330 ha. The annual crops area accounted only 4.14 % of the net cropped area (NCA) in the region. At a glance the region possesses 6% single cropped area (SCA), 52% double cropped area (DCA), 37% triple cropped area (TCA). The quadruple cropped area also exists as a very negligible portion (0.63%). The SCA was dominant in Abhaynagar and had the major share of NCA in Keshabpur of Jessore and Narail sadar upazila followed by corresponding double cropped area (DCA). Most of the upazilas were dominated by DCA. The exceptions are Manirampur of Jessore district; Mirpur, Khoksa and Bheramara of Kushtia district; Shailkupa of Jhenaidaha district and Jibannagar of Chuadanga district

where triple cropped area was the dominating ones (Table 1). The area that could not be defined under SCA, DCA, TCA or QCA was considered as others whose coverage is less than 1% of the NCA.

### Cropping patterns of Jessore

In total 176 cropping patterns were observed in Jessore region of which nine cropping patterns with exclusive rice crop covers about 46% of the NCA. There were 47 cropping patterns with exclusive non-rice crop covering over 12% of the NCA. Rest of the NCA i.e. around 42% area is covered by 120 rice - non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Table 2 presents nine cropping patterns where rice is the only crop round the year. It comprises about 46% of the NCA in the region. Among them single rice, double rice and triple rice areas represent over 5%, about 36% and about 3% respectively. It reflects the unparallel dominance of rice in the cropping systems in Jessore region. In case of individual pattern Boro-Fallow-T. Aman has the highest coverage (32.28%) and was recorded in all 34 upazilas. The second dominant pattern single Boro area occupied 5.29% of NCA which was reported in 24 upazilas. Boro-Aus-T. Aman covered 2.76% area with its existence in only 15 upazilas.

In the current investigation, 47 cropping patterns were identified that was free from rice. Among these 47 patterns, first 32 have been arranged in descending order in Table 3. The rest 15 patterns with negligible area coverage (Table 9) are arranged with other patterns of different categories. Aggregate of the 47 patterns have had over 12% of NCA. In critical comparison, it is clear that exclusive rice area is about four folds of exclusive non-rice area. In Jessore region crop diversity is much wider than that of other regions like Sylhet and Chittagong where exclusive rice area covers 37 folds and 23 folds respectively, of exclusive non-rice area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). Appropriate cropping patterns may facilitate maximum possible land utilization as well as efficient use of other scarce resources

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Jessore sadar	43298	460	80	19790	10520	100	160	31110	233
02 Keshabpur	25903	990	6000	8300	4560	0	190	20040	188
03 Manirampur	44499	570	2500	15800	16200	1000	100	36170	242
04 Abhaynagar	24719	590	8100	4010	3200	200	190	16290	168
05 Jhikargachha	30809	320	100	14450	8550	0	150	23570	235
06 Sarsha	33642	180	700	14650	8900	1200	150	25780	241
07 Bagherpara	27096	350	660	10320	7410	80	130	18950	235
08 Chougachha	26919	560	1300	10420	5320	300	160	18060	223
09 Kushtia sadar	31857	1890	230	11640	8760	400	170	23090	232
10 Mirpur	30454	690	1110	5120	16350	200	120	23590	264
11 Kumarkhali	25837	700	710	8850	6660	0	180	17100	231
12 Khoksa	10376	1020	0	2530	4030	0	140	7720	240
13 Daulatpur	48228	1330	750	17590	14400	0	160	34230	236
14 Bheramara	15370	1650	460	2530	4210	100	100	9050	226
15 Magura sadar	40130	590	680	11680	15480	0	160	28590	250
16 Sreepur	17719	720	170	2200	10730	0	200	14020	271
17 Shalikha	22864	120	0	9000	8120	0	130	17370	246
18 Mohammadpur	22930	230	1730	5310	8400	0	160	15830	241
19 Meherpur sadar	26152	1060	40	10300	9910	0	150	21460	241
20 Gangni	33932	620	0	12000	11090	0	110	23820	244
21 Mujibnagar	11354	660	600	4600	2830	0	120	8810	218
22 Narail sadar	37226	600	5000	17410	5090	0	100	28200	198
23 Lohagara	28485	370	1450	13020	7090	0	140	22070	224
24 Kalia	30177	700	0	19900	2930	0	170	23700	209
25 Jhenaidaha sadar	46775	1620	350	15500	9200	0	150	26820	227
26 Shailkupa	37345	1980	3000	8900	15380	700	120	30080	239
27 Kotchandpur	16095	1090	1040	7550	2780	0	130	12590	205
28 Moheshpur	41903	1310	1970	21360	9020	0	150	33810	217
29 Harinakundu	22723	2330	0	8920	3340	0	140	14730	207
30 Kaliganj	31114	1820	430	11360	8060	0	150	21820	227
31 Chuadnga sadar	29855	990	20	15130	4230	0	120	20490	216
32 Alamdanga	36528	1670	2200	20000	5450	350	100	29770	208
33 Jibannagar	19933	100	0	6500	8450	0	150	15200	255
34 Damurhuda	30344	640	0	14250	7980	0	120	22990	232
Jessore region		30520	41380	380890	274630	4630	4870	736920	229

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-T. Aman	237850	32.28	34
02 Boro-Fallow-Fallow	39010	5.29	24
03 Boro-Aus-T. Aman	20350	2.76	15
04 Boro-Aus-Fallow	17000	2.31	16
05 Boro-B.Aman	8250	1.12	6
06 Fallow-B.Aus+B. Aman	500	0.07	1
07 Fallow-Fallow-T. Aman	300	0.04	1
08 Fallow-B.Aman	180	0.02	3
09 Fallow-Aus-Fallow	70	0.01	1
Total	323510	43.90	

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	19170	2.60	25
02 Maize-Jute-Fallow	9900	1.34	7
03 Wheat-Jute-Fallow	7960	1.08	9
04 Lentil-Jute-Fallow	7550	1.02	13
05 Grasspea-Jute-Fallow	6140	0.83	6
06 Vegetab-Vegetab-Fallow	4120	0.56	9
07 Wheat-Chilli-Fallow	3350	0.45	4
08 Lentil-Vegetab-Vegetab	2780	0.38	10
09 Wheat-Jute-Blackgram	2750	0.37	4
10 Onion-Jute-Fallow	2600	0.35	9
11 Onion-Vegetab-Vegetab	2090	0.28	10
12 Mustard-Jute-Vegetab	1900	0.26	5
13 Maize-Vegetab-Fallow	1750	0.24	4
14 Vegetab-Jute-Fallow	1730	0.23	5
15 Chilli-Vegetab-Fallow	1330	0.18	13
16 Vegetab-Fallow-Blackgram	1250	0.17	4
17 Wheat-Vegetab-Vegetab	1240	0.17	6
18 Pea-Jute-Fallow	1170	0.16	6
19 Wheat-Jute-Vegetab	1100	0.15	3
20 Garlic-Jute-Fallow	1040	0.14	5
21 Garlic-Vegetab-Vegetab	850	0.12	8
22 Chilli-Fallow-Fallow	840	0.12	6
23 Maize-Mungbean-Vegetab	800	0.11	1
24 Pea-Vegetab-Fallow	800	0.11	3
25 Vegetab-Jute-Vegetab	800	0.11	1
26 Lentil-Sesame-Fallow	770	0.11	3
27 Maize-Groundnut	620	0.08	1
28 Potato-Sesame-Fallow	540	0.07	2
29 Potato-Jute-Fallow	530	0.07	4
30 Vegetab-Maize-Fallow	510	0.07	2
31 Mustard-Jute-Fallow	450	0.06	2
32 Coriander-Fallow-Fallow	300	0.04	3
33-47 Other 15 patterns (in Table 9)	1410	0.19	-
Total	90140	12.23	

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).

### Non-rice cereal crops

Forty cropping patterns are holding different non-rice cereal crops (Table 4). Among them wheat, with the largest area, is leading 17 patterns cultivated on 59,920 hectares that is equivalent to 8.11% of NCA. Maize holds

the second position in non-rice cereal crop cultivation in Jessore region. There are 24 cropping patterns for maize, which in-together occupy 7.27% of NCA. In the documentation of non-rice cereal cropping systems wheat reported widest spreading e.g. Wheat-Jute-T. Aman is distributed over 29 upazilas out of 34. Overall, the aggregate area of the non-rice cereal cropping system stands for 15.41% of the NCA in Jessore region. In Bangladesh there is a vast market of maize seeds for feed industries. Loam and sandy-loam soil of the comparative dry area is very suitable for maize

**Table 4. Cropping patterns based on maize and wheat in Jessore region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Jute-T. Aman	30300	4.11	29
02 Maize-Aus-Fallow	10850	1.47	6
03 Maize-Jute-Fallow	9900	1.34	7
04 Maize-Fallow-T. Aman	9000	1.22	7
05 Wheat-Jute-Fallow	7960	1.08	9
06 Maize-Jute-T. Aman	5580	0.76	9
07 Maize-Mungbean-T. Aman	4900	0.66	3
08 Wheat-Sesame-T. Aman	3750	0.51	9
09 Wheat-Chilli-Fallow	3350	0.45	4
10 Maize-Aus-Vegetab	3000	0.41	4
11 Wheat-Fallow-T. Aman	2910	0.39	8
12 Wheat-Jute-Blackgram	2750	0.37	4
13 Wheat-Aus-T. Aman	2130	0.29	8
14 Wheat-Aus-Fallow	1910	0.26	5
15 Maize-Vegetab-Fallow	1750	0.24	4
16 Maize-Sesame-T. Aman	1530	0.21	7
17 Maize-Vegetab-T. Aman	1260	0.17	3
18 Wheat-Vegetab-Vegetab	1240	0.17	6
19 Wheat-Jute-Vegetab	1100	0.15	3
20 Mustard-Maize-T. Aman	900	0.12	2
21 Vegetab-Maize-T. Aman	880	0.12	1
22 Wheat-Mungbean-T. Aman	810	0.11	6
23 Maize-Mungbean-Vegetab	800	0.11	1
24 Wheat-Vegetab-T. Aman	670	0.09	4
25 Maize-Groundnut	620	0.08	1
26 Wheat-Aus-Cotton	600	0.08	1
27 Maize-Aus-T. Aman	580	0.08	3
28 Potato-Maize-T. Aman	550	0.07	2
29 Vegetab-Maize-Fallow	510	0.07	2
30 Wheat-Aus-Blackgram	300	0.04	2
31 Maize-Sesame-Fallow	280	0.04	2
32 Mustard-Maize-Jute	200	0.03	1
33 Tobacco-Maize-T. Aman	190	0.03	2
34-40 Other seven patterns (in Table 9)	480	0.07	
Total area for wheat and maize	113540	15.41	

cultivation. Wheat cultivation with its better yield in this region is specially favoured by long winter season that is normally unavailable in southern parts of the country. Light textured soil with low water-holding capacity as well as less availability of irrigation water are driving forces that discourage the farmers for modern Boro cultivation. During the harvesting period of wheat the crop is privileged by clear sunshine and low humidity. All these are the factors this area is dominated by wheat-based cropping systems (FAO, 1988).

### Fibre crops

Jute is the main fibre crop in Bangladesh. Once it is called Golden Fibre. Socially and economically jute is an important crop in the Jessore region. There are 41 cropping patterns were identified based on jute (Table 5). It is observed that the jute based cropping patterns covered 23.90% of NCA of the Jessore region. Among them Wheat-Jute-T. Aman cropping pattern absolutely occupies 4.11% of the NCA which is distributed over 29 upazilas out of 34 covering 30,300 hectares of land area. The

second prevailing Lentil-Jute-T. Aman covers 29,650 hectare area which is 4.02% of the NCA. Tobacco-Jute-T. Aman stands in third position in terms of area coverage, however, it is narrowly distributed in only eight upazilas out of 34. Well-drained light-textured soil makes the friendly situation for early growth stages of jute. High temperature, high humidity, satisfactory rainfall are the pre-requisites for cultivation of the crop. Plenty of flood water is timely available in the region for jute retting. Clear sun-shine during the harvesting period is

an extra facility for post-harvest management of fibre and stick. Now-a-days jute-stick also has a good market value with export potential. All these make a favourable package which encourages the farmers for extensive jute cultivation in the region (FAO, 1988).

### Tobacco in cropping systems

Tobacco is the exceptional crop which is cultivated in Jessore region mainly in Kushtia district. Product of tobacco is harmful to the human. Table 6 presents nine cropping

**Table 5. Jute-based cropping patterns in Jessore region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Jute-T. Aman	30300	4.11	29
02 Lentil-Jute-T. Aman	29650	4.02	23
03 Tobacco-Jute-T. Aman	12180	1.65	8
04 Onion-Jute-T. Aman	10740	1.46	21
05 Mustard-Jute-T. Aman	10710	1.45	15
06 Maize-Jute-Fallow	9900	1.34	7
07 Wheat-Jute-Fallow	7960	1.08	9
08 Lentil-Jute-Fallow	7550	1.02	13
09 Boro-Jute-T. Aman	6320	0.86	11
10 Boro-Jute-Fallow	6250	0.85	7
11 Grasspea-Jute-Fallow	6140	0.83	6
12 Maize-Jute-T. Aman	5580	0.76	9
13 Tobacco-Jute-Fallow	3950	0.54	6
14 Garlic-Jute-T. Aman	3100	0.42	14
15 Wheat-Jute-Blackgram	2750	0.37	4
16 Onion-Jute-Fallow	2600	0.35	9
17 Mustard-Boro-Jute-T. Aman	2500	0.34	5
18 Grasspea-Jute-T. Aman	2150	0.29	10
19 Mustard-Jute-Vegetab	1900	0.26	5
20 Vegetab-Jute-Fallow	1730	0.23	5
21 Vegetab-Jute-T. Aman	1310	0.18	4
22 Mustard-Boro-Jute	1200	0.16	1
23 Pea-Jute-Fallow	1170	0.16	6
24 Potato-Jute-T. Aman	1150	0.16	9
25 Wheat-Jute-Vegetab	1100	0.15	3
26 Garlic-Jute-Fallow	1040	0.14	5
27 Coriander-Jute-T. Aman	1010	0.14	8
28 Vegetab-Jute-Vegetab	800	0.11	1
29 Chilli-Jute-T. Aman	740	0.10	6
30 Potato-Jute-Fallow	530	0.07	4
31 Mustard-Jute-Fallow	450	0.06	2
32 Blackgram-Jute-T. Aman	300	0.04	1
33 Potato-Boro-Jute	250	0.03	1
34 Coriander-Jute-Fallow	200	0.03	2
35 Mustard-Maize-Jute	200	0.03	1
36 Potato-Boro-Jute-T. Aman	200	0.03	1
37-41 Other five patterns (in table 9)	520	0.07	-
Total area for jute	176130	23.90	

patterns that comprises 3.20% of the NCA in the region mainly of triple cropped areas. The pattern Tobacco–Jute–T. Aman has the highest coverage (1.65% of the NCA) and was recorded in eight upazilas out of 34 followed by Tobacco–Jute–Fallow. In consideration of human health and social impact the tobacco crop is discouraged on principle. However, people of the concerned area can not give up tobacco cultivation. Farmers consider the crop as an insurance of his property. Industry personnel make assurance to purchase their products with high price. Moreover, they pay advance money as production cost. They supply all inputs and technologies for successful production of tobacco. These are privileges of farmers for tobacco cultivation.

### Pulse crops under the cropping systems

Forty-four cropping patterns are holding different pulse crops (Table 7). Among them lentil is covering the largest area whereas chickpea in the smallest area. Twelve cropping patterns of lentil in-together cover 8.52% of NCA. Grasspea holds the second position in pulse crop cultivation in Jessore region. There are 11 cropping patterns for grasspea covering 2.11% NCA in the region. Top three patterns viz Grasspea–Jute–Fallow, Grasspea–B.Aman and Grasspea–Jute–T. Aman in-together occupy over 0.92% of NCA. Finally the aggregate area of the pulse cropping system stands for 12.02% of the NCA in Jessore region. In some specific area of Jessore region Boro cultivation faces some constraints such as scarcity of irrigation water, very light soil with low-water holding capacity. Moreover, high market price of pulse crops is driving force for ample cultivation of pulse crops. Among the Rabi crops stress-

tolerant grasspea can easily be grown as relay system (FAO, 1988).

### Oil-seed crops

Thirty-two cropping patterns have been arranged in descending order according to area coverage in Table 8. Mustard is the most important one among the oil-seed crops in Jessore region. There are 17 cropping patterns had been led by mustard alone which in-together covers 55,700 ha (7.56% of NCA). The pattern Mustard–Boro–T. Aman has the highest coverage (3.07% of the NCA) and was recorded in 21 upazilas out of 34 followed by Mustard–Jute–T. Aman (1.45% of NCA).

### Sporadic and distinct cropping patterns

There are some cropping patterns, which are extremely location-specific, however, with a large area coverage. These are Mustard–Boro–Jute (Table 8), Tobacco–Sesbania–T. Aman (Table 6) and Onion–Fallow–T. Aman (Appendix 1). The Mustard–Boro–Jute is grown on 1,200 ha only in Sarsha of Jessore district. Tobacco–Sesbania–T. Aman is cultivated on 1,600 ha only in Mirpur upazila of Kushtia district. Onion–Fallow–T. Aman is limited to two upazilas viz Bheramara (250 ha) and Kumarkhali (1,500 ha).

### Rare cropping patterns

In the present investigation, 40 cropping patterns have been identified as rare cropping patterns with a negligible area coverage with seldom existence (Table 9). These are location specific system and are limited in one or two or in some cases three upazilas of the region. Total area coverage of the 40 patterns is far below

**Table 6. Tobacco based cropping patterns in Jessore region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
1 Tobacco–Jute–T. Aman	12180	1.65	8
2 Tobacco–Jute–Fallow	3950	0.54	6
3 Tobacco–Aus–T. Aman	2950	0.40	3
4 Tobacco–Fallow–T. Aman	1670	0.23	6
5 Tobacco–Sesbania–T. Aman	1620	0.22	2
6 Tobacco–Aus–Fallow	930	0.13	3
7-9 Other three patterns (in table 9)	280	0.04	
Total tobacco	23580	3.20	

**Table 7. Cropping patterns with pulse crops in Jessore region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Lentil-Jute-T. Aman	29650	4.02	23
02 Lentil-Jute-Fallow	7550	1.02	13
03 Lentil-Sesame-T. Aman	6630	0.90	17
04 Grasspea-Jute-Fallow	6140	0.83	6
05 Lentil-Mungbean-T. Aman	5080	0.69	14
06 Lentil-Aus-T. Aman	4800	0.65	5
07 Grasspea-B.Aman	4450	0.60	5
08 Lentil-Aus-Fallow	2950	0.40	4
09 Lentil-Vegetab-Vegetab	2780	0.38	10
10 Wheat-Jute-Blackgram	2750	0.37	4
11 Lentil-Vegetab-T. Aman	2250	0.31	4
12 Grasspea-Jute-T. Aman	2150	0.29	10
13 Vegetab-Fallow-Blackgram	1250	0.17	4
14 Pea-Jute-Fallow	1170	0.16	6
15 Grasspea-Fallow-T. Aman	1100	0.15	9
16 Grasspea-Aus-T. Aman	900	0.12	5
17 Pea-Aus-Vegetab	900	0.12	4
18 Pea-Vegetab-Fallow	800	0.11	3
19 Lentil-Sesame-Fallow	770	0.10	3
20 Pea-Fallow-T. Aman	740	0.10	6
21 Boro-Fallow-Blackgram	530	0.07	3
22 Blackgram-Jute-T. Aman	300	0.04	1
23 Wheat-Aus-Blackgram	300	0.04	2
24 Pea-B.Aman	280	0.04	3
25 Lentil-Fallow-T. Aman	240	0.03	3
26 Grasspea-B.Aus+B.Aman	200	0.03	1
27 Grasspea-Sesame-Fallow	200	0.03	2
28 Onion-Aus-Blackgram	200	0.03	1
29-44 Other 16 patterns (in table 9)	1500	0.20	
Total area for pulse crops	88560	12.02	

1% of NCA. Among these the highest area was allotted for Groundnut-Fallow-Fallow (190 ha) and it is recorded in Kumarkhali of Kushtia, Mohammadpur upazila of Magura district and of Meherpur sadar upazila. The smallest area was recorded for four cropping patterns whose coverage was 20 hectares for each (Table 9).

### Most dominant cropping pattern

Boro-Fallow-T. Aman was the most dominant cropping pattern in Jessore region. It covers 32.28% of NCA in the region and is available in all 34 upazilas (Table 10). The highest area under this cropping pattern was recorded 17,000 ha in Jessore sadar upazila which represents 7.15% of the total Boro-Fallow-T. Aman area of the region. In consideration of individual upazila

Jhenaidaha sadar upazila stand on the 2<sup>nd</sup> position for area coverage, however, this upazila has allocated biggest share i.e. 58% of its NCA for this pattern alone. Bheramera upazila had a negligible area coverage for this pattern. In the country-wide data compilation it was observed that Boro-F-T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### Second dominant cropping pattern

Single Boro cropping pattern holds the second largest area coverage 39,010 ha in Jessore region. This area is an equivalent to 5.29% of NCA in the region. This pattern Boro-Fallow-

**Table 8. Cropping patterns with oil-seed crops in Jessore region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-T. Aman	22600	3.07	21
02 Mustard-Jute-T. Aman	10710	1.45	15
03 Lentil-Sesame-T. Aman	6630	0.90	17
04 Mustard-Boro-Aus	5050	0.69	4
05 Wheat-Sesame-T. Aman	3750	0.51	9
06 Mustard-Boro-Jute-T. Aman	2500	0.34	5
07 Mustard-Mungbean-T. Aman	2370	0.32	10
08 Mustard-Aus-T. Aman	2220	0.30	6
09 Mustard-Sesame-T. Aman	2060	0.28	6
10 Mustard-Jute-Vegetab	1900	0.26	5
11 Mustard-Boro-Aus-T. Aman	1650	0.22	6
12 Maize-Sesame-T. Aman	1530	0.21	7
13 Mustard-Boro-Fallow	1290	0.18	4
14 Mustard-Boro-Jute	1200	0.16	1
15 Mustard-Maize-T. Aman	900	0.12	2
16 Lentil-Sesame-Fallow	770	0.10	3
17 Onion-Sesame-T. Aman	650	0.09	2
18 Maize-Groundnut	620	0.08	1
19 Potato-Sesame-T. Aman	620	0.08	5
20 Potato-Sesame-Fallow	540	0.07	2
21 Groundnut- Aus-T. Aman	500	0.07	1
22 Mustard-Jute-Fallow	450	0.06	2
23 Mustard-Fallow-T. Aman	300	0.04	1
24 Maize-Sesame-Fallow	280	0.04	2
25 Mustard-Aus-Fallow	200	0.03	3
26 Grasspea-Sesame-Fallow	200	0.03	2
27 Mustard-Maize-Jute	200	0.03	1
28-32 Other five patterns (in table 9)	430	0.06	
Total area for oil-seed crops	72120	9.79	

Fallow is distributed over only 24 upazilas (Table 11). Abhaynagar has an area of 7,800 ha for single Boro which stands for 19.99% of the total area under this pattern in the region. Jessore sadar had a negligible area coverage for this pattern. This pattern is frequent and concurrently experienced by early flash flood in April and cold injury at 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). In the country-wide data compilation it was observed that the single Boro was the 2<sup>nd</sup> 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

The third dominant cropping pattern in Jessore region is Wheat-Jute-T. Aman. It belongs to 4.11% of NCA of the region and spread out over 29 upazilas (Table 12). Shailkupa upazila of Jhenaidaha district hold the highest area (3,500 ha) which represents 11.55% of the total Wheat-Jute-T. Aman area of the region. Sreepur stands in the third position, however, this upazila of Magura district has allocated the biggest share i.e. 21% surface of its NCA. In the country-wide compilation of data it was observed that Wheat-Jute-T. Aman was the 9<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.47 lac ha (1.72% of NCA in the country) with its distribution in 216 upazilas of 43 districts (Nasim *et al.*, 2017).

**Table 9. Rare cropping patterns covering non-significant area in Jessore region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Groundnut-Fallow-Fallow	190	0.03	3	Kumarkhali+Md.pur+Meherpur
02	Tobacco-Maize-T. Aman	190	0.03	2	Daulatpur+Mirpur
03	Fallow-B.Aman	180	0.02	3	Kotchandpur+Kushtia+Magura
04	Chilli-Jute-Fallow	180	0.02	2	Lohagara+Kalia
05	Potato-Aus-Fallow	180	0.02	2	Harinakundu+Jessore
06	Grasspea-Mungbean-T. Aman	170	0.02	1	Narail sadar
07	Garlic-Aus-Fallow	160	0.02	3	Chougachha+Khoksa+Kumarkhali
08	Potato-Boro-T. Aman	150	0.02	3	Jessore+Kaliganj+Moheshpur
09	Grasspea-Fallow-Fallow	150	0.02	1	Magura sadar
10	Vegetab-Fallow-Fallow	150	0.02	1	Kotchandpur
11	Potato-Boro-Fallow	140	0.02	2	Chougachha+Kaliganj
12	Fallow-Fallow-Blackgram	130	0.02	1	Bheramara
13	Chickpea-Fallow-T. Aman	110	0.01	3	Bagherpara+Jessore+Kushtia
14	Coriander-Vegetab-Fallow	110	0.01	3	Khoksa+Kumarkhali+Shalikka
15	Chickpea-Jute-T. Aman	100	0.01	3	Jessore+Magura+Sreepur
16	Coriander-Fallow-T. Aman	100	0.01	3	Jhikargachha+Kushtia+Mirpur
17	Lentil-Mungbean-Jute-T. Aman	100	0.01	1	Manirampur
18	Maize-Fallow-Blackgram	100	0.01	1	Chuadanga sadar
19	Mungbean-Fallow-T. Aman	100	0.01	1	Jessore sadar
20	Mungbean-Jute-Fallow	100	0.01	1	Daulatpur
21	Mustard-M.bean-Aus-T. Aman	100	0.01	1	Manirampur
22	Sesame-Fallow-T. Aman	100	0.01	2	Magura sadar+Kaliganj
23	Wheat-Mungbean-Fallow	100	0.01	1	Jhikargachha
24	Potato-Aus-T. Aman	80	0.01	1	Jessore sadar
25	Potato+S.gourd-M.bean-T. Aman	80	0.01	1	Bagherpara
26	Fallow-Aus-Fallow	70	0.01	1	Mohammadpur
27	Grasspea-Boro-Fallow	70	0.01	1	Kumarkhali
28	S.Potato-Fallow-Fallow	60	0.01	3	Moheshpur+Kumarkhali+Magura
29	Garlic-Aus-T. Aman	60	0.01	1	Moheshpur
30	Grasspea-Sesame-T. Aman	50	0.01	1	Kumarkhali
31	Lentil-B.Aman	50	0.01	1	Kumarkhali
32	Tobacco-Mungbean-T. Aman	50	0.01	1	Mirpur
33	Garlic-Fallow-T. Aman	40	0.01	1	Bheramara
34	S.Potato-Jute-Fallow	40	0.01	1	Daulatpur
35	Tobacco-Mungbean-Vegetab	40	0.01	1	Bheramara
36	Maize-Maize-T. Aman	30	0.00	1	Jessore sadar
37	Onion-Maize-Fallow	20	0.00	1	Kumarkhali
38	Potato-Sesame-Aus	20	0.00	1	Jessore sadar
39	Wheat-Maize-Fallow	20	0.00	1	Kumarkhali
40	Wheat-Sesame-Fallow	20	0.00	1	Chuadanga sadar
	Total	3890	0.53	-	

**Table 10. Distribution of the most dominant Boro–Fallow–T. Aman cropping patterns in Jessore region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Jessore sadar	17000	55.46	7.15
02 Jhenaidaha sadar	14500	57.54	6.10
03 Manirampur	13500	37.92	5.68
04 Sarsha	13000	50.78	5.47
05 Kalia	12900	56.09	5.42
06 Moheshpur	10700	32.92	4.50
07 Kaliganj	10300	51.50	4.33
08 Bagherpara	9800	52.69	4.12
09 Jhikargachha	9800	42.15	4.12
10 Magura sadar	9500	33.93	3.99
11 Narail sadar	9200	33.33	3.87
12 Damurhuda	8900	39.82	3.74
13 Shailkupa	8900	31.67	3.74
14 Chougachha	8300	47.43	3.49
15 Kushtia sadar	8100	38.21	3.41
16 Alamdanga	8000	39.80	3.36
17 Shalikka	7800	45.22	3.28
18 Harinakundu	6500	52.42	2.73
19 Jibannagar	6500	43.05	2.73
20 Keshabpur	5600	29.40	2.35
21 Chuadanga sadar	5400	27.69	2.27
22 Meherpur sadar	4500	22.06	1.89
23 Kotchandpur	4000	34.78	1.68
24 Abhaynagar	3700	23.57	1.56
25 Mirpur	3500	15.28	1.47
26 Gangni	3500	15.09	1.47
27 Kumarkhali	3300	20.12	1.39
28 Lohagara	2850	13.13	1.20
29 Mohammadpur	2200	14.10	0.92
30 Mujibnagar	1800	22.09	0.76
31 Daulatpur	1600	4.86	0.67
32 Sreepur	1300	9.77	0.55
33 Khoksa	1200	17.91	0.50
34 Bheramara	200	2.70	0.08
Jessore region	237850	32.28	100.00

**Fourth dominant cropping pattern**

Fourth dominant cropping pattern Lentil–Jute–T. Aman has occupied 29,650 hectares representing 4.02% share of NCA in Jessore region (Table 13). This pattern is distributed over 23 upazilas where Magura sadar ranked in top position. This upazila has 4,400 ha area Lentil–Jute–T. Aman which is only 15.71% of upazila NCA. Mohammadpur upazila ranks in second position with 2,700 ha area for this pattern, however, this upazila has allotted the biggest share (17.31%) of its NCA.

**Fifth dominant cropping pattern**

Fifth dominant cropping pattern Mustard–Boro–T. Aman had been covering 22,600 hectares representing 3.07% share of NCA in Jessore region (Table 14). This pattern is distributed over 21 upazilas where Magura sadar ranked in top position. This upazila had 3,500 ha area for Mustard–Boro–T. Aman pattern which is only 12.50% of upazila NCA and 15.49 % of total Mustard–Boro–T. Aman area in the region.

**Crop diversity and cropping intensity**

Higher number of available crops under cultivation in an area dictates its higher

**Table 11. Distribution of the 2<sup>nd</sup> dominant Boro–Fallow–Fallow cropping pattern in Jessore region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Abhaynagar	7800	49.68	19.99
02 Keshabpur	6000	31.50	15.38
03 Narail sadar	5000	18.12	12.82
04 Shailkupa	3000	10.68	7.69
05 Manirampur	2500	7.02	6.41
06 Alamdanga	2200	10.90	5.64
07 Moheshpur	1960	6.03	5.02
08 Mohammadpur	1500	9.62	3.85
09 Chougachha	1300	7.43	3.33
10 Lohagara	1200	5.53	3.08
11 Mirpur	1100	4.80	2.82
12 Kotchandpur	850	7.39	2.18
13 Sarsha	700	2.73	1.79
14 Bagherpara	650	3.49	1.67
15 Mujibnagar	600	7.36	1.54
16 Kumarkhali	600	3.66	1.54
17 Kaliganj	400	2.00	1.29
18 Jhenaidaha sadar	350	1.39	1.13
19 Magura sadar	300	1.07	0.97
20 Bheramara	300	4.05	0.97
21 Daulatpur	250	0.76	0.81
22 Kushtia sadar	200	0.94	0.65
23 Sreepur	170	1.28	0.55
24 Jessore sadar	80	0.26	0.26
Jessore region	39010	5.29	100.00

diversity. Number of cropping patterns is also a gross indicator of crop diversity. A total of 176 cropping patterns were identified in the whole area of Jessore region under this investigation. The highest number of cropping patterns was identified 58 in Kushtia sadar, Mirpur and Kumarkhali upazilas; and that was 57 in Jessore sadar; and 46 in Daulatpur (Table 15). The lowest number of cropping patterns was identified 11 in Damurhuda followed by 12 in Jibannagar of Chuadanga district. The higher number of cropping patterns is generally related to higher level of diversity indices for cropping pattern. The lowest diversity index for cropping pattern was recorded 0.649 in Jhenaidaha sadar followed by 0.661 in Narail sadar. Lower diversity index for crops and cropping patterns is associated with water stagnation. In a study Shahidullah *et al.* (2006) found the lowest values for all the diversity and intensity parameters in salt affected area

of greater Noakhali. The highest value of diversity index for cropping pattern was found 0.954 in Daulatpur upazila that was followed by 0.938 in Bheramara upazila. The lowest CDI was reported 0.852 in Narail sadar followed by 0.863 in Jessore sadar. The highest value of CDI was observed 0.981 in Daulatpur followed by 0.978 in Bheramara upazila. The range of cropping intensity values was recorded 168-271%. The maximum value was for Sreepur of Magura district and minimum for Abhaynagar of Jessore district. As a whole the CDI of Jessore region was calculated 0.955 and the average cropping intensity at regional level was 229%. 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

**Table 12. Distribution of the 3<sup>rd</sup> dominant Wheat-Jute-T. Aman cropping pattern in Jessore region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Shailkupa	3500	12.46	11.55
02 Meherpur sadar	3000	14.71	9.90
03 Sreepur	2800	21.05	9.24
04 Alamdanga	2700	13.40	8.91
05 Mohammadpur	1900	12.18	6.27
06 Daulatpur	1700	5.17	5.61
07 Gangni	1600	6.90	5.28
08 Kalia	1500	6.52	4.95
09 Khoksa	1300	19.40	4.29
10 Bheramara	1200	16.22	3.96
11 Lohagara	1150	5.30	3.80
12 Magura sadar	1100	3.93	3.63
13 Mirpur	860	3.76	2.84
14 Harinakundu	650	5.24	2.15
15 Mujibnagar	600	7.36	1.98
16 Kushtia sadar	580	2.74	1.91
17 Kumarkhali	500	3.05	1.65
18 Damurhuda	500	2.24	1.65
19 Sarsha	500	1.95	1.65
20 Manirampur	500	1.40	1.65
21 Jibannagar	400	2.65	1.32
22 Jhenaidaha sadar	350	1.39	1.16
23 Shalikha	350	2.03	1.16
24 Keshabpur	320	1.68	1.06
25 Bagherpara	200	1.08	0.66
26 Moheshpur	200	0.62	0.66
27 Chougachha	140	0.80	0.46
28 Jhikargachha	100	0.43	0.33
29 Kotchandpur	100	0.87	0.33
Jessore region	30300	4.11	100.00

in other (Blade and Slinkard, 2002). The farmers of Kerala diversified their cropping pattern to minimize risk from due to crop failures and price fluctuations (Mahesh, 1999).

## COCLUSION

The cropping intensity of the Jessore region was higher than the national average. Boro-Fallow-T. Aman, Single Boro, Wheat-Jute-T. Aman, Lentil-Jute-T. Aman and Mustard-Boro-T. Aman were the dominant cropping patterns in the region. Exclusive rice area is

about four folds of exclusive non-rice area. In Jessore region crop diversity is much wider than that of other regions. 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. The high yielding varieties of rice along with recommended crop management packages to be adopted.
- Effort might be invested so that a portion of double-rice area could be brought under Potato-Boro-T. Aman and/or other alternative three cropping systems.

**Table 13. Distribution of the 4<sup>th</sup> dominant Lentil–Jute–T. Aman cropping pattern in Jessore region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Magura sadar	4400	15.71	14.84
02 Mohammadpur	2700	17.31	9.11
03 Shalikha	2400	13.91	8.09
04 Sreepur	2300	17.29	7.76
05 Lohagara	2200	10.14	7.42
06 Manirampur	2200	6.18	7.42
07 Bagherpara	1980	10.65	6.68
08 Kaliganj	1600	8.00	5.40
09 Jhenaidaha sadar	1600	6.35	5.40
10 Jhikargachha	1300	5.59	4.38
11 Gangni	1200	5.17	4.05
12 Kumarkhali	1000	6.10	3.37
13 Sarsha	800	3.13	2.70
14 Mirpur	750	3.28	2.53
15 Khoksa	700	10.45	2.36
16 Bheramara	600	8.11	2.02
17 Chougachha	600	3.43	2.02
18 Keshabpur	550	2.89	1.85
19 Narail sadar	350	1.27	<b>1.18</b>
20 Jessore sadar	200	0.65	<b>0.67</b>
21 Alamdanga	100	0.36	<b>0.34</b>
22 Mujibnagar	80	0.98	<b>0.27</b>
23 Chuadanga sadar	40	0.21	<b>0.13</b>
Jessore region	29650	4.02	100.00

**Table 14. Distribution of the 5<sup>th</sup> dominant Mustard-Boro–T. Aman cropping pattern in Jessore region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Magura sadar	3500	12.50	15.49
02 Jhenaidaha sadar	2400	9.52	10.62
03 Jessore sadar	2200	7.18	9.73
04 Moheshpur	2150	6.62	9.51
05 Bagherpara	1700	9.14	7.52
06 Shalikha	1600	9.28	7.08
07 Chougachha	1300	7.43	5.75
08 Kaliganj	1000	5.00	4.42
09 Meherpur sadar	1000	4.90	4.42
10 Gangni	1000	4.31	4.42
11 Narail sadar	950	3.44	4.20
12 Shailkupa	600	2.14	2.65
13 Kotchandpur	500	4.35	2.21
14 Kushtia sadar	450	2.12	1.77
15 Alamdanga	400	1.42	1.77
16 Abhaynagar	400	2.55	1.77
17 Jhikargachha	400	1.72	1.77
18 Harinakundu	400	3.23	1.77
19 Mujibnagar	400	4.91	1.77
20 Khoksa	200	2.99	0.88
21 Kumarkhali	50	0.30	0.22
Jessore region	22600	3.07	100.00

**Table 15. Crop diversity and cropping intensity in Jessore region, 2014-15.**

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Jessore sadar	57	16	0.679	0.863	233
02 Keshabpur	22	18	0.800	0.921	188
03 Manirampur	24	14	0.792	0.923	242
04 Abhaynagar	20	16	0.685	0.871	168
05 Jhikargachha	30	20	0.797	0.925	235
06 Sarsha	19	18	0.723	0.903	241
07 Bagherpara	27	22	0.695	0.889	235
08 Chougachha	22	18	0.747	0.903	223
09 Kushtia sadar	58	18	0.818	0.946	232
10 Mirpur	58	24	0.900	0.963	264
11 Kumarkhali	58	23	0.928	0.973	231
12 Khoksa	20	20	0.887	0.970	240
13 Daulatpur	46	23	0.954	0.981	236
14 Bheramara	29	19	0.938	0.978	226
15 Magura sadar	33	23	0.830	0.939	250
16 Sreepur	17	16	0.858	0.948	271
17 Shalikka	22	16	0.749	0.911	246
18 Mohammadpur	30	18	0.906	0.960	241
19 Meherpur sadar	23	17	0.892	0.961	241
20 Gangni	25	14	0.925	0.972	244
21 Mujibnagar	19	13	0.902	0.962	218
22 Narail sadar	15	14	0.661	0.852	198
23 Lohagara	19	16	0.906	0.959	224
24 Kalia	22	13	0.830	0.924	209
25 Jhenaidaha sadar	19	17	0.649	0.876	227
26 Shailkupa	14	16	0.842	0.947	239
27 Kotchandpur	22	12	0.794	0.917	205
28 Moheshpur	33	22	0.857	0.942	217
29 Harinakundu	25	17	0.710	0.903	207
30 Kaliganj	26	18	0.712	0.902	227
31 Chuadnga sadar	22	19	0.849	0.938	216
32 Alamdanga	24	18	0.855	0.939	208
33 Jibannagar	12	14	0.767	0.922	255
34 Damurhuda	11	13	0.775	0.914	232
Jessore region	176	35	0.884	0.955	229

- In the single Boro area suitable vegetables 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.

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- Blade, S F and A E Slinkard 2002. New Crop Development: The Canadian Experience. *In: Trends in New Crops*

and New Uses. J Janick and A Whipkey (Editors). ASHS Press, Alexandria.

FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.

Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.

Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.

Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapuram.

Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood

affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.

Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 273-288.

Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.

Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.

Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.

Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-122.

Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
001 Boro-Fallow-T. Aman	237850	069 Wheat-Vegetab-Vegetab	1240
002 Boro-Fallow-Fallow	39010	070 Mustard-Boro-Jute	1200
003 Wheat-Jute-T. Aman	30300	071 Pea-Jute-Fallow	1170
004 Lentil-Jute-T. Aman	29650	072 Potato-Jute-T. Aman	1150
005 Mustard-Boro-T. Aman	22600	073 Potato-Vegetab-T. Aman	1120
006 Boro-Aus-T. Aman	20350	074 Grasspea-Fallow-T. Aman	1100
007 Vegetab-Vegetab-Vegetab	19170	075 Wheat-Jute-Vegetab	1100
008 Boro-Aus-Fallow	17000	076 Onion-Aus-T. Aman	1060
009 Tobacco-Jute-T. Aman	12180	077 Garlic-Jute-Fallow	1040
010 Maize-Aus-Fallow	10850	078 Coriander-Jute-T. Aman	1010
011 Onion-Jute-T. Aman	10740	079 Onion-Aus-Fallow	1000
012 Mustard-Jute-T. Aman	10710	080 Potato-Mungbean-T. Aman	930
013 Maize-Jute-Fallow	9900	081 Tobacco-Aus-Fallow	930
014 Maize-Fallow-T. Aman	9000	082 Grasspea-Aus-T. Aman	900
015 Boro-B.Aman	8250	083 Mustard-Maize-T. Aman	900
016 Wheat-Jute-Fallow	7960	084 Pea-Aus-Vegetab	900
017 Lentil-Jute-Fallow	7550	085 Vegetab-Maize-T. Aman	880
018 Boro-Sesbania-T. Aman	6850	086 Garlic-Vegetab-Vegetab	850
019 Lentil-Sesame-T. Aman	6630	087 Chillli-Fallow-Fallow	840
020 Boro-Jute-T. Aman	6320	088 Wheat-Mungbean-T. Aman	810
021 Boro-Jute-Fallow	6250	089 Maize-Mungbean-Vegetab	800
022 Grasspea-Jute-Fallow	6140	090 Pea-Vegetab-Fallow	800
023 Maize-Jute-T. Aman	5580	091 Vegetab-Jute-Vegetab	800
024 Lentil-Mungbean-T. Aman	5080	092 Lentil-Sesame-Fallow	770
025 Mustard-Boro-Aus	5050	093 Chillli-Jute-T. Aman	740
026 Maize-Mungbean-T. Aman	4900	094 Pea-Fallow-T. Aman	740

**Appendix 1. Continued.**

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
027 Lentil-Aus-T. Aman	4800	095 Wheat-Vegetab-T. Aman	670
028 Grasspea-B.Aman	4450	096 Onion-Sesame-T. Aman	650
029 Vegetab-Vegetab-T. Aman	4360	097 Cotton-Aus-Fallow	630
030 Vegetab-Vegetab-Fallow	4120	098 Maize-Groundnut	620
031 Tobacco-Jute-Fallow	3950	099 Potato-Sesame-T. Aman	620
032 Wheat-Sesame-T. Aman	3750	100 Vegetab-Boro-T. Aman	600
033 Wheat-Chilli-Fallow	3350	101 Wheat-Aus-Cotton	600
034 Garlic-Jute-T. Aman	3100	102 Maize-Aus-T. Aman	580
035 Maize-Aus-Vegetab	3000	103 Chilli-Fallow-T. Aman	570
036 Lentil-Aus-Fallow	2950	104 Potato-Maize-T. Aman	550
037 Tobacco-Aus-T. Aman	2950	105 Potato-Sesame-Fallow	540
038 Wheat-Fallow-T. Aman	2910	106 Boro-Fallow-Blackgram	530
039 Boro-Vegetab(Float/Norm)	2850	107 Potato-Jute-Fallow	530
040 Lentil-Vegetab-Vegetab	2780	108 Vegetab-Maize-Fallow	510
041 Wheat-Jute-Blackgram	2750	109 Fallow-B.Aus+B.Aman	500
042 Onion-Jute-Fallow	2600	110 Groundnut- Aus-T. Aman	500
043 Mustard-Boro-Jute-T. Aman	2500	111 Potato-S.gourd-Aus	500
044 Mustard-Mungbean-T. Aman	2370	112 Vegetab-Fallow-T. Aman	500
045 Lentil-Vegetab-T. Aman	2250	113 Mustard-Jute-Fallow	450
046 Mustard-Aus-T. Aman	2220	114 Boro-Chilli-Fallow	350
047 Grasspea-Jute-T. Aman	2150	115 Coriander-Fallow-Fallow	300
048 Wheat-Aus-T. Aman	2130	116 Blackgram-Jute-T. Aman	300
049 Onion-Vegetab-Vegetab	2090	117 03.Fallow-Fallow-T. Aman	300
050 Mustard-Sesame-T. Aman	2060	118 Mungbean-Aus-T. Aman	300
051 Wheat-Aus-Fallow	1910	119 Mustard-Fallow-T. Aman	300
052 Mustard-Jute-Vegetab	1900	120 Potato-Boro-Vegetab	300
053 Maize-Vegetab-Fallow	1750	121 Wheat-Aus-Blackgram	300
054 Onion-Fallow-T. Aman	1750	122 Pea-B.Aman	280
055 Vegetab-Jute-Fallow	1730	123 Maize-Sesame-Fallow	280
056 Tobacco-Fallow-T. Aman	1670	124 Chilli-Aus-T. Aman	270
057 Mustard-Boro-Aus-T. Aman	1650	125 Potato-Boro-Jute	250
058 Boro-Vegetab-T. Aman	1620	126 Lentil-Fallow-T. Aman	240
059 Tobacco-Sesbania-T. Aman	1620	127 Garlic-B.Aman	210
060 Vegetab-Aus-Fallow	1600	128 Mustard-Aus-Fallow	200
061 Vegetab-Boro-Fallow	1550	129 Chilli-Aus-Fallow	200
062 Maize-Sesame-T. Aman	1530	130 Coriander-Jute-Fallow	200
063 Vegetab-Aus-T. Aman	1400	131 Grasspea-B.Aus+B.Aman	200
064 Chilli-Vegetab-Fallow	1330	132 Grasspea-Sesame-Fallow	200
065 Vegetab-Jute-T. Aman	1310	133 Mustard-Maize-Jute	200
066 Mustard-Boro-Fallow	1290	134 Onion-Aus-Blackgram	200
067 Maize-Vegetab-T. Aman	1260	135 Potato-Boro-Aus	200
068 Vegetab-Fallow-Blackgram	1250	136 Potato-Boro-Jute-T. Aman	200
	137-176	Other 40 patterns (Table 9)	3890

# 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 3<sup>rd</sup> 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
02	Dacope	16100	85.78
03	Shyamnagar	12000	68.61
04	Koyra	10500	67.36
05	Batiaghata	5500	30.78
06	Kaliganj	5000	27.09
07	Dumuria	4900	16.61
08	Rampal	4400	46.81
09	Assasuni	4100	35.65
10	Bagerhat sadar	3800	22.82
11	Sarankhola	3800	40.17
12	Paikgachha	3000	17.53
13	Mongla	2000	74.07
14	Rupsha	2000	24.51
15	Kachua	700	7.67
16	Fakirhat	300	3.41
17	Debhata	100	1.47
	Khulna region	96900	27.24

### 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 2<sup>nd</sup> 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 3<sup>rd</sup> 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 2<sup>nd</sup> largest area 3,500 ha for this cropping and this upazila had allotted also the 2<sup>nd</sup> 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 4<sup>th</sup> 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 5<sup>th</sup> 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.

#### REFERENCES

Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.

Alam, M S. 1994. Optimum cropping patterns of the small farmers under risk: a micro level study in Bangladesh. Ph.D. thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

- BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- MoA and FAO. 2013. Master Plan for Agricultural Development in the Southern Region of Bangladesh, Ministry of Agriculture, Government of the People's Republic of Bangladesh.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rahman, M M and M Ahsan. 2011. Salinity constraints and agricultural productivity in coastal saline area of Bangladesh. *Soil Resources in Bangladesh: Assessment and Utilization*, Soil Resources Development Institute (SRDI), Farmgate, Dhaka 1215, Bangladesh.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems* 49(3): 301-318.
- Singh, J and R S Sidhu. 2006. Accounting for impact of environmental degradation in agriculture of Indian Punjab. *Agric. Economics Res. Rev.* 19: 37-48.
- SRDI, 2010. Saline Soils of Bangladesh. Soil Resource Development Institute, Farmgate, Dhaka-1215. 55p.
- Tscharntke, T, R Bommarco, Y Clough, T O Crist, D Klein, T A Rand, J M Tylianakis, S vanNouhuys, and S Vidal. 2007. Conservation biological control and enemy diversity on a landscape scale. *Biol. Control.* 43: 294-309.
- Tscharntke, T, A M Klein, A Kruess, I S Dewenter, and C Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity-ecosystem service management. *Ecol. Lett.* 8: 857-874.

**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



# 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, extensionists 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 RFS scientists to finalize and validate the data and authenticated data were captured. Crop diversity index was calculated by using the following equation described by Kshirsagar *et al.* (1997).

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

Where,  $CDI_i$  = Crop Diversity Index

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

$A_i$  = Total area planted under all crops

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

## RESULTS AND DISCUSSION

### Land use

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 Vegetab-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 individual 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 highest 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 6<sup>th</sup> 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	Baksganj+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	Baksganj+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	Baksganj+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	Baksganj
28	Must-Boro-Jute- T. Aman	20	0.05	1	Baksganj
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 2<sup>nd</sup> 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 3<sup>rd</sup> 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 individual 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 4<sup>th</sup> 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 5<sup>th</sup> 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 Sreebari 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.

## REFERENCES

- Alam, S and Abedin, M J. 1996. Changing cropping pattern in Bangladesh from 1971-75 through 1991-93: Implications on crop sector growth. *Bangladesh J. Agric. Econ.* XIX: 31-44.
- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- Blade, S F and A E Slinkard. 2002. *New Crop Development: The Canadian Experience. In: Trends in New Crops and New Uses.* J Janick and A Whipkey (Editors). ASHS Press, Alexandria.
- Das, Anup, G I Ramkrushna, G S Yadav, J Layek, C Debnath, B U Choudhury, K P Mohaptara, S V Ngachan and S Das. 2015. Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India. *Applied Ecology and Environmental Sciences.* 3(4): 100-107.

- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.
- Hossain, D. 1996. Relative profitability from alternative cropping patterns under irrigated conditions in selected areas of Bogra district. M. S. Ag. Econ. Thesis. Bangladesh Agricultural University, Mymensingh.
- Hussain, A M M, M Hossain and A Janaiah. 2001. Hybrid rice adoption in Bangladesh: Socio-economic assessment of farmers' experiences. BRAC Research Monograph Series.No. 18.BRAC, Dhaka, Bangladesh.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: The case of rainfed village in eastern India. Discussion paper 5/97. Social Science Division, IRRI.
- Kumari, B A P, S Thiruchelvam, H M H Dissanayake and T Lasantha. 2010. Crop diversification and income inequality in irrigation systems: The case of Minipe. *Tropical Agricultural Research.* 21: 308-320.
- Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapura.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J Agric. Econ.* 68(2): 169-181.
- Mondal, R I, F Begum, A Aziz and S H Sharif. 2015. Crop sequences for increasing cropping intensity and productivity. *SAARC J. Agri.* 13: 135-147.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rahman, A. 2010. Promoting financial inclusion for poverty reduction with inclusive growth. Bazlur Rahman Memorial Lecture, presented at the 17th biennial conference on 'The economy at the golden jubilee of war of liberation: what type of Bangladesh we would like to see?' organized by Bangladesh Economic Association held on 8 - 10 April at Osmani Memorial Auditorium and Institution of Engineers, Bangladesh Dhaka.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *J. Agric. Rural Dev.* 4(1&2): 53-60.

**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-Vegetab-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



# Cropping Systems and Land Use Pattern in Rajshahi Region

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## ABSTRACT

Attempts have been made in this paper to overview the existing cropping patterns, crops diversity and cropping intensity in Rajshahi region. The study was conducted in all the upazilas of four districts of Rajshahi region during 2014-15 using pre-tested semi-structured questionnaires. The most predominating crop in this area was rice where exclusive rice based patterns occupied 40.48% of NCA. Boro-Fallow-T. Aman was the dominant cropping pattern, occupied 22.83% of NCA in 27 upazilas out of 32. The second dominant cropping pattern in Rajshahi region was Boro-Fallow-Fallow. It occupied 7.23% of NCA of the region and existed in 28 upazilas. Wheat-Fallow-T. Aman was the 3<sup>rd</sup> dominant pattern and practiced in 4.34% of the NCA in 14 upazilas. The data also revealed that the wheat based patterns stands for 14.7% of NCA. Mustard-Boro-T. Aman was the 4<sup>th</sup> dominant cropping pattern. A total of 172 cropping patterns were recognized in this region and the maximum (36) numbers of cropping patterns were identified in Paba upazila nearly followed by Durgapur (35) and Chapainawabganj upazila (34) while the lower numbers of cropping patterns were identified in Charghat (11) followed by Bagha (12) upazila of Rajshahi district. The range of cropping intensity values was recorded 171–253%. The maximum value was for Badalgachhi of Naogaon district and minimum for Bagha of Rajshahi district. The overall CDI of Rajshahi region was calculated 0.970 and the average cropping intensity at regional level was 218%.

**Key words:** Crop diversity index, cropping pattern, fruit orchard, Barind tract and drought

## INTRODUCTION

In Bangladesh, Rajshahi region especially the Barind Tract is different from other parts of the country due to its undulating topography having compact and low fertile soils. The High Barind Tract, lying in Rajshahi, Chapai Nawabganj and Naogaon districts, is one of the distinct areas of Barind, occupying 160,000 ha, roughly 21% of the region. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (Ali, 2000). The maximum temperature can exceed 40°C in May and minimum temperature can fall to 6°C in January. Most of the rainfall occurs from June to September and moisture depletion starts from October and in December no residual moisture is available for crop emergence (Idris

and Huq, 1987). Land in the High Barind Tract exhibits grey terrace soil, silty loam to silty clay in texture, and is poorly drained, with a 6–8-cm thick plow pan and low organic matter content (0.8–1.2%). These situations make the area drought prone along with poor crop productivity. The east and southeast of the Barind is the lower Atrai Basin of Naogaon and Natore district. During the rainy season a vast area of lowland is flooded completely where silts and organic matter from aquatic weeds are deposited on soil and therefore the fertile soils of the specific areas are specially suited to Boro rice cultivation.

Cropping pattern is the yearly sequence, temporal and spatial arrangement of crops in a given land area. Cropping pattern depends on physical, historical, social, economic and institutional factor as well as government

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policies (Agarwall and Kassam, 1976). Rajshahi region is specially suited to lentil, chickpea, tomato and potato. Mango, litchi, palmyra palms and guava are also the major fruit crops in this area. Cropping pattern in a specified region is not static; day by day it is changing. The cropping pattern and the changes depend on a large number of factors like climate, soil type, rainfall, irrigation facilities, agricultural technology and other inputs, marketing and transport facilities and growth of agro industries (Gadge, 2003; Rashid *et al.*, 2005). Recently a number of farmers are converting their crops into mango orchard and continuing cultivation of field crops in the young mango orchard. Like other parts of the country, monsoon T. Aman rice is the major crop in Rajshahi region and backbone of the rural economy. Since 1985, the Barind Multipurpose Development Authority (BMDA) developed a network by installing deep tube wells bringing 162,000 ha land under irrigation across the entire Barind of Bangladesh. 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). 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. Existing trends of available agricultural lands is most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The present study was designed with the following specific objectives to :

- understand the existing cropping patterns scenario in Rajshahi region

- visualize the existing land use pattern at upazila and regional level
- determine the crop diversity and cropping intensity at local and regional level.

## METHODOLOGY

Thirty-two upazilas of Rajshahi, Naogaon, Chapainawabganj and Natore districts under Rajshahi 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 32 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during February 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 the Directorate of Agricultural Extension (DAE) during monthly meeting for the sake of accurate data collection. The scientists of RFS Division collected the filled questionnaires. They also checked and analyzed those 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 25 April for Naogaon; 26 April for Natore; 16 August for Rajshahi; and 17 August 2016 for Chapainawabganj. 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, Kushtia, and Rajshahi participated in the data validation workshop. The number of participants of validation workshop ranged from 56 to 98 in each district. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFSI 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 status of agricultural land utilization in the region. The net cropped area of the Rajshahi region is 693,620 ha. Crops occupying the particular land for round the year were considered under annual crops. The major annual crops reported in the region were pineapple, sugarcane, banana, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 40 to 7,940 ha. The annual crops area accounted only 5.96% of the net cropped area (NCA) in the region. At a glance the region possesses 10.73% single cropped area (SCA), 48.38% double cropped area (DCA), 33.58% triple cropped area (TCA). The quadruple cropped area QCA also exists as a very negligible portion (0.67%) and is limited in only six upazilas

viz Badalgachhi, Manda, Mohadevpur and Raninagar of Naogaon district, and Bagha and Mohanpur of Rajshahi district. Compared with DCA and TCA the SCA remained much lower in each and every upazilas. In Rajshahi region, DCA remained higher in Singra upazila of Natore district followed by Godagari upazila of Rajshahi district. Chapainawabganj sadar and Shibganj upazilas are the exceptions where TCA occupied the biggest share of NCA.

### Cropping patterns of Rajshahi

In total 172 cropping patterns were observed in Rajshahi region of which eight cropping patterns with exclusive rice crop covers over 40% of the NCA. There were 40 cropping patterns with exclusive non-rice crop covering over 7% of the NCA. Rest of the NCA i.e. about 53% area is covered by 124 rice - non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

A wide range of cropping patterns were recognized in the study area and the important feature of the region is that eight patterns were composed of absolutely rice crops. Of all lands used for cultivation, 40.48% was used only for rice production showing that the farmers are engaged with the traditional rice farming and it is also applicable in Bangladesh (Haque *et al.*, 2012). Boro-Fallow-T. Aman was the most predominant cropping pattern in this area (Table 2). Out of 32 upazilas, the Boro-Fallow-T. Aman cropping pattern remained in 27 upazilas and 22.83% of the NCA belonged to this pattern. Single Boro was the 2<sup>nd</sup> dominant pattern, which occupied about 7.23% of the net cropped area in 28 upazilas. Boro-T. Aus-T. Aman cropping pattern exists in 17 upazilas which was the 3<sup>rd</sup> dominant cropping pattern and occupied 3.65% of NCA in the region. Single T. Aman was also common in eight upazilas which covered 2.75% of NCA. Very negligible portion i.e less than 1% NCA was practiced by Fallow-Aus-T. Aman cropping system in this region.

In the current investigation, 40 cropping patterns were identified that was free from rice. Among them first 24 have been arranged in descending order in Table 3. The rest 16 patterns

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Bholahat	12352	2200	500	5100	3030	0	170	11000	203
02 Chapainawabganj	45192	550	6050	4520	17640	0	190	28950	238
03 Gomastapur	31812	410	5430	13340	5410	0	120	24710	198
04 Nachol	28368	60	2600	17860	4400	0	140	25060	207
05 Shibganj	52543	7940	700	5350	16500	0	150	30640	226
06 Atrai	28300	40	6800	13950	2700	0	150	23640	182
07 Badalgachhi	21083	320	120	9090	4140	2400	150	16220	253
08 Dhamoirhat	30082	250	1300	13820	7980	0	100	23450	228
09 Manda	71744	360	4010	14790	11120	80	150	30510	223
10 Mohadebpur	39552	160	30	15670	14090	1000	110	31060	251
11 Naogaon sadar	27444	250	5630	6810	7610	0	150	20450	209
12 Niamatpur	44993	340	3300	17500	11650	0	150	32940	224
13 Porsha	27205	430	3500	12070	5820	0	110	21930	209
14 Patnitala	37927	240	3500	14430	11930	0	190	30290	227
15 Raninagar	24810	70	2200	12910	5260	50	180	20670	215
16 Shapahar	24462	40	3300	12480	3750	0	170	19740	202
17 Bagatipara	13992	5660	130	1240	2995	0	135	10160	172
18 Baraigram	30000	1680	1000	11000	10240	0	160	24080	232
19 Gurudaspur	19940	630	1040	8620	5260	0	180	15730	223
20 Lalpur	32987	2590	280	1770	6820	0	130	11590	234
21 Natore	27700	4830	0	4250	7300	0	150	16530	215
22 Naldanga	19500	1700	3500	5000	3600	0	150	13950	188
23 Singra	52778	150	7200	27900	7820	0	130	43200	201
24 Chorghat	16458	730	950	1840	5200	0	160	8880	240
25 Bagha	18426	4350	1700	4850	2250	0	150	13300	171
26 Bagmara	36558	450	2800	14370	9790	900	190	28500	229
27 Durgapur	22200	480	1510	3680	7800	0	110	13580	243
28 Godagari	47526	40	120	36580	2700	0	150	39590	206
29 Mohanpur	16276	50	2250	1020	7660	200	170	11350	252
30 Paba	29783	570	1370	5030	8290	0	160	15420	242
31 Puthia	19264	3600	1170	2880	6150	0	150	13950	210
32 Tanor	29580	150	450	15850	5980	0	120	22550	224
Rajshahi region	-	41320	74440	335570	232885	4630	4775	693620	218

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-T. Aman	158390	22.83	27
02 Boro-Fallow-Fallow	50130	7.23	28
03 Boro-Aus-T. Aman	25290	3.65	17
04 Fallow-Fallow-T. Aman	19100	2.75	8
05 Boro-B.Aman	11650	1.68	8
06 Boro-Aus-Fallow	9500	1.37	9
07 Fallow-Aus-T. Aman	6120	0.88	3
08 Boro-Sesbania-T. Aman	580	0.08	3
Total	280760	40.48	-

with negligible area coverage arranged in Table 8 with other patterns of different categories. Aggregate of the 40 patterns have had 7.43% of NCA. In critical comparison it is clear that exclusive rice area is about six folds of exclusive non-rice area. In Rajshahi region, crop diversity is much wider than that of other regions like Sylhet and Chittagong, where exclusive rice area covers 37 folds and 23 folds, respectively, of exclusive non-rice area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). 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).

### **Non-rice cereal crops**

Table 4 presents detailed existing cropping patterns for non-rice cereal crops with area coverage. Forty-four cropping patterns were identified for non-rice cereal cropping systems covering 143,730 ha which represents 20.72% of NCA in the region. The dominant cropping pattern was the Wheat-Fallow-T. Aman which was practiced on 30,130 ha (4.34% of NCA) in 14 upazilas of Rajshahi region. Next cropping pattern under this combination was Wheat-Aus-T. Aman and existed in 2.31% of the NCA in 14 upazilas. Out of 44 cropping patterns under non-rice cereal systems, 22 patterns were wheat based and the aggregate area under wheat based patterns stands for 16.58% of NCA in this area. In Bangladesh, there is a vast market of wheat for human consumption and maize seeds for feed industries. Local production of wheat and maize is extremely insignificant to meet up the demand. The situation is increasing our dependency on import causing a great pressure on foreign currency (BBS, 2014). Loam and sandy-loam soil of the comparative dry area is very suitable for maize cultivation. Wheat cultivation with its better yield in this region is specially favoured by long winter season that is normally unavailable in southern

parts of the country. Light textured soil with low water-holding capacity as well as less availability of irrigation water are driving forces that discourage the farmers for modern boro cultivation. During the harvesting period of wheat the crop is privileged by clear sun-shine and low humidity. All these are the factors this area is dominated by wheat-based cropping systems (FAO, 1988).

### **Pulse crops**

Fifty cropping patterns are holding different pulse crops (Table 5). Among them blackgram is covering the largest area whereas pea in the smallest area. Thirteen cropping patterns of blackgram in-together cover 31,720 ha representing 4.57% of NCA in the Rajshahi region. Mungbean holds the second position in pulse crop cultivation in the region. There are 10 cropping patterns for mungbean covering 24,020 ha (3.46% of NCA). In some area of Rajshahi region specifically in Barind tract, Boro cultivation faces some constraints such as scarcity of irrigation water and low-water holding capacity of soil. Moreover, high market price of pulse crops is a driving force for ample cultivation of pulse crops. Among the Rabi crops stress-tolerant mungbean, blackgram, grasspea can easily be grown as relay system and other cropping systems (FAO, 1988).

### **Oil-seed crops**

Twenty-eight cropping patterns have been arranged in descending order according to area coverage (Table 6). Mustard is the most important one among the oil-seed crops in Rajshahi region. There are 13 cropping had been led by mustard alone which in-together covers 66,050 ha (9.52% of NCA). The pattern Mustard-Boro-T. Aman has the highest coverage (3.70% of the NCA) and was recorded in 17 upazilas out of 32 followed by Mustard-Boro-Fallow (1.88% of NCA). Oil is an essential ingredient of human food and also for feed industries. The country is almost dependent on import for oil. Mustard is a very potential crop that can be grown widely in various parts of the country (BBS, 2014). At present, the lion-share

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetable-Vegetable-Vegetable	10715	1.54	19
02 Wheat-Jute-Fallow	6720	0.97	6
03 Garlic-Jute-Fallow	4310	0.62	4
04 Vegetab-Vegetab-Fallow	3500	0.54	6
05 Maize-Fallow-Blackgram	3350	0.50	2
06 Lentil-Fallow-Fallow (Orchard)	2780	0.43	5
07 Wheat-Mungbean-Fallow	2670	0.40	4
08 Potato-Jute-Fallow	2450	0.35	3
09 Onion-Vegetab-Vegetab	2370	0.34	11
10 Wheat-Mung-Fallow (Orchard)	2150	0.31	3
11 Onion-Jute-Fallow	2010	0.29	5
12 Garlic-Vegetab-Vegetab	1030	0.15	10
13 Maize-Fallow-Fallow	1000	0.14	2
14 Potato-Chilli-Fallow	980	0.14	6
15 Lentil-Vegetab-Vegetab	760	0.11	2
16 Wht-Sesame-B.gram (Orchard)	730	0.11	2
17 Chilli-Vegetab-Fallow	600	0.09	5
18 Wheat-Vegetab-Vegetab	500	0.07	2
19 Wheat-Jute-Blackgram	370	0.05	2
20 Wheat-Chilli-Fallow	290	0.04	3
21 Potato-Maize-Fallow	270	0.04	3
22 Chilli-Fallow-Fallow	240	0.04	3
23 S.Potato-Fallow-Fallow	220	0.03	4
24 Groundnut-Fallow-Fallow	210	0.03	2
25-40 Other 16 patterns (in Table 8)	1540	0.22	
Total	51765	7.43	

of mustard cultivation is related to the land for double rice. If technology transfer activities could be strengthen much more area of the aforesaid category will be possible to make room for the mustard crop (FAO, 1988).

### Vegetables and spices crops

A total of 66 cropping patterns were identified in Rajshahi region for vegetables and spices crops. Potato and other vegetables belong to Rabi, Kharif-I and Kharif-II, spices crops viz onion, garlic, coriander, blackcumin and chilli had been included in this list (Table 7). Total area coverage under spices and vegetables is 106,355 ha (15.27% of NCA). Among them Potato-Boro-T. Aman is holding the largest coverage with 15,610 ha (2.31% of NCA) distributed to 12 upazilas. The 2<sup>nd</sup> contributing pattern

in this category was year-round vegetables, which occupied 1.54% of NCA with its widest spreading into 19 upazilas.

### Sporadic and distinct cropping patterns

Boro-Aus-Blackgram is an extremely location specific cropping pattern which is limited only in Chapainawabganj sadar upazila with an area of 8,000 ha. Felon-Fallow-T. Aman is another exception which is practiced in Porsha upazila of Naogaon district. This pattern has occupied an area of 6,400 ha of under Barind tract. The third one is the single T. Aman with fruit garden/orchard. The system practiced only in Porsha with an area coverage of 1,000 ha. Rice is cultivated from the time of garden establishment and it is continued up to 7 or 8 years age of fruit trees. The fourth one is Wheat-Aus-Blackgram which is absolutely

**Table 4. Cropping patterns for wheat and maize in Rajshahi region, 2014-15 .**

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Wheat-Fallow-T. Aman	30130	4.34	14
02	Wheat-Aus-T. Aman	16010	2.31	14
03	Wheat-Mungbean-T. Aman	12570	1.81	17
04	Wheat-Aus-Blackgram	12030	1.73	3
05	Wheat-Jute-T. Aman	10270	1.48	18
06	Wheat-Aus-Fallow	7020	1.01	8
07	Wheat-Jute-Fallow	6720	0.97	6
08	Potato-Maize-T. Aman	5350	0.77	11
09	Potato-Maize-Aus	4000	0.58	3
10	Maize-Fallow-T. Aman	3780	0.54	8
11	Wheat-F-T. Aman(Orchard)	3700	0.53	2
12	Maize-Fallow-Blackgram	3350	0.48	2
13	Wheat-Maize-T. Aman	2920	0.42	4
14	Lentil-Maize-T. Aman	2890	0.42	6
15	Wheat-Mungbean-Fallow	2670	0.38	4
16	Wheat-Mung-Fallow(Orchard)	2150	0.31	3
17	Wheat-Sesame-T. Aman	2100	0.30	7
18	Maize-B.Aman	2000	0.29	2
19	Wheat-Aus-Onion	1900	0.27	1
20	Maize-Aus-Blackgram	1300	0.19	1
21	Wheat-Vegetab-T. Aman	1160	0.17	6
22	Wheat-B.Aman	1150	0.17	2
23	Onion-Maize-T. Aman	1050	0.15	3
24	Maize-Fallow-Fallow	1000	0.14	2
25	Wht-Sesame-B.gram(Orchard)	730	0.11	2
26	Potato-Maize-Aus-Vegetab	700	0.10	1
27	Wheat-Vegetab-Vegetab	500	0.07	2
28	Maize-Aus-T. Aman	440	0.06	3
29	Vegetab-Maize-Fallow	430	0.06	1
30	Maize-Maize-Fallow	400	0.06	1
31	Onion-Maize-Fallow	400	0.06	1
32	Wheat-Jute-Blackgram	370	0.05	2
33	Boro-Maize-Blackgram	350	0.05	1
34	Boro-Maize-Fallow	350	0.05	1
35	Maize-Aus-Fallow	300	0.04	1
36	Potato-Maize-Vegetab	300	0.04	1
37	Wheat-Chilli-Fallow	290	0.04	3
38	Potato-Maize-Fallow	270	0.04	3
39-44	Other six patterns (table 8)	680	0.10	-
	Total maize and wheat	143730	20.72	

practiced in Chapainawabganj district with an area coverage of 12,030 ha. This pattern, as far known, does not exist anywhere in Bangladesh out of the district. Three upazilas of the district viz Shibiganj, sadar and Bholahat are holding 10,000 ha, 1,400 ha and 630 ha of land, respectively, for the cropping pattern.

#### **Rare cropping patterns**

Rajshahi region is a diversified cropping zone. Forty-four rare cropping patterns with negligible area coverage in the specific one or two upazilas had been identified in this region (Table 8). However, total area coverage of these patterns was only 0.54% of NCA. Out

**Table 5. Cropping patterns of pulses crops in Rajshahi region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Wheat-Mungbean-T. Aman	12570	1.81	17
02 Wheat-Aus-Blackgram	12030	1.73	3
03 Boro-Aus-Blackgram	8000	1.15	1
04 Felon-Fallow-T. Aman	6400	0.92	1
05 Lentil-Fallow-T. Aman	4370	0.63	6
06 Maize-Fallow-Blackgram	3350	0.48	2
07 Lentil-Maize-T. Aman	2890	0.42	6
08 Lentil-Fallow-Fallow(Orchard)	2780	0.40	5
09 Wheat-Mungbean-Fallow	2670	0.38	4
10 Garlic-Mungbean-T. Aman	2500	0.36	2
11 Lentil-Jute-T. Aman	2410	0.35	6
12 Wheat-Mung-Fallow(Orchard)	2150	0.31	3
13 Chickpea-Fallow-T. Aman	2110	0.30	5
14 Boro-Fallow-Blackgram	2000	0.29	4
15 Grasspea-Boro-Aus	1800	0.26	1
16 Lentil-Mungbean-T. Aman	1750	0.25	5
17 Mustard-Mungbean-T. Aman	1700	0.25	2
18 Mustard-Aus-Blackgram	1500	0.22	1
19 Vegetab-Aus-Blackgram	1500	0.22	1
20 Grasspea-B.Aman	1380	0.20	3
21 Maize-Aus-Blackgram	1300	0.19	1
22 Onion-Aus-Blackgram	870	0.13	2
23 Lentil-Vegetab-Vegetab	760	0.11	2
24 Wht-Sesame-B.gram(Orchard)	730	0.11	2
25 Lentil-Aus-T. Aman	710	0.10	3
26 Lentil-Sesame-T. Aman	710	0.10	3
27 Lentil-Aus-Fallow	620	0.09	2
28 Mungbean-Aus-T. Aman	600	0.09	1
29 Wheat-Jute-Blackgram	370	0.05	2
30 Boro-Maize-Blackgram	350	0.05	1
31 Grasspea-Fallow-T. Aman	350	0.05	4
32 Lentil-Sesame-Fallow	300	0.04	1
33 Grasspea-Aus-Blackgram	250	0.04	1
34-50 Other 17 patterns (Table 8)	1410	0.20	
Total pulse crop	85190	12.23	

of 43 patterns, each of nine patterns namely Groundnut-Aus-Fallow, Lentil-B. Aman, Lentil-Jute-Fallow, Lentil-Jute-Fallow, Lentil-Jute-Fallow, Vegetab-Onion-Jute-T. Aman, Wheat-Fallow-Fallow, Wheat-Jute-Vegetab and Wheat-Sesame-Fallow occupied the same areas of 200 ha land in different nine upazilas of this region.

#### Most dominant cropping pattern

Boro-Fallow-T. Aman was the major cropping pattern in Rajshahi region and the pattern was common in 27 upazilas which occupied 22.83%

of NCA in the region (Table 9). The highest area coverage under Boro-Fallow-T. Aman pattern was found in Singra (19,100 ha) upazila of Natore district followed by Dhamoirhat (13,000 ha), Mohadebpur (12,800 ha), Patnitala (12,600 ha) and Raninagar (12,600 ha) upazilas of Naogaon district indicated that Naogaon district was the dominant rice growing zone. Although the higher area coverage was found in Singra upazila but the percent of upazila net cropped area with this pattern remained higher in Raninagar (61%) upazila followed by Dhamoirhat upazila (56%) of Naogaon district.

**Table 6. Cropping patterns of oil-seed crops in Rajshahi region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-T. Aman	25650	3.70	17
02 Mustard-Boro-Fallow	13050	1.88	9
03 Mustard-Boro-Aus	10200	1.47	8
04 Mustard-Fallow-T. Aman	6000	0.87	7
05 Mustard-Aus-T. Aman	3800	0.55	4
06 Wheat-Sesame-T. Aman	2100	0.30	7
07 Mustard-Boro-B.Aman	1800	0.26	1
08 Mustard-Boro-Aus-T. Aman	1700	0.25	4
09 Mustard-Mungbean-T. Aman	1700	0.25	2
10 Mustard-Aus-Blackgram	1500	0.22	1
11 Wht-Sesame-Blackgram (Orchard)	730	0.11	2
12 Lentil-Sesame-T. Aman	710	0.10	3
13 Lentil-Sesame-Fallow	300	0.04	1
14 Onion-Sesame-Fallow	280	0.04	1
15 Mustard-Aus-Fallow	250	0.04	1
16 Groundnut-Fallow-Fallow	210	0.03	2
17-28 Other 12 patterns (in Table 8)	1120	0.16	-
Total oil-seed crop	71100	10.21	

The lowest area coverage as well as percent of upazila net cropped area under Boro-Fallow-T. Aman cropping pattern in Rajshahi region existed in Charghat upazila decreasingly followed by Paba upazila of Rajshahi district. In the country-wide compilation of data it was observed that Boro-F-T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### Second dominant cropping pattern

The second most dominant cropping pattern in Rajshahi region was Boro-Fallow-Fallow. It occupied 7.23 of NCA of the region and existed in 28 upazilas (Table 10). The area coverage under single Boro remained higher in Singra upazila of Natore holds the largest area 7,200 ha which is equivalent to 14.36% of the total area for the pattern in the region. Naldanga upazila of Natore district stands fifth position for area coverage (3,500 ha), however, this upazila had allocated the biggest share i.e. 28.57% of its NCA. The lowest area (50 ha) coverage under Boro-Fallow-Fallow cropping pattern has been identified in Chapainawabganj sadar and Charghat upazila of Rajshahi district. Out of

nine upazilas of Rajshahi district, only Bagmara upazila holds considerable area 2,800 ha (9.98% of upazila NCA) under this single Boro cropping pattern. This pattern is frequent and concurrently experienced by early flashflood in April and cold injury at 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). In the country-wide compilation of data it was observed that the single Boro was the 2<sup>nd</sup> 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

Third dominant cropping Wheat-Fallow-T. Aman occupied the 30,130 ha of land and represented 4.34% of NCA in Rajshahi region (Table 11). This pattern distributed over 14 upazilas where Shapahar ranked top position covering 7,500 ha of land. Godagari and Nachol ranked the 2<sup>nd</sup> and 3<sup>rd</sup> position under Wheat-Fallow-T. Aman cropping pattern covering 6,000 ha and 5,000 ha of land, respectively.

**Table 7. Cropping patterns for vegetables and spices crops in Rajshahi region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Boro-T. Aman	15610	2.25	12
02 Vegetable-Vegetable-Vegetable	10715	1.54	19
03 Potato-Boro-Aus	7200	1.04	4
04 Garlic-B.Aman	6200	0.89	3
05 Potato-Boro-Fallow	5800	0.84	2
06 Onion-Aus-Fallow	4450	0.64	5
07 Garlic-Jute-Fallow	4310	0.62	4
08 Potato-Fallow-T. Aman	4050	0.58	6
09 Vegetab-Aus-Fallow	3680	0.53	4
10 Vegetab-Vegetab-T. Aman	3550	0.51	7
11 Vegetab-Vegetab-Fallow	3500	0.50	6
12 Onion-Jute-T. Aman	2750	0.40	6
13 Chilli-Aus-T. Aman	2600	0.37	2
14 Potato-Aus-T. Aman	2600	0.37	5
15 Potato-Jute-Fallow	2450	0.35	3
16 Onion-Vegetab-Vegetab	2370	0.34	11
17 Garlic-Jute-T. Aman	2320	0.33	8
18 Onion-Jute-Fallow	2010	0.29	5
19 Potato-Jute-T. Aman	1980	0.29	5
20 Onion-Fallow-T. Aman	1840	0.27	7
21 Vegetab-Aus-T. Aman	1640	0.24	5
22 Vegetab-Fallow-T. Aman	1550	0.22	4
23 Potato-Aus-Fallow	1300	0.19	4
24 Garlic-Vegetab-Vegetab	1030	0.15	10
25 Potato-Chilli-Fallow	980	0.14	6
26 Lentil-Vegetab-Vegetab	760	0.11	2
27 Potato-Vegetab-T. Aman	700	0.10	2
28 Chilli-Fallow-T. Aman	670	0.10	6
29 Garlic-Aus-Fallow	660	0.10	5
30 Boro-Vegetab(Float/Norm)	630	0.09	2
31 Chilli-Vegetab-Fallow	600	0.09	5
32 Wheat-Vegetab-Vegetab	500	0.07	2
33 Garlic-Aus-T. Aman	490	0.07	3
34 Garlic-Fallow-T. Aman	410	0.06	4
35 Chilli-Aus-Fallow	400	0.06	3
36 Garlic+Muskmelon-B.Aman	320	0.05	2
37 Garlic+W.Melon-B.Aman	320	0.05	2
38 Vegetab-Boro-T. Aman	300	0.04	2
39 Wheat-Chilli-Fallow	290	0.04	3
40 Potato-Maize-Fallow	270	0.04	3
41 Vegetab-Jute-T. Aman	270	0.04	2
42 Potato-Boro-Aus-T. Aman	230	0.03	2
43 Coriander-Fallow-Fallow	220	0.03	2
44 Chilli-Fallow-Fallow	240	0.03	3
45 Chilli-Vegetab-T. Aman	210	0.03	2
46-66 Other 21 patterns (in Table 8)	1380	0.20	-
Total veg. and spices crops	106355	15.27	

**Table 8. Rare cropping patterns covering non-significant area in Rajshahi region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Groundnut- Aus-Fallow	200	0.03	1	Lalpur
02	Lentil-B.Aman	200	0.03	1	Gurudaspur
03	Lentil-Jute-Fallow	200	0.03	1	Nachol
04	Lentil-Vegetab-T. Aman	200	0.03	1	Nachol
05	Lentil-Jute-Fallow	200	0.03	1	Gurudaspur
06	Vegetab-Onion-Jute-T. Aman	200	0.03	1	Mohanpur
07	Wheat-Fallow-Fallow	200	0.03	1	Bagatipara
08	Wheat-Jute-Vegetab	200	0.03	1	Naogaon sadar
09	Wheat-Sesame-Fallow	200	0.03	1	Bagatipara
10	Grasspea-Jute-T. Aman	190	0.03	2	Lalpur+Bagatipara
11	Fallow-Fallow-Blackgram	170	0.02	3	Manda+Gurudaspur+Paba
12	Chilli-Jute-T. Aman	170	0.02	2	Dhamoirhat+Shibganj
13	Grasspea-Boro-Fallow	150	0.02	1	Paba
14	Mustard-Fallow-Fallow	150	0.02	1	Paba
15	Garlic-Fallow-Fallow	120	0.02	1	Lalpur
16	Potato-Sesame-Aus	120	0.02	1	Bagmara
17	Groundnut-Fallow-T. Aman	100	0.01	1	Atrai
18	Boro-Sesbania-Fallow	80	0.01	1	Godagari
19	Boro-Vegetab-T. Aman	70	0.01	1	Paba
20	Coriander-Fallow-T. Aman	50	0.01	2	Chapai sadar +Gomastapur
21	Grasspea-Mungbean-T. Aman	50	0.01	1	Lalpur
22	Mustard-Maize-T. Aman	50	0.01	1	Manda
23	Grasspea-Sesame-T. Aman	40	0.01	1	Lalpur
24	Pea-Aus-Vegetab	40	0.01	2	Paba+Nachol
25	Pea-Fallow-T. Aman	40	0.01	2	Chapai sadar +Gomastapur
26	Blackgram-Jute-Fallow	30	0.00	1	Manda
27	Coriander-Vegetab-Fallow	30	0.00	1	Naogaon sadar
28	Potato-Sesame-T. Aman	30	0.00	1	Durgapur
29	Blackcumin-Jute-T. Aman	20	0.00	1	Gurudaspur
30	Chickpea-Aus-T. Aman	20	0.00	1	Paba
31	Chilli-Jute-Fallow	20	0.00	1	Badalgachhi
32	Coriander-B.Aman	20	0.00	1	Gurudaspur
33	Coriander-Jute-T. Aman	20	0.00	2	Gurudaspur+Dhamoirhat
34	Grasspea-Jute-Fallow	20	0.00	1	Manda
35	Maize-Jute-T. Aman	20	0.00	1	Durgapur
36	Pea-Jute-Fallow	20	0.00	1	Lalpur
37	Potato-Mungbean-T. Aman	20	0.00	2	Durgapur+Chapai sadar
38	Coriander-Sesame-T. Aman	10	0.00	1	Mohadebpur
39	Grasspea-Fallow-Fallow	10	0.00	1	Gomastapur
40	Maize-Vegetab-T. Aman	10	0.00	1	Durgapur
41	Mungbean-Fallow-T. Aman	10	0.00	1	Charghat
42	Potato-Groundnut	10	0.00	1	Raninagar
43	Potato-Groundnut-T. Aman	10	0.00	1	Raninagar
44	Vegetab-Fallow-Fallow	10	0.00	1	Durgapur
	Total	3730	0.54		

**Table 9. Distribution of the most dominant Boro–Fallow–T. Aman cropping patterns in Rajshahi region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Singra	19100	45.00	12.06
02 Dhamoirhat	13000	56.00	8.21
03 Mohadebpur	12800	41.00	8.08
04 Patnitala	12600	42.00	7.96
05 Raninagar	12600	61.00	7.96
06 Niamatpur	12000	37.00	7.58
07 Godagari	12000	30.00	7.58
08 Badalgachhi	8500	53.00	5.37
09 Tanor	7400	33.00	4.67
10 Manda	6500	22.00	4.10
11 Naogan Sodar	6000	30.00	3.79
12 Gomastapur	5800	23.90	3.66
13 Atrai	5300	22.50	3.35
14 Nachol	5000	20.00	3.16
15 Porsha	4100	19.00	2.59
16 Naldanga	3500	29.00	2.21
17 Shapahar	3000	15.00	1.89
18 Bholahat	1900	22.00	1.20
19 Natore	1700	15.00	1.07
20 Puthia	1700	17.00	1.07
21 Chapainawabganj	1000	3.50	0.63
22 Durgapur	1000	7.60	0.63
23 Baraigram	700	3.10	0.44
24 Bagatipara	490	10.90	0.31
25 Shibganj	400	1.80	0.25
26 Paba	200	1.40	0.13
27 Chorghat	100	1.20	0.06
Rajshahi region	158390	22.83	100.00

The lowest area coverage (100 ha) under this cropping pattern existed in Chapai sadar upazila decreasingly followed by Porsha and Raninagar upazila where each of two upazila held only 150 ha of land.

#### Fourth dominant cropping pattern

The fourth dominant cropping pattern in Rajshahi region was Mustard-Boro-T. Aman existed in 17 upazilas representing 3.70% share of NCA (Table 12). The area coverage under this pattern remained higher (4,700 ha each) in Patnitala and Manda upazilas of Naogaon district. The distribution of %NCA under this pattern in Patnitala and Manda upzilas was 15.6% for both. Dhamoirhat upazila ranked in 3<sup>rd</sup> in terms of area coverage (3,000 ha) and % NCA (12.93%) for this pattern. Out of top 11 upazilas of Rajshahi region, the Mustard-Boro- T. Aman

cropping pattern existed in top 10 upazilas of Naogaon district covering 88% (22600 ha) of total Mustard-Boro- T. Aman area in the region indicating that the Naogaon district remained predominated with this pattern. In the country-wide compilation of data it was observed that Mustard–Boro– T. Aman was the 6<sup>th</sup> 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).

#### Fifth dominant cropping pattern

Fifth dominant cropping pattern Boro-Aus-T. Aman existed in 17 upazilas of Rajshahi region covering 25,290 ha of land (Table 13). The pattern represented 3.65% of NCA where Niamatpur upazila of Naogaon district ranked

**Table 10. Distribution of the 2<sup>nd</sup> dominant Boro-Fallow-Fallow cropping patterns in Rajshahi region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Singra	7200	16.72	14.36
02 Atrai	5900	25.00	11.77
03 Naogaon sadar	5500	27.23	10.97
04 Manda	4000	13.27	7.98
05 Naldanga	3500	28.57	6.98
06 Baghmara	2800	9.98	5.59
07 Porsha	2500	11.63	4.99
08 Shapahar	2500	12.69	4.99
09 Gomastapur	2300	9.47	4.59
10 Mohanpur	2250	19.91	4.49
11 Raninagar	2100	10.19	4.19
12 Durgapur	1500	11.45	2.99
13 Paba	1100	7.41	2.19
14 Baraigram	1000	4.46	1.99
15 Gurudaspur	1000	6.62	1.99
16 Patnitala	800	2.66	1.60
17 Nachol	600	2.40	1.20
18 Shibganj	600	2.64	1.20
19 Niamatpur	500	1.53	1.00
20 Bagha	500	5.59	1.00
21 Bholahat	500	5.68	1.00
22 Tanor	450	2.01	0.90
23 Puthia	400	3.86	0.80
24 Dhamoirhat	300	1.29	0.60
25 Bagatipara	130	2.89	0.26
26 Godagari	100	0.25	0.20
27 Chapai sadar	50	0.18	0.10
28 Chorghat	50	0.61	0.10
Rajshahi region	50130	7.23	100.00

the top position in terms of area coverage (6,000 ha) and % NCA (18.4%). Next to Niamatpur, Gomastapur upazila of Chapainawabganj district occupied the highest area (3,600 ha) and % of NCA (14.8%) for the pattern. Patnitala and Raninagar upazilas of Naogaon district ranked in 3<sup>rd</sup> position with this pattern in terms of area coverage and %NCA, respectively. The area coverage as well as of %NCA under Boro-Aus- T. Aman cropping system remained lower in Mohanpur upazila of Rajshahi district represented only 0.02% of total Boro-Aus-T. Aman area in the region.

#### **Crop diversity and cropping intensity**

A wide variation was observed in cropping patterns and crops among the different

upazilas of Rajshahi region (Table 14). A total of 172 cropping patterns were recognized in this region. The maximum (36) numbers of cropping patterns were identified in Paba upazila nearly followed by Durgapur (35) and Chapainawabganj upazila (34) while the lower numbers of cropping patterns were found in Chorghat (11), which is decreasing followed by Bagha (12) upazila of Rajshahi district. It was evident that Rajshahi region represented a lower rainfall area in the country and thus BMDA established lots of deep tube-wells for irrigation purpose. It has been assumed that lower number of cropping patterns existed in those upazilas where irrigation facilities were limited. The higher number of cropping patterns is generally related to higher level of diversity for cropping pattern.

**Table 11. Distribution of the 3<sup>rd</sup> dominant Wheat–Fallow–T. Aman cropping patterns in Rajshahi region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Shapahar	7500	38.07	24.89
02 Godagari	6000	15.17	19.91
03 Nachol	5000	20.00	16.59
04 Gomastapur	4600	18.93	15.27
05 Niamatpur	2500	7.67	8.30
06 Paba	1100	7.41	3.65
07 Bholahat	1100	12.50	3.65
08 Durgapur	730	5.57	2.42
09 Manda	700	2.32	2.32
10 Bagatipara	300	6.67	1.00
11 Dhamoirhat	200	0.86	0.66
12 Raninagar	150	0.73	0.50
13 Porsha	150	0.70	0.50
14 Chapai sadar	100	0.35	0.33
Rajshahi region	30130	4.34	100.00

**Table 12. Distribution of the 4<sup>th</sup> dominant Mustard–Boro–T. Aman cropping patterns in Rajshahi region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Patnitala	4700	15.64	18.32
02 Manda	4700	15.59	18.32
03 Dhamoirhat	3000	12.93	11.70
04 Naogaon sadar	2500	12.38	9.75
05 Niamatpur	2100	6.44	8.19
06 Mohadebpur	1600	5.18	6.24
07 Raninagar	1400	6.80	5.46
08 Shapahar	1000	5.08	3.90
09 Porsha	1000	4.65	3.90
10 Tanor	850	3.79	3.31
11 Badalgachhi	600	3.77	2.34
12 Nachol	600	2.40	2.34
13 Naldanga	500	4.08	1.95
14 Paba	400	2.69	1.56
15 Gomastapur	400	1.65	1.56
16 Shibganj	200	0.88	0.78
17 Bholahat	100	1.14	0.39
Rajshahi region	25650	3.70	100.00

The highest (0.972) diversity index for cropping pattern was found Bagatipara upazila of Natore district followed by Puthia (0.965) upazila of Rajshahi district while the lowest value of diversity for cropping pattern remained in Raninagar upazila of Naogaon district. Crop diversity index (CDI) ranged from 0.528 in Bagmara upazila to 0.989 in Puthia upazila of Rajshahi district. Next to Puthia, the CDI remained higher (0.979) in Charghat and Durgapur upazila of Rajshahi district indicated that this district represented a diversified cropping zone. The

highest cropping intensity (253%) remained in Badalgachhi upazila of Naogaon district closely followed by Mohanpur (252) upazila of Rajshahi district. Next to Mohanpur upazila, the highest cropping intensity existed in Mohadebpur upazila of Naogaon district while the lowest cropping intensity was found in Bagha (171%) upazila of Rajshahi district. However, the average cropping intensity in Rajshahi region was 218%. 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

**Table 13. Distribution of the 5<sup>th</sup> dominant Boro–Aus–T. Aman cropping patterns in Rajshahi region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Niamatpur	6000	18.40	23.72
02 Gomastapur	3600	14.81	14.23
03 Patnitala	2900	9.65	11.47
04 Singra	2800	6.50	11.07
05 Raninagar	2500	12.14	9.89
06 Chapai sadar	2040	7.18	8.07
07 Shapahar	1000	5.08	3.95
08 Naogaon sadar	1000	4.95	3.95
09 Godagari	900	2.28	3.56
10 Tanor	700	3.13	2.77
11 Nachol	700	2.80	2.77
12 Baraigram	500	2.23	1.98
13 Bholahat	300	3.41	1.19
14 Natore sadar	100	0.85	0.40
15 Porsha	100	0.47	0.40
16 Dhamoirhat	100	0.43	0.40
17 Mohanpur	50	0.44	0.20
Rajshahi region	25290	3.65	100.00

**Table 14. Crop diversity and cropping intensity in Rajshahi region, 2014-15.**

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Bholahat	13	09	0.923	0.962	203
02 Chapainawabganj	34	19	0.862	0.942	238
03 Gomastapur	29	18	0.859	0.929	199
04 Nachol	20	11	0.876	0.943	207
05 Shibganj	14	13	0.869	0.925	226
06 Atrai	18	13	0.853	0.933	190
07 Badalgachhi	19	12	0.694	0.897	253
08 Dhamoirhat	21	16	0.665	0.867	228
09 Manda	32	19	0.884	0.951	223
10 Mohadebpur	23	12	0.762	0.914	251
11 Naogaon sadar	26	17	0.814	0.926	209
12 Niamatpur	16	09	0.810	0.918	224
13 Porsha	16	11	0.831	0.922	209
14 Patnitala	15	12	0.775	0.907	227
15 Raninagar	18	13	0.596	0.823	215
16 Shapahar	15	11	0.803	0.906	202
17 Bagatipara	15	13	0.972	0.978	172
18 Baraigram	21	12	0.930	0.969	232
19 Gurudaspur	29	17	0.929	0.969	223
20 Lalpur	20	17	0.905	0.949	234
21 Natore	20	14	0.953	0.970	215
22 Naldanga	12	07	0.852	0.931	188
23 Singra	17	13	0.749	0.881	201
24 Charghat	11	07	0.955	0.979	240
25 Bagha	12	07	0.933	0.956	171
26 Bagmara	22	13	0.664	0.528	206
27 Durgapur	35	21	0.940	0.979	243
28 Godagari	29	18	0.859	0.934	206
29 Mohanpur	15	08	0.801	0.916	252
30 Paba	36	24	0.911	0.958	242
31 Puthia	21	17	0.965	0.989	210
32 Tanor	16	11	0.799	0.902	224
Rajshahi regeion	172	34	0.928	0.970	218

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). The farmers of Kerala diversified their cropping pattern to minimize risk from due to crop failures and price fluctuations (Mahesh, 1999).

## CONCLUSION

The survey results conducted in 32 upazilas of Rajshahi region indicated that the Boro-Fallow-T. Aman was the most predominant cropping pattern. The number of cropping pattern ranged from 11 to 35 while the cropping intensity values varied from 171 to 253%. The average cropping intensity of the region is 218% which is higher than the national average. A wide ranged also existed in CDI. Based on the findings following recommendations were made.

- Initiative to be taken to increase productivity of exclusive rice based cropping pattern. As rice is the synonym of the primary food security, the high yielding stress tolerant varieties of rice along with recommended crop management packages to be adopted.
- The upazila s having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate to similar environments.
- In the single Boro area suitable vegetables might be grown on floating bed system in wet season.
- A large portion of single T. Aman area might be intensified by the inclusion of some stress-tolerant Rabi crops like felon, grasspea etc.

## REFERENCES

Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.

Ali, M Y. 2000. Influence of phosphorus fertilizer and soil moisture regimes on root system development growth dynamics and yield of chickpea. PhD thesis, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur 1706.

Blade, S F and A E Slinkard 2002. New Crop Development: The Canadian Experience. *In: Trends in New Crops and New Uses.* J Janick and A Whipkey (Editors). ASHS Press, Alexandria.

FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.

Gadge, S S. 2003. Influence of changes in cropping pattern on farmers' economic status. *Indian J. Ext. Edu.* 39(1&2): 99-101.

Idris, K M, N M Huq. 1987. Soil moisture status of *Barind Tract*. Soil Resources and Development Institute. Rajshahi 25:21.

Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.

Mahesh, R. 1999. Causes and consequences of change in cropping pattern: A location specific study. Discussion Paper No. 11, Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapura.

Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.

Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 273-288.

Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.

Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.

Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-122.

Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems.* 49(3): 301-318.

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

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
001 Boro-Fallow-T. Aman	158390	065 Mustard-Boro-Aus-T. Aman	1700
002 Boro-Fallow-Fallow	50130	066 Mustard-Mungbean-T. Aman	1700
003 Wheat-Fallow-T. Aman	30130	067 Vegetab-Aus-T. Aman	1640
004 Mustard-Boro-T. Aman	25650	068 Vegetab-Fallow-T. Aman	1550
005 Boro-Aus-T. Aman	25290	069 Boro-Jute-T. Aman	1500
006 Fallow-Fallow-T. Aman	19100	070 Mustard-Aus-Blackgram	1500
007 Wheat-Aus-T. Aman	16010	071 Vegetab-Aus-Blackgram	1500
008 Potato-Boro-T. Aman	15610	072 Grasspea-B.Aman	1380
009 Mustard-Boro-Fallow	13050	073 Maize-Aus-Blackgram	1300
010 Wheat-Mungbean-T. Aman	12570	074 Potato-Aus-Fallow	1300
011 Wheat-Aus-Blackgram	12030	075 Boro-Jute-Fallow	1200
012 Boro-B.Aman	11650	076 Wheat-Vegetab-T. Aman	1160
013 Vegetab-Vegetab-Vegetab	10715	077 Wheat-B.Aman	1150
014 Wheat-Jute-T. Aman	10270	078 Onion-Maize-T. Aman	1050
015 Mustard-Boro-Aus	10200	079 Garlic-Vegetab-Vegetab	1030
016 Boro-Aus-Fallow	9500	080 Fallo-Fallo-T. Aman(Orchard)	1000
017 Boro-Aus-Blackgram	8000	081 Maize-Fallow-Fallow	1000
018 Potato-Boro-Aus	7200	082 Potato-Chilli-Fallow	980
019 Wheat-Aus-Fallow	7020	083 Onion-Aus-Blackgram	870
020 Wheat-Jute-Fallow	6720	084 Lentil-Vegetab-Vegetab	760
021 Felon-Fallow-T. Aman	6400	085 Wht-Sesame-B.gram(Orchard)	730
022 Garlic-B.Aman	6200	086 Lentil-Aus-T. Aman	710
023 Fallow-Aus-T. Aman	6120	087 Lentil-Sesame-T. Aman	710
024 Mustard-Fallow-T. Aman	6000	088 Potato-Maize-Aus-Vegetab	700
025 Potato-Boro-Fallow	5800	089 Potato-Vegetab-T. Aman	700
026 Potato-Maize-T. Aman	5350	090 Chilli-Fallow-T. Aman	670
027 Onion-Aus-Fallow	4450	091 Garlic-Aus-Fallow	660
028 Lentil-Fallow-T. Aman	4370	092 Boro-Vegetab(Float/Norm)	630
029 Garlic-Jute-Fallow	4310	093 Lentil-Aus-Fallow	620
030 Potato-Fallow-T. Aman	4050	094 Chilli-Vegetab-Fallow	600
031 Potato-Maize-Aus	4000	095 Mungbean-Aus-T. Aman	600
032 Mustard-Aus-T. Aman	3800	096 Boro-Sesbania-T. Aman	580
033 Maize-Fallow-T. Aman	3780	097 Wheat-Vegetab-Vegetab	500
034 Wheat-F-T. Aman(Orchard)	3700	098 Garlic-Aus-T. Aman	490
035 Vegetab-Aus-Fallow	3680	099 Maize-Aus-T. Aman	440
036 Vegetab-Vegetab-T. Aman	3550	100 Vegetab-Maize-Fallow	430
037 Vegetab-Vegetab-Fallow	3500	101 Garlic-Fallow-T. Aman	410
038 Maize-Fallow-Blackgram	3350	102 Chilli-Aus-Fallow	400
039 Wheat-Maize-T. Aman	2920	103 Maize-Maize-Fallow	400
040 Lentil-Maize-T. Aman	2890	104 Onion-Maize-Fallow	400
041 Lentil-Fallow-F (Orchard)	2780	105 Vegetab-B.Aman	400
042 Onion-Jute-T. Aman	2750	106 Wheat-Jute-Blackgram	370
043 Wheat-Mungbean-Fallow	2670	107 Boro-Maize-Blackgram	350
044 Chilli-Aus-T. Aman	2600	108 Boro-Maize-Fallow	350
045 Potato-Aus-T. Aman	2600	109 Grasspea-Fallow-T. Aman	350
046 Garlic-Mungbean-T. Aman	2500	110 Garlic+Muskmelon-B.Aman	320
047 Potato-Jute-Fallow	2450	111 Garlic+W.Melon-B.Aman	320
048 Lentil-Jute-T. Aman	2410	112 Lentil-Sesame-Fallow	300

**Appendix 1. Continued.**

Cropping pattern	Area (ha)	Cropping pattern	Area (ha)
049 Onion-Vegtab-Vegtab	2370	113 Maize-Aus-Fallow	300
050 Garlic-Jute-T. Aman	2320	114 Potato-Maize-Vegtab	300
051 Wheat-Mung-F (Orchard)	2150	115 Vegtab-Boro-T. Aman	300
052 Chickpea-Fallow-T. Aman	2110	116 Vegtab-Jute-Fallow	300
053 Vegtab-Onion-Aus	2100	117 Wheat-Chilli-Fallow	290
054 Wheat-Sesame-T. Aman	2100	118 Onion-Sesame-Fallow	280
055 Onion-Jute-Fallow	2010	119 Potato-Maize-Fallow	270
056 Boro-Fallow-Blackgram	2000	120 Vegtab-Jute-T. Aman	270
057 Maize-B.Aman	2000	121 Grasspea-Aus-Blackgram	250
058 Potato-Jute-T. Aman	1980	122 Mustard-Aus-Fallow	250
059 Wheat-Aus-Onion	1900	123 Chilli-Fallow-Fallow	240
060 Onion-Fallow-T. Aman	1840	124 Potato-Boro-Aus-T. Aman	230
061 Grasspea-Boro-Aus	1800	125 Coriander-Fallow-Fallow	220
062 Mustard-Boro-B.Aman	1800	126 S.Potato-Fallow-Fallow	220
063 Potato-Boro-Jute-T. Aman	1800	127 Chilli-Vegtab-T. Aman	210
064 Lentil-Mungbean-T. Aman	1750	128 Groundnut-Fallow-Fallow	210
		129-172 Other 44 patterns (Table 8)	3730

# Crop Diversification in Rangpur Region

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## ABSTRACT

For the planning of future research and development elaborate information and a reliable database on existing cropping patterns, cropping intensity and crop diversity of a particular area are of prime importance for guiding policy makers, researchers, extensionists and development workers. A massive group work was accomplished over all 35 upazilas of Rangpur region during 2016 using pre-tested semi-structured questionnaire with a view to document the existing cropping patterns, cropping intensity and crop diversity in the area. Boro-Fallow-T. Aman occupied the largest portion (53%) of net cropped area (NCA) with its distribution in all upazilas. The second largest area, 5% of NCA, was covered by Maize-Fallow-T. Aman which was spread out over 23 upazilas. Under the current investigation 134 cropping patterns were identified. The highest number of cropping patterns was identified 31 in Badarganj of Rangpur and the lowest was 10 in Razibpur of Kurigram district. The highest value of CDI was observed 0.991 in Razibpur upazila followed by 0.989 in Chilmari of Kurigram. The range of cropping intensity values was recorded 190-255%. The maximum value was for Gangachara upazila of Rangpur and minimum for Gaibandha sadar upazila. The overall CDI of Rangpur region was calculated 0.871 and the average cropping intensity at regional level was 219%.

**Key words:** Cropping system, tobacco, land use, diversity index and Jamuna Floodplain

## INTRODUCTION

Five districts namely Rangpur, Gaibandha, Nilphamari, Lalmonirhat and Kurigram are included in Rangpur region. It belongs to mainly Tista Meander Floodplain (AEZ-3) and also to North-eastern Barind Tract (AEZ-27), Active Tista Floodplain (AEZ-2), Active Brahmaputra-Jamuna Floodplain (AEZ-7) and Young Brahmaputra and Jamuna Floodplains (AEZ-8). In this region some areas are susceptible to flooding when the Jamuna river overflows its banks leaving local communities without land, housing and sanitation, or any assets to make normal living to continue. Extreme weather events are already affecting crop production and water resources in this region. The region has been facing the early impact of climate change. These changes have already creates major impacts on the livelihoods of the large number of poor people. It has reduced fresh water availability, increased drought, floods, and natural disaster in different forms.

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

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production (Shriar, 2000). There is a strong need for judicious and appropriate use limited resources in case of intervention selection that does not lead to increased mal adaptation or inequity in the society over long term. Existing trend of available agricultural lands are most essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping system is essential for the appropriate intervention in sustainable way. In these context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial for risk minimization and overall productivity improvement. The present study was designed with the following specific objectives to:

- understand the existing cropping patterns scenario in Rangpur region
- visualize the existing land use pattern at upazila and regional level
- determine the crop diversity and cropping intensity at local and regional level.

## METHODOLOGY

Thirty-five upazilas of Rangpur, Gaibandha, Nilphamari, Lalmonirhat and Kurigram were the location of this study. Data were collected using double stage procedure. At initial stage, data were collected through pre-tested semi-structured questionnaire from 35 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during June 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 the Directorate of Agricultural Extension (DAE) during monthly meeting for the sake of accurate data collection.

The scientists of RFS Division collected The filled questionnaires, checked and analyzed those 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 day-long data validation workshop at district level. The workshop dates were 30 August for Kurigram; 31 August for Rangpur; 19 September for Lalmonirhat; 21 September for Gaibandha; and 5 October 2016 for Nilphamari. 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, Rangpur participated in the data validation workshop. The number of participants of validation workshop ranged from 48 to 84 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 lists status of agricultural land utilization. The net cropped area of the Rangpur region is 696,420 ha. Crops occupying the particular land for round the year were considered under annual crops. The major annual crops reported in the region were pineapple, sugarcane, banana, papaya, betel leaf, ginger and turmeric. The annual crops area in different upazilas ranged from 20 to 2,610 ha. The annual crops area accounted only 2% of the net cropped area (NCA) in the region. At a glance the region possesses about 6% single cropped area (SCA), 64% double cropped area (DCA), 27% triple cropped area (TCA). The quadruple cropped area (QCA) also exists as a very negligible portion (0.03%) and is limited in only two upazilas viz Gangachara and Rowmari. The SCA had the major share of NCA in Pirganj upazilas of Rangpur district; Chilmari and Nagesawari of Kurigram district; Sundarganj, Fulchhari and sadar upazila of Gaibandha district followed by corresponding double cropped area (DCA). Pirgachha upazila of Rangpur district, Palasbari of Gaibandha, Saidpur and Dimla of Nilphamari had no single cropped area at all. Most of the upazilas were dominated by DCA. The exceptions are Gangachara upazila of Rangpur district where triple cropped area is the dominating one (Table 1). 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 Rangpur

In total 134 cropping patterns were observed in Rangpur region of which five cropping patterns with exclusive rice crop covers over 58% of the NCA. There were 49 cropping patterns with exclusive non-rice crop covering over 6% of the NCA. Rest of the NCA ie about 36% area is covered by 80 rice - non rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Rice is the only crop round the year in five cropping patterns (Table 2). It comprises

58.32% of the NCA in the region. Among them single rice and double rice represent around 4.12% and 54.20% respectively. There is no triple rice area in Rangpur region. It reflects the unparallel dominance of rice in the cropping systems in Rangpur region. In case of individual pattern Boro-Fallow-T. Aman has the highest coverage (53.33%) and was recorded in all 35 upazilas. The second dominant pattern single Boro area occupied 4.07% of NCA which was reported in 28 upazilas. Single T. Aman covered 0.05% area with its existence in Rangpur sadar upazila only.

In the current investigation, 49 cropping patterns were identified that was free from rice. Among them, first 30 have been arranged in descending order (Table 3). The rest 19 patterns with negligible area coverage are arranged in Table 8 with other patterns of different categories. Aggregate of the 49 patterns have had 6.41% of NCA. In critical comparison is clear that exclusive rice area is about nine folds of exclusive non-rice area. In Rangpur region crop diversity is much wider than that of other regions like Sylhet and Chittagong where exclusive rice area covers 37 folds and 23 fold, respectively, of exclusive non-rice area (Muttaleb *et al.*, 2017; Shahidullah *et al.*, 2017). 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 cropping 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).

### Non-rice cereal crops

Thirty-five cropping patterns holding different non-rice cereal crops viz maize, wheat, millets (*cheena* and *kaon*) (Table 4) which in-together covered 15.82% of NCA. Among them two cropping patterns viz Maize-Fallow-T. Aman and Wheat-Jute-T. Aman jointly occupied 8.65% of NCA. Maize is covering the largest

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Rangpur	13981	190	470	7510	3250	0	170	11590	223
02 Gangachara	24574	140	500	8150	11720	200	130	20840	255
03 Kaunia	14757	200	600	5620	5460	0	120	12000	239
04 Pirgachha	26518	630	0	13580	5500	0	120	19830	225
05 Pirganj	40932	940	5390	19000	7200	0	110	32640	203
06 Badarganj	30127	900	350	14010	6880	0	160	22300	225
07 Mithapukur	51584	630	1510	26320	15950	0	120	44530	231
08 Taraganj	12866	720	150	7300	3180	0	170	11520	220
09 Gaiba. sadar	32024	30	3340	14650	1360	0	150	19530	190
10 Palasbari	18525	500	0	11670	1950	0	130	14250	210
11 Gobindaganj	46003	2610	1740	20100	11780	0	180	36410	221
12 Saghata	23109	100	1080	11350	4220	0	150	16900	218
13 Fulchhari	30654	20	2270	11370	2320	0	140	16120	200
14 Sundarganj	41214	270	2090	23550	4950	0	110	30970	208
15 Sadullapur	22800	580	20	13290	3100	0	190	17180	215
16 Kurigram	26566	500	900	11140	6370	0	190	19100	226
17 Ulipur	45867	60	1450	17510	5090	0	150	24260	215
18 Chilmari	22998	50	3500	5750	2500	0	150	11950	191
19 Rowmari	19200	190	140	7630	5900	10	120	13990	240
20 Razibpur	11303	240	1750	4140	2480	0	130	8740	206
21 Bhurungamari	22800	220	1230	11190	4640	0	140	17420	218
22 Nageswari	42080	160	4000	19265	4275	0	160	27860	200
23 Phulbari	15658	250	50	9500	2600	0	150	12550	219
24 Rajarhat	16622	90	1010	9630	2610	0	150	13490	211
25 Nilphamari	37308	140	1200	18230	10510	0	160	30240	230
26 Saidpur	12167	160	0	7360	1420	0	120	9060	214
27 Domar	25084	310	150	14540	4920	0	140	20060	222
28 Dimla	32688	640	1050	16710	4940	0	100	23440	214
29 Jaldhaka	33675	540	0	16990	6030	0	130	23690	223
30 Kishoreganj	20502	520	250	7510	6690	0	150	15120	240
31 Lalmonirhat	26075	500	500	11300	6820	0	180	19300	230
32 Aditmari	19503	280	1090	8520	6115	0	125	16130	230
33 Kaliganj	23694	170	250	15040	3860	0	150	19470	218
34 Hatibandha	28777	230	1050	15820	5770	0	160	23030	220
35 Patgram	26151	110	200	16060	4390	0	150	20910	220
Rangpur region		13820	39280	451305	186750	210	5055	696420	219

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Boro-Fallow-T. Aman	371370	53.33	35
02 Boro-Fallow-Fallow	28320	4.07	28
03 Boro-Aus-T. Aman	5640	0.81	13
04 Fallow-Fallow-T. Aman	350	0.05	1
05 Boro-Sesbania-T. Aman	480	0.07	3
Total	406160	58.32	

**Table 3. Cropping patterns with exclusivenon-rice in Rangpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Vegetab	10590	1.52	25
02 Vegetab-Vegetab-Fallow	4670	0.67	11
03 Maize-Fallow-Fallow	4220	0.61	6
04 Groundnut-Fallow-Fallow	2430	0.35	9
05 Chilli-Jute-Fallow	1950	0.28	6
06 Tobacco-Vegetab-Vegetab	1500	0.22	1
07 Wheat-Jute-Fallow	1460	0.21	6
08 Chilli-Vegetab-Fallow	1340	0.19	16
09 Maize-Jute-Fallow	1150	0.17	3
10 Vegetab-Fallow-Fallow	1150	0.17	3
11 Maize-Vegetab-Fallow	1120	0.16	4
12 Onion-Vegetab-Vegetab	1050	0.15	7
13 Onion-Jute-Fallow	980	0.14	5
14 Potato-Groundnut	930	0.13	6
15 Millet ( <i>cheena</i> )-Fallow-Fallow	890	0.13	3
16 S.Potato-Jute-Fallow	770	0.11	2
17 Lentil-Jute-Fallow	760	0.11	4
18 Vegetab-Jute-Fallow	730	0.10	3
19 Tobacco-Maize-Vegetab	600	0.09	1
20 Garlic-Vegetab-Vegetab	580	0.08	6
21 Chilli-Fallow-Fallow	530	0.08	4
22 Vegetab-Fallow-Blackgram	530	0.08	8
23 Maize-Sesame-Fallow	500	0.07	1
24 Tobacco-Fallow-Fallow	490	0.07	2
25 Millet ( <i>cheena</i> )-Jute-Fallow	450	0.06	1
26 S.Potato-Fallow-Fallow	360	0.05	5
27 Fallow-Fallow-Blackgram	290	0.04	4
28 Garlic-Jute-Fallow	260	0.04	4
29 Wheat-Ginger/Turmeric	230	0.03	1
30 Blackgram-Jute-Fallow	200	0.03	1
31-49 Other 19 patterns (in Table 8)	1930	0.28	-
Total for exclusive non-rice crop	44640	6.41	

area whereas millet is cultivated in the smallest area. After Maize, wheat is widely cultivated cereal crops under diversified cropping systems in Rangpur region. There were 21 patterns based on maize, which all-together covers 81,130 ha of land (11.65% of NCA) in the region. Wheat was leading 11 cropping patterns with an area coverage of 26,925 ha (3.87% of NCA). In Bangladesh there is a vast market of wheat for human consumption and maize seeds for feed industries. Local production of wheat and maize is extremely insignificant to meet up the demand. The situation is increasing our dependency on import causing a great pressure on foreign currency (BBS, 2014). Loam and

sandy-loam soil of the comparative dry area is very suitable for maize cultivation. Wheat cultivation with its better yield in this region is specially favoured by long winter season that is normally unavailable in southern parts of the country. Light textured soil with low water-holding capacity as well as less availability of irrigation water are driving forces that discourage the farmers for modern Boro cultivation. During the harvesting period of wheat the crop is privileged by clear sun-shine and low humidity. All these are the factors for which this area is dominated by maize and wheat cropping systems (FAO, 1988).

**Table 4. Cropping patterns with wheat and maize and other minor cereals in Rangpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Maize-Fallow-T. Aman	37630	5.40	24
02 Wheat-Jute-T. Aman	22660	3.25	34
03 Potato-Maize-T. Aman	12720	1.83	22
04 Maize-Jute-T. Aman	9760	1.40	16
05 Tobacco-Maize-T. Aman	6880	0.99	9
06 Maize-Fallow-Fallow	4220	0.61	6
07 Vegetab-Maize-T. Aman	2520	0.36	6
08 Boro-Fallow-Maize	1500	0.22	1
09 Wheat-Jute-Fallow	1460	0.21	6
10 Wheat-Fallow-T. Aman	1260	0.18	6
11 Maize-Jute-Fallow	1150	0.17	3
12 Maize-Vegetab-Fallow	1120	0.16	4
13 Maize-Aus-T. Aman	930	0.13	3
14 Millet ( <i>cheena</i> )-Fallow-Fallow	890	0.13	3
15 Millet ( <i>kaon</i> )-Fallow-T. Aman	800	0.11	2
16 Wheat-Aus-T. Aman	650	0.09	10
17 Tobacco-Maize-Vegetab	600	0.09	1
18 Mustard-Maize-T. Aman	550	0.08	3
19 Maize-Sesame-Fallow	500	0.07	1
20 Millet ( <i>cheena</i> )-Jute-Fallow	450	0.06	1
21 Wheat-Vegetab-T. Aman	305	0.04	2
22 Wheat-Ginger/Turmeric	230	0.03	1
23 Onion-Maize-T. Aman	220	0.03	2
24 Maize-Boro-T. Aman	200	0.03	1
25 Potato+Maize-Vegetab-T. Aman	200	0.03	1
26 Millet ( <i>kaon</i> )+Sesame-Fallow	40	0.01	1
27-35 Other nine patterns (in Table 8)	710	0.10	-
Total of non-rice cereal crops	110155	15.82	

### Vegetables and spices crops

Sixty-three cropping patterns have been arranged in descending order according to area coverage (Table 5). Potato and other vegetables of Rabi, Kharif-I and Kharif-II; spices (chilli, onion, garlic, coriander and black cumin) are included in this list. Total area for vegetables and spices crops in the region is 127,455 ha (18.30% of NCA). The most contributing cropping pattern is Potato-Boro-T. Aman covering 5.16% of NCA, which is distributed over 22 upazilas. The second one is Potato-Maize-T. Aman covering 1.83% of NCA. Year-round vegetables here is the most available pattern recorded in 25 upazilas out of 35. 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 vegetables, good communication and marketing facilities enhanced the extensive production of various types of vegetables in Rangpur region (FAO, 1988). Vegetables like colocasia, okra, amaranthus, brinjal, cucurbits, etc are grown in medium upland adjacent to rice fields during rainy season and potato, sweet gourd, cole crops, leafy vegetables etc are grown during winter season in Tripura (Das *et.al.*, 2015).

### Pulses and oil-seed crops

Forty-three cropping patterns are holding different pulses and oilseed crops (Table 6). Among them mustard is covering the largest area. Nine cropping patterns of mustard all-together cover 29,210 ha (4.19% of NCA). The second largest area is covered by groundnut. There were five cropping patterns for

**Table 5. Cropping patterns with vegetables and spices in Rangpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Potato-Boro-T. Aman	35960	5.16	22
02 Potato-Maize-T. Aman	12720	1.83	22
03 Potato-Jute-T. Aman	10790	1.55	24
04 Vegetab-Vegetab-Vegetab	10590	1.52	25
05 Potato-Aus-T. Aman	6470	0.93	16
06 Vegetab-Vegetab-Fallow	4670	0.67	11
07 Potato-Fallow-T. Aman	3850	0.55	5
08 Onion-Jute-T. Aman	3720	0.53	20
09 Vegetab-Vegetab-T. Aman	2710	0.39	12
10 Chilli-Fallow-T. Aman	2660	0.38	9
11 Vegetab-Maize-T. Aman	2520	0.36	6
12 Potato-Vegetab-T. Aman	2390	0.34	9
13 Potato-Boro-Fallow	2000	0.29	1
14 Chilli-Jute-Fallow	1950	0.28	6
15 Vegetab-Fallow-T. Aman	1650	0.24	7
16 Chilli-Jute-T. Aman	1560	0.22	9
17 Vegetab-Boro-T. Aman	1520	0.22	4
18 Tobacco-Vegetab-Vegetab	1500	0.22	1
19 Garlic-Jute-T. Aman	1380	0.20	16
20 Chilli-Vegetab-Fallow	1340	0.19	16
21 Vegetab-Fallow-Fallow	1150	0.17	3
22 Maize-Vegetab-Fallow	1120	0.16	4
23 Onion-Vegetab-Vegetab	1050	0.15	7
24 Onion-Jute-Fallow	980	0.14	5
25 Potato-Groundnut	930	0.13	6
26 Vegetab-Groundnut-T. Aman	860	0.12	2
27 Vegetab-Jute-Fallow	730	0.10	3
28 Vegetab-Aus-T. Aman	660	0.09	2
29 Boro-Vegetab(Float/Norm)	600	0.09	1
30 Tobacco-Maize-Vegetab	600	0.09	1
31 Vegetab-Jute-T. Aman	590	0.08	6
32 Garlic-Vegetab-Vegetab	580	0.08	6
33 Chilli-Fallow-Fallow	530	0.08	4
34 Vegetab-Fallow-Blackgram	530	0.08	8
35 Onion-Aus-T. Aman	400	0.06	1
36 Wheat-Vegetab-T. Aman	305	0.04	2
37 Vegetab-Boro-Fallow	300	0.04	1
38 Chilli-Vegetab-T. Aman	260	0.04	4
39 Garlic-Fallow-T. Aman	260	0.04	5
40 Garlic-Jute-Fallow	260	0.04	4
41 Onion-Fallow-T. Aman	260	0.04	3
42 Wheat-Ginger/Turmeric	230	0.03	1
43 Onion-Maize-T. Aman	220	0.03	2
44 Fallow-Vegetab-T. Aman	200	0.03	1
45 Potato+Maize-Vegetab-T. Aman	200	0.03	1
46-63 Other 18 patterns (in Table 8)	1700	0.24	-
Total vegetables and spices	127455	18.30	

groundnut, which unitedly has a coverage of 3,460 ha (0.50% of NCA). Other pulses and oil-seed crops hold a number of cropping patterns, however, with non-significant coverage for each individual. Oil is an essential ingredient of human food and also for feed industries. The country is almost dependent on import for oil. Mustard is a very potential crop that can be grown widely in various parts of the country (BBS, 2014). At present, the lion-share of mustard cultivation is related to the land for double rice. If technology transfer activities are strengthened much more area of the aforesaid category will be possible to make room for the mustard crop (FAO, 1988).

### **Hazardous crop**

In this investigation, tobacco was found to grow under eight cropping patterns covering 19,120 ha (Table 7) which is equivalent to 2.75% of total NCA in the region. The major pattern Tobacco–Maize–T. Aman solely cover 6,800 ha that represents one-third of total tobacco area. The most distributed pattern in this region is Tobacco–Fallow–T. Aman that found in 10 upazilas out of 35. Vegetables, fibre and cereal are grown after tobacco cultivation. Tobacco is one of the major cash crop in Rangpur region. But now-a-day's government and some other organizations are making campaign for not growing tobacco. In consideration of human health and social impact the tobacco crop is discouraged on principle. However, people of the concerned area can not give up the cultivation of tobacco. Farmers consider the crop as an insurance of his property. Industry personnel make assurance to purchase their products with price. Moreover, they pay money in advance as production cost. They supply all inputs and technologies for successful production of tobacco. These are privileges of farmers for tobacco cultivation.

### **Sporadic and distinct cropping patterns**

Tobacco–Vegetables–Vegetables is an extremely location specific cropping pattern which is limited only in Aditmari upazila of Lalmonirhat district with an area of 1,500 ha (Table 7). Potato–Boro–Fallow is another exception, which is practiced in Pirgachha

upazila of Rangpur district. This pattern has occupied an area of 2,000 ha (Table 5). The third one is Boro–F–Maize, which is practiced only in Gobindaganj upazila of Gaibandha district with an area coverage of 1,500 ha (Table 4).

### **Rare cropping patterns**

In the present investigation, 40 cropping patterns have been identified as rare cropping patterns with negligible area coverage and seldom existence (Table 8). These are location specific system and are limited in one to three upazilas of the region. Total area coverage of the 40 patterns is far less than 1% of NCA. Among them the highest area was allotted for Lentil–Vegetables–Vegetables (190 ha) and it is recorded only in Razibpur upazila of Kurigram district and Pirganj upazila of Rangpur district. The smallest area was recorded for two cropping patterns whose coverage was five hectares for each (Table 8).

### **Most dominant cropping pattern**

Boro–Fallow– T. Aman was the most dominant cropping pattern in Rangpur region. It covers 53.33% of NCA in the region and is available in almost all upazilas (Table 9). The highest area under this cropping was recorded 23,200 ha in Sundarganj upazila which represents 6.25% of the total Boro–Fallow–T. Aman area of the region. In consideration of individual upazila, Palasbari upazila stand 15<sup>th</sup> position (11,000 ha), however, this upazila has allocated highest share and it is 80% of its NCA for this pattern alone. Razibpur, Chilmari and Kaunia upazila had negligible area coverage for this cropping pattern. In the country-wide compilation of data it was observed that Boro–F–T. Aman was the most dominant cropping pattern in Bangladesh covering 2.31 million ha (27% of NCA in the country) with its distribution in 426 upazilas of 63 districts (Nasim *et al.*, 2017).

### **Second dominant cropping pattern**

The second dominant cropping pattern in Rangpur region is Maize–Fallow–T. Aman . It belongs to 5.40% of NCA of the region and spread out over 23 upazilas (Table 10). Patgram

**Table 6. Cropping patterns with pulses and oil-seed crops in Rangpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Mustard-Boro-T. Aman	22840	3.28	30
02 Mustard-Boro-Fallow	2650	0.38	5
03 Groundnut-Fallow-Fallow	2430	0.35	9
04 Mustard-Jute-T. Aman	2210	0.32	6
05 Potato-Groundnut	930	0.13	6
06 Vegetab-Groundnut-T. Aman	860	0.12	2
07 Lentil-Jute-Fallow	760	0.11	4
08 Boro-Fallow-Blackgram	700	0.10	2
09 Mustard-Maize-T. Aman	550	0.08	3
10 Vegetab-Fallow-Blackgram	530	0.08	8
11 Maize-Sesame-Fallow	500	0.07	1
12 Groundnut-Fallow-T. Aman	490	0.07	2
13 Lentil-Jute-T. Aman	460	0.07	10
14 Lentil-Fallow-T. Aman	440	0.06	4
15 Groundnut-Jute-T. Aman	390	0.06	3
16 Mustard-Aus-T. Aman	350	0.05	2
17 Mustard-Fallow-T. Aman	350	0.05	2
18 Blackgram-Jute-T. Aman	320	0.05	2
19 Fallow-Fallow-Blackgram	290	0.04	4
20 Blackgram-Jute-Fallow	200	0.03	1
21-43 Other 23 patterns (in Table 8)	1260	0.18	-
Total pulses and oil-seeds	39510	5.67	

**Table 7. Cropping patterns of hazardous crop in Rangpur region, 2014-15.**

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Tobacco-Maize-T. Aman	6880	0.99	9
02 Tobacco-Aus-T. Aman	3090	0.44	9
03 Tobacco-Jute-T. Aman	3010	0.43	9
04 Tobacco-Boro-T. Aman	1850	0.27	3
05 Tobacco-Fallow-T. Aman	1700	0.24	10
06 Tobacco-Vegetab-Vegetab	1500	0.22	1
07 Tobacco-Maize-Vegetab	600	0.09	1
08 Tobacco-Fallow-Fallow	490	0.07	2
Total	19120	2.75	

upazila of Lalmonirhat district holds the highest area of 10,200 ha followed by Hatibandha upazila of the same district (6,500 ha) under this Maize-Fallow-T. Aman cropping pattern. These two upazilas jointly contribute about 45% share of Maize-Fallow-T. Aman cropping area in the region. Sadullapur and Kishoreganj upazilas are holding the lowest area (below 1%) of this pattern.

### Third dominant cropping pattern

Potato-Boro-T. Aman cropping pattern holds the third largest area coverage 35,960 ha in Rangpur region. This area is an equivalent

to 5.16% of NCA in the region. Potato is the most cultivated vegetable crop in Rangpur region. This pattern Potato-Boro-T. Aman is distributed over 22 upazilas. Mithapukur upazila of Rangpur district has an area of 6,300 ha for this pattern, which alone stands for 17.52% of the total area under this pattern in the region (Table 11). In the country-wide compilation of data it was observed that Potato-Boro-T. Aman was the 8<sup>th</sup> dominant cropping pattern in Bangladesh covering 1.80 lac ha (2.11% of NCA in the country) with its distribution in 115 upazilas of 33 districts (Nasim *et al.*, 2017).

**Table 8. Rare cropping patterns covering non-significant area in Rangpur region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Lentil-Vegetab-Vegetab	190	0.03	2	Razibpur+Pirganj
02	Wheat-Vegetab-Vegetab	170	0.02	1	Badarganj
03	Coriander-Fallow-Fallow	160	0.02	3	Rowmari+Domar+Pirganj
04	Potato-Chilli-Fallow	160	0.02	1	Domar
05	Coriander-Jute-Fallow	150	0.02	2	Fulchhari+Saghata
06	Lentil-Sesame-Fallow	150	0.02	1	Kurigram sadar
07	Mustard-Jute-Fallow	150	0.02	1	Lalmonirhat sadar
08	Potato-Jute-Fallow	150	0.02	1	Nageswari
09	Maize-Mungbean-Vegetab	120	0.02	1	Kurigram sadar
10	S.Potato-Fallow-T. Aman	120	0.02	3	Kurigramsadar+Domar+Kishoreganj
11	Groundnut- Aus-Fallow	100	0.01	1	Nageswari
12	Mustard- Aus-Fallow	100	0.01	1	Pirganj
13	Vegetab-Jute-Vegetab	100	0.01	1	Kishoreganj
14	Coriander-Vegetab-Fallow	90	0.01	3	Dimla+Kishoreganj+Saidpur
15	Potato-Maize-Fallow	90	0.01	2	Rajarhat+Saidpur
16	Grasspea-Jute-T. Aman	80	0.01	2	Rajarhat+Sundarganj
17	Maize-Vegetab-T. Aman	80	0.01	2	Phulbari+Kaliganj
18	Wheat-Maize-T. Aman	80	0.01	1	Kurigram sadar
19	Potato-Mungbean-T. Aman	70	0.01	3	Kaliganj+Dimla+Badarganj
20	Coriander-Fallow-T. Aman	60	0.01	1	Jhaldhaka
21	Onion-Maize-Fallow	60	0.01	1	Lalmonirhat sadar
22	Wheat-Mungbean-T. Aman	60	0.01	3	Sundarganj+Domar+Kishoreganj
23	Grasspea-Fallow-T. Aman	50	0.01	1	Fulchhari
24	Groundnut-Sesame-Fallow	50	0.01	1	Sundarganj
25	Blackgram-Aus-T. Aman	40	0.01	1	Aditmari
26	Fallow-Sesame-T. Aman	40	0.01	1	Rajarhat
27	Millet( <i>kaon</i> )+Sesame-Fallow	40	0.01	1	Sundarganj
28	S.Potato-Vegetab-Fallow	40	0.01	2	Dimla+Mithapukur
29	Lentil-Vegetab-T. Aman	30	0.00	1	Phulbari
30	Wht-Sesame-B.gram(Orchard)	30	0.00	1	Badarganj
31	Blackcumin-Jute-Fallow	20	0.00	1	Rowmari
32	Sesame-Fallow-T. Aman	20	0.00	1	Aditmari
33	Wheat-Aus-Fallow	20	0.00	1	Bhurungamari
34	Grasspea-Fallow-Fallow	10	0.00	1	Gaibandha sadar
35	Lentil-Aus-T. Aman	10	0.00	1	Phulbari
36	Mustard-Boro-Jute-T. Aman	10	0.00	1	Rowmari
37	Potato-Groundnut-T. Aman	10	0.00	1	Kishoreganj
38	Potato-Sesame-T. Aman	10	0.00	1	Mithapukur
39	Mungbean-Fallow-T. Aman	5	0.00	1	Nageswari
40	Mungbean-Jute-T. Aman	5	0.00	1	Nageswari
	Total	2930	0.40		

**Table 9. Distribution of the most dominant Boro–Fallow–T. Aman cropping patterns in Rangpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Sundarganj	23200	74.91	6.25
02 Mithapukur	22500	50.53	6.06
03 Gobindaganj	17800	48.89	4.79
04 Nageswari	17400	62.46	4.69
05 Ulipur	17200	70.90	4.63
06 Nilphamri sadar	16000	52.91	4.31
07 Gaibandha sadar	14600	74.76	3.93
08 Pirganj	14000	42.89	3.77
09 Domar	13100	65.30	3.53
10 Kaliganj	12500	64.20	3.37
11 Sadullapur	12300	71.59	3.31
12 Badarganj	12000	53.81	3.23
13 Jaldhaka	12000	50.65	3.23
14 Saghata	11070	65.50	2.98
15 Palasbari	11000	77.19	2.96
16 Dimla	10700	45.65	2.88
17 Bhurungamari	10000	57.41	2.69
18 Rajarhat	9300	68.94	2.50
19 Kurigram sadar	9300	48.69	2.50
20 Phulbari	9200	73.31	2.48
21 Lal. sadar	9200	47.67	2.48
22 Hatibandha	8800	38.21	2.37
23 Aditmari	8400	52.08	2.26
24 Pirgachha	8000	40.34	2.15
25 Kishoreganj	7000	46.30	1.88
26 Gangachara	7000	33.59	1.88
27 Rangpur sadar	6800	58.67	1.83
28 Fulchhari	6700	41.56	1.80
29 Saidpur	6500	71.74	1.75
30 Taraganj	6000	52.08	1.62
31 Patgram	5700	27.26	1.53
32 Rowmari	5100	36.45	1.37
33 Kaunia	5000	41.67	1.35
34 Razibpur	3000	34.32	0.81
35 Chilmari	3000	25.10	0.81
Rangpur region	371370	53.33	100.00

#### Fourth dominant cropping pattern

Single Boro cropping pattern holds the fourth largest area coverage 28,320 ha in Rangpur region. This area is an equivalent to 4.07% of NCA in the region. This pattern Boro–Fallow–Fallow is distributed over 28 upazilas. Pirgachha has an area of 4,900 ha for single Boro which stands for 17.3% of the total area under this pattern in the region (Table 12). This pattern is frequent and concurrently experienced by early flash flood in April and cold injury at 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). In the country-wide compilation of data it was observed that the single Boro was the 2<sup>nd</sup> 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).

**Table 10. Distribution of the 2<sup>nd</sup> dominant Maize–Fallow–T. Aman cropping pattern in Rangpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Patgram	10200	49.04	27.11
02 Hatibandha	6500	28.51	17.27
03 Dimla	5000	21.93	13.29
04 Kaliganj	2250	11.66	5.98
05 Pirganj	2900	9.15	7.71
06 Mithapukur	3600	8.20	9.57
07 Jaldhaka	1350	5.83	3.59
08 Gobindaganj	1200	3.55	3.19
09 Nilphamari sadar	1000	3.32	2.66
10 Badarganj	750	3.50	1.99
11 Lalmonirhat sadar	600	3.19	1.59
12 Palasbari	400	2.91	1.06
13 Domar	370	1.87	0.98
14 Pirgachha	300	1.56	0.80
15 Nageswari	200	0.72	0.53
16 Rajarhat	200	1.49	0.53
17 Kaunia	200	1.69	0.53
18 Sundarganj	150	0.49	0.40
19 Ulipur	150	0.62	0.40
20 Kurigram sadar	100	0.54	0.27
21 Saaidpur	90	1.01	0.24
22 Sadullapur	60	0.36	0.16
23 Kishoreganj	50	0.34	0.13
Rangpur region	37630	5.40	100.00

**Table 11. Distribution of the 3<sup>rd</sup> dominant Potato–Boro–T. Aman cropping pattern in Rangpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Mithapukur	6300	14.35	17.52
02 Gobindaganj	4700	13.91	13.07
03 Nilphamari sadar	4000	13.29	11.12
04 Pirganj	3000	15.63	8.34
05 Kishoreganj	2100	14.38	5.84
06 Kaunia	1700	14.41	4.73
07 Badarganj	1500	7.01	4.17
08 Gangachara	1500	7.25	4.17
09 Pirgachha	1200	3.79	3.34
10 Jaldhaka	1170	5.05	3.25
11 Sundarganj	1100	3.58	3.06
12 Sadullapur	1000	6.02	2.78
13 Dimla	1000	4.39	2.78
14 Domar	1000	5.06	2.78
15 Saaidpur	800	8.99	2.22
16 Palasbari	800	5.82	2.22
17 Kurigram sadar	780	4.19	2.17
18 Rajarhat	700	5.22	1.95
19 Lalmonirhat sadar	550	2.93	1.53
20 Phulbari	500	4.07	1.39
21 Saghata	400	2.38	1.11
22 Patgram	160	0.77	0.44
Rangpur region	35960	5.16	100.00

### Fifth dominant cropping pattern

Fifth dominant cropping pattern Mustard–Boro–T. Aman had been covering 22,840 ha representing 3.28% share of NCA in Rangpur region (Table 13). This pattern is distributed over 30 upazilas where Gobindaganj ranked in top position. This upazila has 3,600 ha area for this pattern which is only 10.65% of upazila NCA. In consideration of area coverage Rowmari upazila stands in second position, however, it has allotted the biggest share ie 18.12% of upazila NCA. In the country-wide compilation of data, it was observed that Mustard–Boro–T. Aman was the 6<sup>th</sup> 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).

### 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 134 cropping patterns were identified in the whole area of Rangpur region under this investigation. The highest number of cropping patterns was identified 31 in Badarganj of Rangpur and Dimla upazila of Nilphamari respectively (Table 14). The lowest number of cropping patterns was identified 10 in Razibpur followed by 13 in Saghata and 14 in Rangpur sadar, Kaunia and Gobindaganj. Higher number of cropping patterns is generally related to higher level of diversity indices. The upazilas having lower number of cropping patterns were related to either drought or flood or both. The

**Table 12. Distribution of the 4<sup>th</sup> dominant Boro–F–F cropping pattern in Rangpur region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Pirgachha	4900	15.46	17.30
02 Nageswari	4000	14.44	14.12
03 Gaibandha	2400	12.31	8.47
04 Chilmari	1700	14.29	6.00
05 Gobindaganj	1600	4.73	5.65
06 Mithapukur	1500	3.42	5.30
07 Razibpur	1450	17.06	5.12
08 Bhurungamari	1200	6.98	4.24
09 Nilphamari sadar	1200	3.99	4.24
10 Fulchhari	1100	6.83	3.88
11 Saghata	1000	5.95	3.53
12 Aditmari	1000	6.31	3.53
13 Ulipur	750	3.10	2.65
14 Kurigram sadar	750	4.03	2.65
15 Rajarhat	700	5.22	2.47
16 Kaunia	600	5.08	2.12
17 Sundarganj	600	1.95	2.12
18 Lalmonirhat	500	2.66	1.77
19 Kaliganj	250	1.30	0.88
20 Badarganj	200	0.93	0.71
21 Kishoreganj	200	1.37	0.71
22 Patgram	200	0.96	0.71
23 Hatibandha	150	0.66	0.53
24 Rangpur sadar	120	1.05	0.42
25 Gangachara	100	0.48	0.35
26 Taraganj	50	0.46	0.18
27 Dimla	50	0.22	0.18
28 Phulbari	50	0.41	0.18
Rangpur region	28320	4.07	100.00

**Table 13. Distribution of the 5<sup>th</sup> dominant Mustard-Boro-T. Aman cropping pattern, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Gobindaganj	3600	10.65	15.76
02 Rowmari	2500	18.12	10.95
03 Badarganj	2000	9.35	8.76
04 Kurigram sadar	1500	8.06	6.57
05 Nageswari	1500	5.42	6.57
06 Nilphamari sadar	1500	4.98	6.57
07 Ulipr	1200	4.96	5.25
08 Fulchhari	1100	6.83	4.82
09 Sadullapur	700	4.22	3.06
10 Phulbari	700	5.69	3.06
11 Saghata	500	2.98	2.19
12 Bhurungamari	500	2.91	2.19
13 Mithapukur	500	1.14	2.19
14 Sundarganj	450	1.47	1.97
15 Hatibandha	450	1.97	1.97
16 Jaldhaka	450	1.94	1.97
17 Pirgachha	400	2.08	1.75
18 Pirganj	350	1.10	1.53
19 Kaliganj	340	1.76	1.49
20 Palasbari	300	2.18	1.31
21 Lalmonirhat sadar	300	1.60	1.31
22 Patgram	300	1.44	1.31
23 Dimla	300	1.32	1.31
24 Kishoreganj	300	2.05	1.31
25 Kaunia	300	2.54	1.31
26 Domar	200	1.01	0.88
27 Rangpur sadar	200	1.75	0.88
28 Taraganj	200	1.85	0.88
29 Rajarhat	100	0.75	0.44
30 Saidpur	100	1.12	0.44
Rangpur region	22840	3.28	100.00

lowest diversity index for cropping pattern was recorded 0.281 in Sundarganj followed by 0.527 in Gobindaganj. The highest value of diversity index for cropping pattern was found 0.991 in Rajibpur upazila that was followed by 0.989 in Chilmari upazila. The lowest CDI was reported 0.651 in Sundarganj followed by 0.745 in Pirganj. The highest value of CDI was observed 0.991 in Razibpur followed by 0.989 in Chilmari upazila. The range of cropping intensity values was recorded 190-255%. The maximum value was for Gangachara upazila of Rangpur district and minimum for Gaibandha sadar upazila. As a whole the CDI of Rangpur region was calculated 0.871 and the average cropping intensity at regional

level was 219%. In a simultaneous study, the investigators identified 316 cropping patterns for whole Bangladesh; where the CDI value was 0.952 at national level and the national average of cropping intensity was 200% (Nasim *et al.*, 2017). Diversified cropping pattern may enabled the farmers compulsion of extracting the maximum possible utilization of land in the flood free period (Mandal and Bezbaruah, 2013). Singh and Sidhu (2006) reported that a number of crops like sun hemp, cluster beans and sorghum had almost disappeared and there is reduced varietal diversification in rice and wheat. Crop diversification index of wheat-rice system has decreased from 0.75 in 1975-76 to 0.58 in 2006-07 in Punjab though diversification

**Table 14. Crop diversity and cropping intensity in Rangpur region, 2014-15.**

Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01 Rangpur	14	11	0.935	0.968	223
02 Gangachara	26	13	0.913	0.954	255
03 Kaunia	14	12	0.958	0.978	239
04 Pirgachha	20	17	0.721	0.876	225
05 Pirganj	29	15	0.685	0.745	203
06 Badarganj	31	14	0.799	0.902	225
07 Mithapukur	23	12	0.788	0.872	231
08 Taraganj	18	11	0.874	0.902	220
09 Gaibandha sadar	16	15	0.710	0.860	190
10 Palasbari	18	13	0.839	0.921	210
11 Gobindaganj	14	12	0.527	0.772	221
12 Saghata	13	16	0.833	0.918	218
13 Fulchhari	21	17	0.932	0.967	200
14 Sundarganj	26	18	0.281	0.651	208
15 Sadullapur	18	12	0.798	0.901	215
16 Kurigram	28	19	0.778	0.823	227
17 Ulipur	20	17	0.601	0.804	210
18 Chilmari	18	16	0.978	0.989	191
19 Rowmari	24	15	0.756	0.829	240
20 Razibpur	10	14	0.982	0.991	206
21 Bhurungamari	18	13	0.855	0.929	218
22 Nageswari	25	17	0.678	0.874	200
23 Phulbari	18	12	0.772	0.845	219
24 Rajarhat	23	17	0.852	0.935	211
25 Nilphamari	19	13	0.630	0.819	230
26 Saidpur	20	12	0.943	0.972	214
27 Domar	25	16	0.725	0.836	222
28 Dimla	31	14	0.701	0.835	214
29 Jaldhaka	19	11	0.915	0.913	223
30 Kishoreganj	28	14	0.919	0.960	240
31 Lalmonirhat	25	17	0.698	0.865	230
32 Aditmari	16	11	0.795	0.924	230
33 Kaliganj	20	14	0.674	0.872	237
34 Hatibandha	20	12	0.914	0.918	220
35 Patgram	17	13	0.815	0.909	220
Rangpur region	134	31	0.694	0.871	219

forces pests to continuously relocate and re-colonize their preferred host plants from year to year (Tscharrntke *et al.*, 2005, 2007).

## CONCLUSION

Boro-Fallow-T. Aman , Maize-Fallow-T. Aman , Potato-Boro-T. Aman and Single Boro were the dominant cropping patterns in

the region. The area under pulses and oil-seed crops was much lower, which is a challenge to food and nutritional security for the people of the Rangpur region. Based on the findings of the study, the following recommendations were made.

- Initiative has to be taken to increase productivity of exclusive rice based cropping pattern along with recommended crop management packages.

- Effort might be given so that a portion of double-rice area could be brought under Potato-Boro-T. Aman and/or Mustard-Boro-T. Aman cropping systems.
- In the single Boro area suitable vegetables might be grown on floating bed system in wet season.
- For sustainable food and nutritional security the area under pulses and oil seed crops should be escalated
- The upazilas having unique or exceptional cropping patterns with large area coverage might be studied in-depth to extrapolate the similar environments.
- Scope might be explored for the establishment of agro-food industry on the basis of potato crop.

## REFERENCES

- Agrawal, D J and A H Kassam. 1976. The importance of multiple cropping in increasing world food supplies. A special publication No. 27, American Society of Agronomy, Madison, Wisconsin. pp. 2-3.
- BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- Das, Anup, G I Ramkrushna, G S Yadav, J Layek, C Debnath, B U Choudhury, K P Mohaptara, S V Ngachan and S Das. 2015. Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India. *Applied Ecology and Environmental Sciences*. 3(4): 100-107.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development- Report 2: Agroecological regions of Bangladesh. Food and Agriculture Organization of the United Nations, Rome, Italy, 570p.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' perception, varietal characteristics and technology adoption: the case of rainfed village in eastern India. Discussion paper 5/97. Social Sciences Division, International Rice Research Institute. Los Baños, Laguna, Philippines.
- Mandal, R and M P Bezbaruah. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Muttaleb, M A, S M Shahidullah, M Nasim and A Saha. 2017. Cropping systems and land use in Sylhet region. *Bangladesh Rice J.* 21(2): 273-288.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Neena, D. 1998. Interstate variation in cropping pattern in India. *Indian J. Regi. Sci.* 30(2): 57-69.
- Rashid, M H, A H Khan and M M Alam. 2005. Cropping systems dynamics in greater Khustia. *J. Bangladesh Agril. Univ.* 3(2): 213-238.
- Shahidullah, S M, M Nasim, M K Quais and A Saha. 2017. Diversity of Cropping Systems in Chittagong Region. *Bangladesh Rice J.* 21(2): 109-122.
- Shriar, A J. 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems*. 49(3): 301-318.
- Tscharntke, T, R Bommarco, Y Clough, T O Crist, D Klein, T A Rand, J M Tylianakis, S vanNouhuys, and S Vidal. 2007. Conservation biological control and enemy diversity on a landscape scale. *Biol. Control*. 43: 294-309.
- Tscharntke, T, A M Klein, A Kruess, I S Dewenter, and C Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity-ecosystem service management. *Ecol. Lett.* 8: 857-874.

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

	Cropping pattern	Area (ha)		Cropping pattern	Area (ha)
01	Boro-Fallow-T. Aman	371370	48	Potato-Groundnut	930
02	Maize-Fallow-T. Aman	37630	49	Millet( <i>cheena</i> )-Fallow-Fallow	890
03	Potato-Boro-T. Aman	35960	50	Vegetab-Groundnut-T. Aman	860
04	Boro-Fallow-Fallow	28320	51	Millet( <i>kaon</i> )-F-T. Aman	800
05	Mustard-Boro-T. Aman	22840	52	S.Potato-Jute-Fallow	770
06	Wheat-Jute-T. Aman	22660	53	Lentil-Jute-Fallow	760
07	Potato-Maize-T. Aman	12720	54	Vegetab-Jute-Fallow	730
08	Potato-Jute-T. Aman	10790	55	Boro-Fallow-Blackgram	700
09	Vegetab-Vegetab-Vegetab	10590	56	Vegetab-Aus-T. Aman	660
10	Maize-Jute-T. Aman	9760	57	Wheat-Aus-T. Aman	650
11	Tobacco-Maize-T. Aman	6880	58	Boro-Vegetab(Float/Norm)	600
12	Potato-Aus-T. Aman	6470	59	Tobacco-Maize-Vegetab	600
13	Boro-Aus-T. Aman	5640	60	Vegetab-Jute-T. Aman	590
14	Vegetab-Vegetab-Fallow	4670	61	Garlic-Vegetab-Vegetab	580
15	Maize-Fallow-Fallow	4220	62	Mustard-Maize-T. Aman	550
16	Potato-Fallow-T. Aman	3850	63	Chilli-Fallow-Fallow	530
17	Onion-Jute-T. Aman	3720	64	Vegetab-Fallow-Blackgram	530
18	Tobacco-Aus-T. Aman	3090	65	Maize-Sesame-Fallow	500
19	Tobacco-Jute-T. Aman	3010	66	Groundnut-Fallow-T. Aman	490
20	Vegetab-Vegetab-T. Aman	2710	67	Tobacco-Fallow-Fallow	490
21	Chilli-Fallow-T. Aman	2660	68	Boro-Sesbania-T. Aman	480
22	Mustard-Boro-Fallow	2650	69	Lentil-Jute-T. Aman	460
23	Vegetab-Maize-T. Aman	2520	70	Millet( <i>cheena</i> )-Jute-Fallow	450
24	Groundnut-Fallow-Fallow	2430	71	Lentil-Fallow-T. Aman	440
25	Potato-Vegetab-T. Aman	2390	72	Onion-Aus-T. Aman	400
26	Mustard-Jute-T. Aman	2210	73	Groundnut-Jute-T. Aman	390
27	Boro-Jute-T. Aman	2080	74	S.Potato-Fallow-Fallow	360
28	Fallow-Jute-T. Aman	2030	75	Fallow-Fallow-T. Aman	350
29	Potato-Boro-Fallow	2000	76	Mustard-Aus-T. Aman	350
30	Chilli-Jute-Fallow	1950	77	Mustard-Fallow-T. Aman	350
31	Tobacco-Boro-T. Aman	1850	78	S.Potato-Jute-T. Aman	350
32	Tobacco-Fallow-T. Aman	1700	79	Blackgram-Jute-T. Aman	320
33	Vegetab-Fallow-T. Aman	1650	80	Wheat-Vegetab-T. Aman	305
34	Chilli-Jute-T. Aman	1560	81	Boro-Jute-Fallow	300
35	Vegetab-Boro-T. Aman	1520	82	Boro-Sesbania-Fallow	300
36	Boro-Fallow-Maize	1500	83	Vegetab-Boro-Fallow	300
37	Tobacco-Vegetab-Vegetab	1500	84	Fallow-Fallow-Blackgram	290
38	Wheat-Jute-Fallow	1460	85	Chilli-Vegetab-T. Aman	260
39	Garlic-Jute-T. Aman	1380	86	Garlic-Fallow-T. Aman	260
40	Chilli-Vegetab-Fallow	1340	87	Garlic-Jute-Fallow	260
41	Wheat-Fallow-T. Aman	1260	88	Onion-Fallow-T. Aman	260
42	Maize-Jute-Fallow	1150	89	Wheat-Ginger/Turmeric	230
43	Vegetab-Fallow-Fallow	1150	90	Onion-Maize-T. Aman	220
44	Maize-Vegetab-Fallow	1120	91	Blackgram-Jute-Fallow	200
45	Onion-Vegetab-Vegetab	1050	92	Fallow-Vegetab-T. Aman	200
46	Onion-Jute-Fallow	980	93	Maize-Boro-T. Aman	200
47	Maize-Aus-T. Aman	930	94	Potato+Maize-Vegetab-T. Aman	200
			95-134	Other 40 patterns (Table 8)	2930



# Cropping Systems and Land Use in Sylhet Region

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## ABSTRACT

Towards the sustainable food security for a particular area, the policymakers, researchers, extension and development agents need the detailed information of cropping patterns, cropping intensity and crop diversity. Sylhet, a potential region of enormous potentiality of growing crops across the *haor* area lying below the northeastern Himalyan foothills experience the highest rainfall in the world to make the basin prone to flashflood. That is why, a study was conducted in the region considering all the upazillas during 2016 using the pretested semi-structured questionnaire and validated by appropriate informants with a view to documenting the existing cropping patterns, cropping intensity and crop diversity in the region. As per the study the region is dominated by the rice based cropping pattern. The non-rice based cropping pattern are either few or the area under those cropping patterns are not enough to satisfy the non-rice food requirement of people of the region. Beside these, the cropping patterns and crop diversity appeared as below the expected level. Therefore, much thrust is needed to initiate research and development activities to diversify the single or double-cropped cropping pattern with the introduction of appropriate crops and crop varieties even other non-crop agricultural commodities.

**Key words:** Cropping pattern, land use intensity, diversity index and Sylhet basin

## INTRODUCTION

The cropping pattern is an important indicator of agricultural land use. It has implications for agricultural growth in general and livelihood improvement of the millions of farmers. Environmental or Agro-ecological conditions, and related risks or relative advantages are the main determinants of cropping pattern along with several socioeconomic factors (Mandal and Bezbaruah, 2013). Available data on total available arable lands of the country is not conclusive and seem to be varied due to the methodology and timeframe followed by the organizations (Hasan *et al.*, 2013). Statistics on the conversion rate of agricultural lands to non-agricultural activities also vary with the studies, i.e. an annual change of about 0.13% (Rahman and Hasan, 2003) or 0.27% between the years of 1976-77 and 2010-11 (BBS 2011). Furthermore, climate change showed recurrent floods, droughts and unpredicted rainfall patterns that worsen the existing pressure on land, water and natural resources (Shirsath, 2017). Sylhet

agricultural region is a complex region with a multitude of diverse micro-environments (FAO, 1988) with variable landscape ranged from hills to very lowlands. This region is consists of six dominant agroecological zones namely, Old Meghna Estuarine Floodplain, Eastern Surma-Kusiyara Floodplain, Sylhet Basin, Northern and Eastern Piedmont Plains, Northern and Eastern Hills and Akhaura Terrace (FAO, 1988). The yearly decreasing trend of cropland was 3,122 ha (0.33%) during 1976-2010 in Sylhet division (Hasan *et al.*, 2013). Cropping intensity of Sylhet agricultural region is almost stagnant for last two decades (BBS 2011, 2014, 2015) even though agriculture is the main source of income of farmers (Banglapedia, 2004). The rapid increase in human population creates additional pressure on natural resources at above optimal levels of their inherent potential, which resulted in the loss of biodiversity, serious soil erosion leading to depletion of plant nutrient, gradual degradation and decline in productivity and carrying capacity, etc (Borthakur *et al.*, 1998). Even though appropriate cropping

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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 the option for the farmers as a coping strategy against different risks (Mandal and Bezbaruah, 2013). Typology of different cropping systems is the base for the managers of these systems to intensify production (Shriar, 2000). Hence, judicious and appropriate use of limited resources in the case of intervention selection that does not lead to increased mal adoption or inequity in the society over the long term. Existing trends of available agricultural lands is an essential requirement for any land use planning related to farming and food security in a sustainable manner. Therefore, an increased understanding of arable land use based on the cropping systems, patterns along with diversity are very essential for the appropriate intervention in a sustainable way. But very few studies are available related to cropping systems and patterns. In this context, existing cropping patterns along with their diversity of such complex agricultural region are very crucial to minimize risk and to improve overall crop productivity. Accordingly, the present study was designed with the following objectives to:

- Build up a database on major existing cropping patterns in the Sylhet region
- Determine the crop diversity at the local and the regional level.

## METHODOLOGY

Thirty-eight upazilas of Sylhet, Sunamganj, Habiganj and Maulvibazar district under Sylhet agricultural region were the locale of this study. Data were collected using double stage procedure through semistructured questionnaire. At the initial stage, data were collected through pre-tested semi-structured questionnaire from 38 pre-assigned Sub-Assistant Agriculture Officers (SAAO) of each upazila during September 2016 at upazila level. The SAAOs were purposively selected by Agriculture Extension Officer

(AEO) or Additional Agriculture Officer (AAO) or Upazila Agriculture Officer (UAO) or their united decision. 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, checked and analyzed to find the inconsistencies of the supplied data before validation workshop. All the inconsistencies among the information were documented. Second stage of data collection was a daylong data validation workshop at district level during 23 to 26 October 2016. Participants of validation workshop were one SAPPO and three SAAOs experienced and engaged in crop-based data documentation, all officers from all upazilas viz UAOs, AEOs, AAEOs, DD (DAE), DD (Horticulture), DD of Seed Certification Agency, DTO and ADDs, one representative from Agricultural Training Institute (ATI) and scientists of BRRI regional station, Habiganj. The number of participants of validation workshop ranged from 59 to 88. All the participants were divided into three to four groups for data validation. Each group was facilitated by two RFSD scientists. After thorough discussion on collected data along with documented inconsistencies by each group, 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  $j^{\text{th}}$  crop in the  $i^{\text{th}}$  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 Sylhet region is 773,480 ha. Crops occupied the particular land for around the year were considered under annual crops. Crops that completed life span within one year were regarded as annual crops (Martin and Leonard, 1953). The major annual crops reported in the region were pineapple, sugarcane, banana, papaya, betel leaf, ginger and turmeric. The coverage of annual crops varied from zero to 1,040 ha accounted to only 0.60 % of the net cropped area (NCA) in the region. The coverage was exclusively poor compared to those of the other crops due to the mal-adjustment with the land type and climatic conditions. The annual erratic and uneven distribution of rainfall is responsible for the varying intensities of flood from the natural to the extreme (flash flood in March-April). At a glance, the region possesses 57% single cropped area (SCA), 37% double cropped area (DCA), 6% triple cropped area (TCA). All the upazilas were dominated by SCA followed by DCA except three upazilas (Table 1). These type of cropping patterns are due to the availability of adequate water or excess water that does not permit cultivation of more crops in this region. Another cause may be conservativeness of absentee landowner. Mean cropping intensity of Sylhet region was 148%. According to BBS cropping intensity of Sylhet agricultural region is almost stagnant at around 150% for last few decades and much lower than the national average 192%. The area that could not be defined under SCA, DCA, TCA or QCA was considered as others whose coverage is less than 1% of the NCA. An overwhelming majority of single or double cropping pattern with exclusive rice due to land type and class along with the environmental and climatic factors that is unsuitable for non-rice crops (FAO, 1988).

### Cropping patterns of Sylhet

In total 87 cropping patterns were observed in Sylhet region of which eight cropping patterns with exclusive rice crop covers over 90% of the NCA. There were 21 cropping patterns with exclusive non-rice crops covering over 2% of the NCA. Rest of the NCA i.e. around 8% area is covered by 58 rice - non-rice cropping patterns (Appendix 1).

### Rice and non-rice crops at a glance

Table 2 presents eight cropping patterns where rice is the only crop round the year. It comprises 90.24% of the NCA in the region. Among them, single rice, double rice and triple rice areas are 56%, 28% and 2%, respectively. It reflects the unparalleled dominance of rice in the cropping systems in Sylhet region. According to FAO (1988), modern and local rice varieties are the main crop in medium lowland and lowland in this region. In case of individual pattern single Boro i.e. Boro-Fallow-Fallow has the highest coverage (39.64%) and was recorded in 36 upazilas out of 38 upazilas. The second dominant pattern Boro-Fallow-T. Aman occupied 15.74% of NCA which was reported in 37 upazilas. Single T. Aman i.e. Fallow-Fallow-T. Aman covered third highest area (15.29%) with its existence in only 30 upazilas. Another important pattern Fallow-Aus-T. Aman found in 29 upazilas with the fourth position (12.62%) in respect of area coverage. Thus, the overwhelming majority (90.24%) is under exclusive rice systems. The dominance of exclusive rice-based cropping systems is due to lion share of land under medium and lowland ecosystems where recession of floodwater usually delayed. This situation is also worsened by high rainfall. Ultimately, soils of this region remain wet most of the time due to the cumulative effect of these factors. In this circumstance, soils of this region are more suitable for wetland crops than for dryland crops in Kharif season. The delayed recession of floodwater tends to delay the establishment of dryland Rabi crops until after the optimum date (FAO, 1988). Farmers of Tripura state of India have been following rice-rice systems from centuries in India due to food habit and agro-climatic situations (Anup *et al.*, 2015).

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

Upazila	Area of upazila	Annual crop	SCA	DCA	TCA	QCA	Other	NCA	C.I. (%)
01 Ajmiriganj	22400	0	10850	4550	0	0	100	15500	130
02 Bahubal	30100	550	5900	8100	1800	0	100	16450	172
03 Baniachang	48246	0	22960	14320	50	0	170	37500	139
04 Chunarughat	42696	310	460	13500	8160	0	180	22610	233
05 Habiganj	25139	180	4000	9010	6400	0	140	19730	211
06 Lakhai	19042	10	8360	6815	205	0	120	15510	147
07 Madhabpur	22427	140	0	11070	4800	0	130	16140	229
08 Nabiganj	30262	10	18820	5795	200	0	185	25010	125
09 Barlekha	44905	450	5215	5225	655	0	105	11650	157
10 Juri	18630	70	3550	5695	1140	0	115	10570	176
11 Kamalganj	48526	620	1850	13070	2390	0	140	18070	200
12 Kulaura	54500	70	12000	7030	3220	0	100	22420	160
13 Maulvibazar	34419	60	14700	10350	360	0	90	25560	143
14 Rajnagar	33815	100	8010	11870	160	0	160	20300	161
15 Sreemangal	45093	450	3600	13030	1710	0	110	18900	188
16 Biswambarpur	24900	150	8000	8630	175	0	95	17050	153
17 Chhatak	44067	10	16530	3300	0	0	70	19910	117
18 Dharampasha	53123	100	30910	3750	550	0	190	35500	114
19 Derai	42093	0	28470	2250	0	0	80	30800	107
20 Dowarabazar	28492	70	13615	7700	1055	0	130	22570	144
21 Jagannathpur	37591	80	24600	2230	550	0	70	27530	112
22 Jamalganj	30938	10	21320	4280	0	0	100	25710	117
23 Sulla	26085	0	17150	6020	0	0	130	23300	126
24 Sunamganj South	30317	10	21000	2090	0	0	110	23210	109
25 Sunamganj	29083	10	10500	7430	930	0	40	18910	149
26 Tahirpur	31425	70	14710	7720	300	0	120	22920	136
27 Balaganj	37592	0	13900	12500	1100	0	150	27650	153
28 Beanibazar	25072	0	9300	4300	200	0	150	13950	134
29 Biswanath	21450	0	7300	7800	1300	0	150	16550	163
30 Companiganj	27803	10	12235	5575	785	0	105	18710	138
31 Fenchuganj	11480	0	5400	2750	200	0	150	8500	138
32 Goainghat	48273	10	15000	6800	1850	0	150	23810	144
33 Golapganj	27355	10	4900	11500	200	0	100	16710	172
34 Jaintapur	17883	1040	7010	5665	650	0	125	14490	148
35 Zakiganj	26955	10	13660	5480	520	0	140	19810	133
36 Kanaighat	41225	10	11745	10110	1200	0	145	23210	154
37 Surma	19449	0	6400	8500	0	0	150	15050	157
38 Sylhet	30570	10	3500	7140	950	0	110	11710	178
Sylhet region	-	4630	437430	282950	43765	0	4705	773480	148

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
1 Boro-Fallow-Fallow	304800	39.64	36
2 Boro -Fallow- T. Aman	121020	15.74	37
3 Fallow -Fallow- T. Aman	117560	15.29	30
4 Fallow-Aus- T. Aman	97055	12.62	29
5 Boro-B.Aman	23830	3.10	11
6 Boro-Aus- T. Aman	17840	2.32	12
7 Fallow- B.Aman	10140	1.32	15
8 Boro-Aus-Fallow	1600	0.21	2
Total	693845	90.24	-

In the current investigation, 21 cropping patterns were identified that was free from rice (Table 3). The aggregate of 21 patterns has had only 2.44% of NCA. In critical comparison, it is clear that exclusive rice area is about 37 folds of the exclusive non-rice area. Among these 21 patterns, vegetable production system has the highest coverage that practised on or around the homestead area. Very limited lands are available for Rabi crops cultivation in this region (FAO, 1988). Cropping pattern diversification cannot be a risk minimization strategy in the Tripura state of India even though it clearly helps farmers to raise their farm income (Mandal and Bezbaruah, 2013). Anup *et al.* (2015) reported that about 15-20% land under different vegetables like colocasia, okra, amaranthus, brinjal, cucurbits, etc are grown in during rainy season and potato, sweet gourd, cole crops, leafy vegetables etc are grown during winter season on medium upland adjacent to rice fields in the Indian state of Tripura.

### Boro/Haor ecosystem

#### Deepwater rice ecosystem

Deepwater is a special type of ecosystem in the country. In the context of Sylhet region, this ecosystem represents a considerable portion. Table 4 presents the cropping patterns under deep water ecosystem. Among the listed 13

patterns Boro-B. Aman cropping pattern covers the largest area of 23,830 ha which represents 3.08% of the region's NCA. This pattern is distributed over 11 upazilas out of 38. The second highest Fallow-B. Aman cropping pattern covers 10,140 hectares and distributed over 15 upazilas. The first two patterns jointly covered 4.39% NCA which is more than four-fifths of the total deep-water rice area in the region. The water level of this ecosystem ranges between 150 and 400 cm, and water usually remains 3-4 months. Special rice varieties known as 'floating rice' are planted in these areas. In past Bangladesh had a land coverage of 3 million hectares for deepwater rice (Jackson *et al.*, 1972). In course of time, the continuous effort on modern agriculture shifted DWR area mainly to modern Boro. Now the area under deepwater rice in Bangladesh is reduced to 0.4 million hectares (Nasim *et al.*, 2017). Though this cropping system is less productive than other modern cropping systems, the specific fragile ecosystem still struggling because of no other alternatives.

#### Vegetables and spices crops

Fifty-one cropping patterns were identified for vegetables and spices crops covering an area of 60,810 ha which represents 7.86% of the NCA in the region (Table 6). Potato and other vegetables of Rabi, Kharif-I and Kharif-II; Spices

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

Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01 Vegetab-Vegetab-Fallow	5890	0.76	19
02 Vegetab-Vegetab-Vegetab	5395	0.70	16
03 Vegetab-Fallow-Fallow	5370	0.69	14
04 Chilli-Fallow-Fallow	735	0.10	10
05 Coriander-Fallow-Fallow	265	0.03	7
06 Fallow-Fallow-Blackgram	200	0.03	3
07 S.Potato-Fallow-Fallow	180	0.02	4
08 Potato-Jute-Fallow	150	0.02	1
09 Groundnut-Fallow-Fallow	115	0.01	4
10 Mustard-Fallow-Fallow	100	0.01	2
11 Vegetab-Fallow-Blackgram	70	0.01	2
12 Coriander-Vegetab-Fallow	60	0.01	3
13 Chilli-Vegetab-Fallow	55	0.01	5
14 Wheat-Vegetab-Vegetab	50	0.01	1
15-21 Other seven patterns (in Table 7)	85	0.01	1
Total non-rice area	18720	2.44	

**Table 4. Cropping patterns under deep water rice ecosystem in Sylhet region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Boro-B.Aman	23830	3.08	11
02	Fallow-B.Aman	10140	1.31	15
03	Mustard-B.Aman	2690	0.35	4
04	Wheat-B.Aman	435	0.06	3
05	Vegetab-B.Aman	200	0.03	1
06	Coriander-B.Aman	120	0.02	1
07	Blackgram-B.Aman	110	0.01	3
08	Chilli-B.Aman	80	0.01	1
09	Lentil-B.Aman	70	0.01	1
10	Potato-B.Aman	70	0.01	1
11	S.Potato-B.Aman	30	0.00	1
12	Grasspea-B.Aman	25	0.00	1
13	Onion-B.Aman	10	0.00	1
	Total DWR area	37810	4.89	

**Table 5. Cropping patterns with pulses and oil-seed crops in Sylhet region, 2014-15.**

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Mustard-B.Aman	2690	0.35	4
02	Groundnut-Fallow- T. Aman	1245	0.16	4
03	Mustard-Fallow- T. Aman	950	0.12	11
04	Vegetab-Groundnut- T. Aman	800	0.10	1
05	Mustard-Boro- T. Aman	560	0.07	4
06	Mustard-Aus- T. Aman	510	0.07	6
07	Mustard-Boro-Fallow	340	0.04	4
08	Fallow-Fallow-Blackgram	200	0.03	3
09	Mustard-Jute- T. Aman	200	0.03	1
10	Mustard-Aus-Fallow	140	0.02	4
11	Groundnut-Fallow-Fallow	115	0.01	4
12	Blackgram-B.Aman	110	0.01	3
13	Lentil-Jute- T. Aman	100	0.01	1
14	Mustard-Fallow-Fallow	100	0.01	2
15	Lentil-B.Aman	70	0.01	1
16	Vegetab-Fallow-Blackgram	70	0.01	2
17	Lentil-Aus- T. Aman	60	0.01	2
18-25	Other eight patterns (in Table 7)	130	0.02	
	Total pulses and oil-seed crops	8390	1.08	

(chilli, onion, garlic, coriander) are included in this list. The most contributing cropping pattern is Vegetable-Fallow-T. Aman covering 2% of NCA which distributed in 23 upazilas. The second one is Vegetable-Aus- T. Aman covering over 1.18% of NCA and it is available in 19 upazilas out of 38 upazilas. Vegetables like colocasia, okra, amaranthus, brinjal, cucurbits, etc are grown in medium upland adjacent to rice fields during the rainy season and potato, sweet gourd, cole crops, leafy vegetables etc

are grown during the winter season in Tripura (Anup *et al.*, 2015).

### Rare cropping patterns

In the present investigation, 26 cropping patterns have been identified as rare cropping patterns with a negligible area (5-30 ha) coverage with seldom existence (Table 7). These are location specific system and are limited in one or two upazilas of the region. Total area coverage of the 26 patterns is only 0.048% of NCA. Among

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

	Cropping pattern	Area (ha)	% of NCA	Frequency (no. of upazila)
01	Vegetab-Fallow- T. Aman	15495	2.00	23
02	Vegetab-Aus- T. Aman	9130	1.18	19
03	Vegetab-Vegetab-Fallow	5890	0.76	19
04	Vegetab-Vegetab- T. Aman	5780	0.75	13
05	Vegetab-Vegetab-Vegetab	5395	0.70	16
06	Vegetab-Fallow-Fallow	5370	0.69	14
07	Fallow-Vegetab- T. Aman	2470	0.32	9
08	Potato-Aus- T. Aman	2170	0.28	11
09	Vegetab-Aus-Fallow	1980	0.26	4
10	Potato-Fallow- T. Aman	1570	0.20	15
11	Vegetab-Groundnut- T. Aman	800	0.10	1
12	Chilli-Fallow-Fallow	735	0.10	10
13	Chilli-Fallow- T. Aman	500	0.06	8
14	S.Potato-Fallow- T. Aman	475	0.06	10
15	Potato-Vegetab- T. Aman	380	0.05	3
16	Chilli-Aus- T. Aman	300	0.04	6
17	Coriander-Fallow- T. Aman	275	0.04	6
18	Coriander-Fallow-Fallow	265	0.03	7
19	Chilli-Aus-Fallow	240	0.03	2
20	Vegetab-B.Aman	200	0.03	1
21	S.Potato-Fallow-Fallow	180	0.02	4
22	Potato-Jute-Fallow	150	0.02	1
23	Potato-Jute- T. Aman	150	0.02	1
24	Coriander-B.Aman	120	0.02	1
25	Potato-Boro-Fallow	100	0.01	1
26	Chilli-B.Aman	80	0.01	1
27	Potato-B.Aman	70	0.01	1
28	Vegetab-Fallow-Blackgram	70	0.01	2
29	Coriander-Vegetab-Fallow	60	0.01	3
30	Chilli-Vegetab-Fallow	55	0.01	5
31	Potato-Aus-Fallow	50	0.01	1
32	Wheat-Vegetab-Vegetab	50	0.01	1
33	Wheat-Vegetab- T. Aman	40	0.01	2
34-51	Other 18 patterns (in Table 7)	215	0.03	-
	Total vegetab and spices crops	60810	7.86	

these, the top three patterns viz Onion-Aus- T. Aman, Sweet potato-B.Aman and Wheat-Jute-Fallow were holding the same area i.e. 30 ha for each in Kamalganj, Biswambarpur, Lakhai and Tahirpur. The smallest area was recorded for nine cropping patterns whose coverage was only five hectares for each.

### Most dominant cropping pattern

Boro-Fallow-Fallow was the most dominant cropping pattern in Sylhet region. It covers 39.64% of NCA in the region and is available in 36 upazilas out of 38 upazilas (Table 8). The highest area under this cropping was recorded

29,500 ha in Dharampasha upazila which represents 9.68% of the total Boro-Fallow-Fallow area of the region and the lowest covered area was found in Kamalganj upazila. This pattern is frequent and concurrently experienced by early flash at in April and cold injury at reproductive stage. Diversified cropping pattern may be a resort for the farmer as a coping strategy with flood-related risk (Mandal and Bezbaruah, 2013) but scope of diversification is limited due to situational, environmental and climatic condition (FAO, 1988). Farmers of eastern India remained confined to their traditionally perceived

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

	Cropping pattern	Area (ha)	% of NCA	Frequency	Upazila
01	Onion-Aus- T. Aman	30	0.004	2	Kamalganj+Biswambarpur
02	S.Potato-B.Aman	30	0.004	1	Lakhai
03	Wheat-Jute-Fallow	30	0.004	1	Tahirpur
04	Grasspea-B.Aman	25	0.003	1	Madabpur
05	Boro-Fallow-Blackgram	20	0.003	2	Dowarabazar+Companiganj
06	Lentil-Vegetab-Vegetab	20	0.003	1	Rajnagar
07	Maize-Fallow- T. Aman	20	0.003	2	Biswambarpur+Jagannathpur
08	Potato-Sesame-Aus	20	0.003	1	Barlekha
09	Garlic-Aus- T. Aman	15	0.002	1	Biswambarpur
10	Grasspea-Fallow- T. Aman	15	0.002	2	Barlekha+Rajnagar
11	Potato-Sesame- T. Aman	15	0.002	2	Barlekha+Kamalganj
12	Garlic-Jute-Fallow	10	0.001	1	Golapganj
13	Onion-B.Aman	10	0.001	1	Lakhai
14	Onion-Jute-Fallow	10	0.001	1	Golapganj
15	Onion-Jute- T. Aman	10	0.001	1	Lakhai
16	Potato-Mungbean- T. Aman	10	0.001	1	Kamalganj
17	W.Melon-Aus- T. Aman	10	0.001	1	Kamalganj
18	Chilli-Vegetab- T. Aman	5	0.001	1	Companiganj
19	Garlic-Fallow-Fallow	5	0.001	1	Dowarabazar
20	Garlic-Fallow- T. Aman	5	0.001	1	Dowarabazar
21	Garlic-Vegetab-Vegetab	5	0.001	1	Dowarabazar
22	Lentil-Fallow- T. Aman	5	0.001	1	Barlekha
23	Maize-Aus-Fallow	5	0.001	1	Companiganj
24	Onion-Fallow- T. Aman	5	0.001	1	Dowarabazar
25	Onion-Vegetab-Vegetab	5	0.001	1	Dowarabazar
26	Vegetab-Jute- T. Aman	5	0.001	1	Dowarabazar
	Total	345	0.048	-	-

farming system i.e. low productive mono-cropped farming (Sasmal, 2015). In the country-wide compilation of data, it was observed that the single Boro was the 2<sup>nd</sup> 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).

### Second dominant cropping pattern

The second dominant cropping pattern in Sylhet region is Boro-Fallow-T. Aman. It belongs to 15.74% of NCA of the region and spread over 37 upazilas (Table 9). Sunamganj sadar upazila of Sunamganj district holds the highest area of 7,000 ha under the Boro-Fallow- T. Aman cropping pattern. 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

Single T. Aman cropping pattern holds the third largest area coverage 117,560 hectares in Sylhet region. This area is 15.29% of NCA in the region and is distributed over 30 upazilas. Maulvibazar upazila occupied highest area of 8,700 ha for single T. Aman pattern which stands for 7.40% area of this pattern in the region and lowest area (170 ha) for the same pattern was observed in Sreemangal upazila (Table 10). It was observed that the single T. Aman was the third dominant cropping pattern in Bangladesh covering 5.09 lac ha (6% of NCA in the country) with its distribution in 162 upazilas of 36 districts (Nasim *et al.*, 2017).

**Table 8. Distribution of the most dominant Boro–Fallow–Fallow cropping patterns in Sylhet region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Dharampasha	29500	83.10	9.68
02	Derai	27100	87.99	8.89
03	Jamalganj	21000	81.68	6.89
04	Sunamganj South	19900	85.74	6.53
05	Baniachang	19200	51.20	6.30
06	Jagannathpur	18600	67.56	6.10
07	Sulla	16200	69.53	5.31
08	Tahirpur	14000	61.08	4.59
09	Nabiganj	11000	43.98	3.61
10	Chhatak	10000	50.23	3.28
11	Ajmiriganj	9100	58.71	2.99
12	Dowarabazar	8800	38.99	2.89
13	Sunamganj	8500	44.95	2.79
14	Balaganj	8200	29.66	2.69
15	Biswambarpur	8000	46.92	2.62
16	Lakhai	7600	49.00	2.49
17	Companiganj	7500	40.09	2.46
18	Maulvibazar	6000	23.47	1.97
19	Rajnagar	6000	29.56	1.97
20	Bahubal	5000	30.40	1.64
21	Jaintapur	4500	31.06	1.48
22	Habiganj	4000	20.27	1.31
23	Goainghat	4000	16.80	1.31
24	Kulaura	3600	16.06	1.18
25	Fenchuganj	3600	42.35	1.18
26	Biswanath	3500	21.15	1.15
27	Sreemangal	3400	17.99	1.12
28	Baanibazar	3400	24.37	1.12
29	Surma	2500	16.61	0.82
30	Golapganj	2300	13.76	0.75
31	Barlekha	2100	18.03	0.69
32	Sylhet	1750	14.94	0.57
33	Juri	1700	16.08	0.56
34	Zakiganj	1700	8.58	0.56
35	Kanaighat	1500	6.46	0.49
36	Kamalganj	50	0.28	0.02
	Sylhet region	304800	39.14	100.00

**Fourth dominant cropping pattern**

Fourth dominant cropping pattern Fallow–Aus–T. Aman has occupied 97,055 hectares representing 12.62% share of NCA in Sylhet region (Table 11). This pattern is distributed over 29 upazilas where Chunarughat ranked in top position. This upazila has 10,500 ha area under Fallow–Aus–T. Aman which is only 46.44% of upazila NCA. Kamalganj upazila ranks in the second position with 8,800 ha area for this

pattern, however, this upazila has allotted the biggest share (48.70%) of its NCA. Aus–T. Aman pattern is almost common on high land and medium highland floodplain ridges soils (FAO, 1988).

**Fifth dominant cropping pattern**

Fifth dominant cropping pattern Boro–B. Aman had been covering 23,830 ha representing 3.10% share of NCA in Sylhet region (Table 12). This

**Table 9. Distribution of the 2<sup>nd</sup> dominant Boro-Fallow- T. Aman cropping pattern in Sylhet region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Sunamganj	7000	37.02	5.78
02 Tahirpur	6000	26.18	4.96
03 Balaganj	6000	21.70	4.96
04 Rajnagar	5400	26.60	4.46
05 Sulla	5400	23.18	4.46
06 Sreemangal	5300	28.04	4.38
07 Biswambarpur	5000	29.33	4.13
08 Companiganj	5000	26.72	4.13
09 Dowarabazar	4900	21.71	4.05
10 Golappanj	4500	26.93	3.72
11 Maulvibazar	4200	16.43	3.47
12 Madhabpur	4000	24.78	3.31
13 Jamalganj	3900	15.17	3.22
14 Kamalganj	3600	19.92	2.97
15 Surma	3500	23.26	2.89
16 Baniachang	3000	8.00	2.48
17 Chunarughat	3000	13.27	2.48
18 Juri	3000	28.38	2.48
19 Biswanath	3000	18.13	2.48
20 Goainghat	3000	12.60	2.48
21 Sylhet	2700	23.06	2.23
22 Habiganj	2500	12.67	2.07
23 Dharampasha	2500	7.04	2.07
24 Kanaighat	2500	10.77	2.07
25 Baanibazar	2400	17.20	1.98
26 Chhatak	2200	11.05	1.82
27 Derai	2200	7.14	1.82
28 Jagannathpur	2100	7.63	1.74
29 Ajmiriganj	2050	13.23	1.69
30 Barlekha	2000	17.17	1.65
31 Nabiganj	1900	7.60	1.57
32 Sunamganj South	1900	8.19	1.57
33 Lakhai	1620	10.44	1.34
34 Jaintapur	1500	10.35	1.24
35 Kulaura	1150	5.13	0.95
36 Bahubal	1000	6.08	0.83
37 Fenchuganj	100	1.18	0.08
Sylhet region	121020	15.74	100.00

pattern is distributed over 11 upazilas where Baniachang ranked in top position. This upazila had 9,300 ha area for Boro-B. Aman pattern which is 24.80% of upazila NCA. Companiganj and Kanaighat upazila had only nominal area coverage for this system.

### Sixth dominant cropping pattern

Sixth dominant cropping pattern Boro-Aus- T. Aman had been covering 17,840 hectares representing 2.32% share of NCA in Sylhet region (Table 13) and distributed over 12 upazilas. Chunarughat ranked in top

position with 5,500 ha area which is 24.33% of upazila NCA.

### Crop diversity and cropping intensity

Bio-diversity plays important role in a good production of food, fodder, fuel, medicinal plants, aromatic plants and non-timber produce along with ecosystem service and climate regulation service (Manju and Sharma, 2016). The higher number of available crops under cultivation in an area dictates its higher diversity. The number of cropping patterns is also a gross indicator of crop diversity. A total of 87 cropping patterns were identified in the whole

**Table 10. Distribution of the 3<sup>rd</sup> dominant Fallow-Fallow- T. Aman cropping pattern in Sylhet region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Maulvibazar	8700	34.04	7.40
02 Kanaighat	8500	36.62	7.23
03 Kulaura	8400	37.47	7.15
04 Jaintapur	8300	57.28	7.06
05 Goainghat	8000	33.60	6.81
06 Nabiganj	7780	31.11	6.62
07 Chhatak	6000	35.19	5.10
08 Jagannathpur	6000	26.58	5.10
09 Balaganj	5700	20.61	4.85
10 Beanibazar	5000	35.84	4.25
11 Zakiganj	5000	25.24	4.25
12 Dowarabazar	4700	15.26	4.00
13 Companiganj	4500	24.05	3.83
14 Biswanath	3800	22.96	3.23
15 Baniachang	3500	9.33	2.98
16 Surma	3500	23.26	2.98
17 Barlekha	2700	23.18	2.30
18 Golapganj	2400	14.36	2.04
19 Sunamganj	2000	10.58	1.70
20 Kamalganj	1800	9.96	1.53
21 Fenchuganj	1800	21.18	1.53
22 Sylhet	1750	14.94	1.49
23 Juri	1650	15.61	1.40
24 Rajnagar	1650	8.13	1.40
25 Dharampasha	1100	5.52	0.94
26 Sunamganj South	1100	4.74	0.94
27 Derai	1000	2.82	0.85
28 Bahubal	600	3.65	0.51
29 Chunarughat	460	2.03	0.39
30 Sreemangal	170	0.90	0.14
Sylhet region	117560	15.29	100.00

area of Sylhet region under this investigation. The highest number of cropping patterns was 34 identified in Dowarabazar upazila and that was 32 in Barlekha and 25 in Companiganj (Table 14). The lowest number of cropping patterns was identified 4 in Sulla followed by 6 in Derai. Higher number of cropping patterns is generally related to higher crop diversity indices. The upazilas having the lower number of cropping patterns were related to either low land or waterlogging or both. Sulla and Derai upazila face both limitations. The lowest diversity index for cropping pattern was recorded 0.219 in Derai followed by 0.255 in Sunamganj south. In a study, Shahidullah *et al.* (2006) also found the lowest values for all the diversity and intensity parameters in the salt-

affected area of greater Noakhali. The highest value of diversity index for cropping pattern was found 0.844 in Sylhet sadar upazila that was followed by 0.842 in Juri upazila. Cropping pattern diversification clearly helps farmers to raise their farm income and has significant implications for making farming a remunerative profession in the Tripura state of India (Mandal and Bezbaruah, 2013). Diversified cropping pattern is an important strategy to cope with risk and uncertainty associated with agriculture due to unusual climatic and biological factors (Shiyani and Pandya, 1998). Since the lowest CDI was reported 0.313 in Derai followed by 0.367 in Sunamganj south. The highest value of CDI was observed 0.923 in Madhabpur followed by 0.915 in Habiganj sadar upazila.

**Table 11. Distribution of the 4<sup>th</sup> dominant Fallow–Aus– T. Aman cropping pattern in Sylhet region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Chunarughat	10500	46.44	10.82
02	Kamalganj	8800	48.70	9.07
03	Sreemangal	7700	40.74	7.93
04	Bahubal	6000	36.47	6.18
05	Kulaura	5600	24.98	5.77
06	Habiganj	5000	25.34	5.15
07	Kanaighat	5000	21.54	5.15
08	Rajnagar	4700	23.15	4.84
09	Jaintapur	4500	31.06	4.64
10	Golapganj	4200	25.13	4.33
11	Maulvibazar	3700	14.48	3.81
12	Biswanath	3600	21.75	3.71
13	Goaighat	3500	14.70	3.61
14	Zakiganj	3500	17.67	3.61
15	Surma	3000	19.93	3.09
16	Balaganj	2750	9.95	2.83
17	Sylhet	2500	21.35	2.58
18	Dowarabazar	2200	9.75	2.27
19	Barlekha	2100	18.03	2.16
20	Fenchuganj	2100	24.71	2.16
21	Madhabpur	1400	8.67	1.44
22	Juri	1300	12.30	1.34
23	Biswambarpur	1100	6.45	1.13
24	Beanibazar	900	6.45	0.93
25	Lakhai	525	3.38	0.54
26	Nabiganj	400	1.60	0.41
27	Sunamganj	230	1.22	0.24
28	Chhatak	200	1.00	0.21
29	Companiganj	50	0.27	0.05
	Sylhet region	97055	12.62	100.00

**Table 12. Distribution of the 5<sup>th</sup> dominant Boro–B. Aman cropping pattern in Sylhet region, 2014-15.**

	Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01	Baniachang	9300	24.80	39.03
02	Madhabpur	3800	23.54	15.95
03	Nabiganj	3300	13.19	13.85
04	Ajmiriganj	2200	14.19	9.23
05	Lakhai	2000	12.89	8.39
06	Rajnagar	1000	4.93	4.20
07	Balaganj	900	3.25	3.78
08	Habiganj	800	4.05	3.36
09	Bahubal	500	3.04	2.10
10	Companiganj	20	0.11	0.08
11	Kanaighat	10	0.04	0.04
	Sylhet region	23830	3.10	100.00

**Table 13. Distribution of the 6<sup>th</sup> dominant Boro–Aus– T. Aman cropping pattern in Sylhet region, 2014-15.**

Upazila	Area (ha)	% of upazila NCA	% of the pattern in region
01 Chunarughat	5500	24.33	30.83
02 Habiganj	4500	22.81	25.22
03 Madhabpur	3400	21.07	19.06
04 Kulaura	1600	7.14	8.97
05 Bahubal	700	4.26	3.92
06 Juri	500	4.73	2.80
07 Kamalganj	490	2.71	2.75
08 Sreemangal	350	1.85	1.96
09 Biswanath	300	1.81	1.68
10 Jaintapur	300	2.07	1.68
11 Nabiganj	100	0.40	0.56
12 Maulvibazar	100	0.39	0.56
Sylhet region	17840	2.32	100.00

Hajjar *et al.* (2008) reported that genetic diversity of crop play an important role in enhancing the provision many services concurrently in multifunctional and sustainable agriculture through positive interactions or complementary functions. The range of cropping intensity values was recorded 107-233%. The maximum value was for Chunarughat upazila of Habiganj district and minimum for Derai upazila of Sunamganj district. As a whole, the CDI of Sylhet region was calculated 0.877 and the average cropping intensity at the regional level was 148%. In a simultaneous, the investigators identified 316 cropping patterns for whole Bangladesh; where the CDI value was 0.952 at the national level and the national average of cropping intensity was 200% (Nasim *et al.*, 2017). Diversified cropping pattern may enable the farmers compulsion of extracting the maximum possible utilization of land in the flood-free period (Mandal and Bezbaruah, 2013). Singh and Sidhu (2006) reported that a number of crops like sun hemp, cluster beans and sorghum had almost disappeared and there is reduced varietal diversification in rice and wheat. Crop diversification index of the 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 (Tschardt *et al.*, 2005, 2007).

## CONCLUSION

Agricultural land is decreasing due to many factors and landscapes of Sylhet agricultural region are heterogeneous with the dominance of lowland. The cropping intensity of the Sylhet region was far lower (148%) than the national average (192%). The dominant cropping patterns were Boro-Fallow-Fallow, Boro-Fallow-T. Aman, Fallow-Fallow-T. Aman, Fallow-Aus-T Aman, Boro-B.Aman, Boro-Aus-T. Aman and Fallow-B.Aman in the region. Thus, overwhelming majority cropping patterns are consists of absolutely rice crop. The non-rice based cropping patterns were very few or area under those cropping patterns were much lower which are challenges to food and nutritional security for the people of the Sylhet region. Cropping patterns and crop diversity are also not up to the expected level. Based on the findings of the study, the following recommendations were made.

- Initiative has to be taken to increase the productivity of exclusive rice-based cropping pattern. As rice is the synonym of the primary food security, the high yielding stress tolerant varieties of rice along with recommended crop management packages to be adopted. Vegetable cultivation through the raised bed or floating method also needs to adopt in the suitable wetland area of this region.

**Table 14. Crop diversity and cropping intensity in Sylhet region, 2014-15.**

	Upazila	No. of identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)	C.I. (%)
01	Ajmiriganj	07	06	0.607	0.741	130
02	Bahubal	14	08	0.746	0.861	172
03	Baniachang	11	09	0.659	0.784	139
04	Chunarughat	07	06	0.693	0.876	233
05	Habiganj	15	14	0.817	0.915	211
06	Lakhai	21	16	0.711	0.843	147
07	Madhabpur	15	12	0.823	0.923	229
08	Nabiganj	17	12	0.686	0.780	125
09	Barlekha	32	16	0.836	0.910	157
10	Juri	16	10	0.842	0.913	176
11	Kamalganj	22	18	0.688	0.853	200
12	Kulaura	09	07	0.779	0.873	160
13	Maulvibazar	09	06	0.775	0.866	143
14	Rajnagar	16	12	0.776	0.862	161
15	Sreemangal	13	10	0.706	0.847	188
16	Biswambarpur	20	20	0.676	0.819	153
17	Chhatak	08	05	0.642	0.724	117
18	Dharampasha	14	12	0.298	0.446	114
19	Derai	06	05	0.219	0.313	107
20	Dowarabazar	34	25	0.745	0.846	144
21	Jagannathpur	11	11	0.486	0.585	112
22	Jamalganj	09	09	0.309	0.469	117
23	Sulla	04	03	0.460	0.623	126
24	Sunamganj South	07	06	0.255	0.367	109
25	Sunamganj	09	08	0.647	0.682	149
26	Tahirpur	12	11	0.552	0.719	136
27	Balaganj	10	07	0.806	0.889	153
28	Beanibazar	08	06	0.770	0.848	134
29	Biswanath	08	06	0.814	0.894	163
30	Companiganj	25	12	0.708	0.808	138
31	Fenchuganj	08	07	0.712	0.806	138
32	Goainghat	08	08	0.802	0.883	144
33	Golapganj	15	13	0.811	0.884	172
34	Jaintapur	15	10	0.763	0.873	148
35	Zakiganj	11	09	0.716	0.806	133
36	Kanaighat	13	10	0.787	0.878	154
37	Surma	08	07	0.814	0.879	157
38	Sylhetsadar	13	08	0.844	0.912	178
	Sylhet region	87	29	0.778	0.877	148

- Overwhelming majority cropping patterns are consist of either single rice/double rice/triple rice crop. To enhancing the existing productivity of these rice-cropping patterns, adoption of high yielding varieties along with the integration of other suitable crops, livestock, fisheries and management technologies for the judicious and efficient use of on-farm resources are essential to sustain the productivity, soil health and enhance the carrying capacity of the ecosystem.
- The upazilas having higher cropping pattern index might be studied in depth to extrapolate potential cropping patterns to other upazilas of similar environments.
- Research and development programmes can be taken in hand to diversify the single and double-cropped cropping pattern with the inclusion of appropriate new crops, crop varieties and non-crop species.

## REFERENCES

- Anup Das, G I Ramkrishna, G S Yadav, JayantaLayek, C Debnath, B U Choudhury, K P Mohaptara, S V Ngachan and Supriya Das. 2015. Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India. *Applied Ecology and Environmental Sciences*, 4: 100-107.
- Banglapedia (2004). National Encyclopedia of Bangladesh. Dhaka: Asiatic Society of Bangladesh.
- BBS (Bangladesh Bureau of Statistics). 2011. Agricultural Census of Bangladesh. Dhaka: Ministry of Planning, Government of the People's Republic of Bangladesh.
- BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- BBS (Bangladesh Bureau of Statistics). 2016. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- BBS (Bangladesh Bureau of Statistics). 2017. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- Borthakur, S K, T R Sarma, K K Nath, P Deka. 1998. The house gardens of Assam : a traditional Indian experience of management and conservation of biodiversity— I. *Ethnobotany*, 10:32 –37.
- FAO (Food and agriculture Organization), 1988. Land resources of Bangladesh for Agricultural development (Report 2: Agro-ecological regions of Bangladesh). Rome, Italy.
- Hajjar, R, D I Jarvis and B Gemmil-Herren. 2008. The utility of crop genetic diversity in maintaining ecosystem services. *Agriculture, Ecosystems and Environment*, 123:261-270.
- Hasan, M N, M S Hossain, M A Bari, and M R Islam. 2013. Agricultural land availability in Bangladesh. SRDI, Dhaka, Bangladesh, 42 pp.
- Jackson, B R, A Yantasast, C Prechachat, M A Chowdhury and S M H Zaman. 1972. Breeding rice for deep-water areas. Pages 517-528 *In: International Rice Research Institute, Rice Breeding*, LosBaños, Philippines.
- Kshirsagar, K G, S Pandey and M R Bellon. 1997. Farmers' Perception, Varietal Characteristics and Technology Adoption: The Case of Rainfed Village in Eastern India. Discussion paper5/97. Social Sciences Division, IRRI, Philippines.
- Mandal, R and M P Bezbaruah. 2013. Diversification of Cropping Pattern: Its Determinants and Role in Flood Affected Agriculture of Assam Plains. *Indian J. Agric. Econ.* 68(2): 169-181.
- Manju Sundriyal and Bhavtosh Sharma. 2016. Status of biodiversity in central Himalaya. *Applied Ecology and Environmental Sciences*, 4(2): 37-43.
- Martin, J H and W H Leonard. 1953. Principles of Field Crop Production. McMillan Company, New York.
- Nasim, M, S M Shahidullah, A Saha, M A Muttaleb, T L Aditya, M A Ali and M S Kabir. 2017. Distribution of Crops and Cropping Patterns in Bangladesh. *Bangladesh Rice J.* 21(2): 1-55.
- Rahman, M T and M N Hasan. 2003. Assessment of Shifting of Agricultural Land to Non-Agricultural Land in Bangladesh, SRDI, Ministry of Agriculture, Dhaka.
- Sasmal, T K. 2015. Adoption of New Agricultural Technologies for Sustainable Agriculture in Eastern India: An Empirical Study. *Indian Res. J. Ext. Edu.* 15 (2): 38-42.
- Shahidullah, S M, M S A Talukder, M S Kabir, A H Khan and N E Elahi. 2006. Cropping patterns in the South East Coastal Region of Bangladesh. *Journal of Agriculture and Rural Development*, 4 (1&2): 53-60.
- Shirsath, P B, P K Aggarwal, P K Thornton and A Dunnett. 2017. Prioritizing Climate-Smart Agricultural Land Use Options at a Regional Scale. *Agricultural Systems*, 151:174-183.

- Shriar, A J. 2000. Agricultural Intensity and its Measurement in Frontier Regions. *Agroforestry Systems*, 49: 301–318.
- Shiyani, R L and H R Pandya. 1998. Diversification of agriculture in Gujarat: A spatio-temporal analysis. *Indian J. Agric. Econ.* 53(4):627-639.
- Singh, J and R S Sidhu. 2006. Accounting for Impact of Environmental Degradation in Agriculture of Indian Punjab. *Agric. Economics Res. Rev.* 19: 37-48.
- Tscharntke, T, R Bommarco, Y Clough, T O Crist, D Klein, T A Rand, J M Tylianakis, S van Nouhuys, S Vidal. 2007. Conservation Biological Control and Enemy Diversity on a Landscape Scale. *Biol. Control* 43, 294–309.
- Tscharntke, T, A M Klein, A Kruess, I Steffan-Dewenter, C Thies. 2005. Landscape Perspectives on Agricultural Intensification and Biodiversity-Ecosystem Service Management. *Ecol. Lett.* 8, 857–874.

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

Cropping pattern		Area (ha)	Cropping pattern		Area (ha)
01	Boro-Fallow-Fallow	304800	32	Wheat-Fallow- T. Aman	325
02	Boro-Fallow- T. Aman	121020	33	Chilli-Aus- T. Aman	300
03	Fallow-Fallow- T. Aman	117560	34	Coriander-Fallow- T. Aman	275
04	Fallow-Aus- T. Aman	97055	35	Coriander-Fallow-Fallow	265
05	Boro-B.Aman	23830	36	Chilli-Aus-Fallow	240
06	Boro-Aus- T. Aman	17840	37	Fallow-Fallow-Blackgram	200
07	Vegetab-Fallow- T. Aman	15495	38	Mustard-Jute- T. Aman	200
08	Fallow-B.Aman	10140	39	Vegetab-B.Aman	200
09	Vegetab-Aus- T. Aman	9130	40	S.Potato-Fallow-Fallow	180
10	Vegetab-Vegetab-Fallow	5890	41	W.Melon-Fallow- T. Aman	170
11	Vegetab-Vegetab- T. Aman	5780	42	Potato-Jute-Fallow	150
12	Vegetab-Vegetab-Vegetab	5395	43	Potato-Jute- T. Aman	150
13	Vegetab-Fallow-Fallow	5370	44	Wheat-Aus- T. Aman	150
14	Mustard-B.Aman	2690	45	Mustard-Aus-Fallow	140
15	Fallow-Vegetab- T. Aman	2470	46	Coriander-B.Aman	120
16	Potato-Aus- T. Aman	2170	47	Groundnut-Fallow-Fallow	115
17	Vegetab-Aus-Fallow	1980	48	Blackgram-B.Aman	110
18	Boro-Aus-Fallow	1600	49	Lentil-Jute- T. Aman	100
19	Potato-Fallow- T. Aman	1570	50	Mustard-Fallow-Fallow	100
20	Groundnut-Fallow- T. Aman	1245	51	Potato-Boro-Fallow	100
21	Mustard-Fallow- T. Aman	950	52	Chilli-B.Aman	80
22	Fallow-Jute- T. Aman	890	53	Lentil-B.Aman	70
23	Vegetab-Groundnut- T. Aman	800	54	Potato-B.Aman	70
24	Chilli-Fallow-Fallow	735	55	Vegetab-Fallow-Blackgram	70
25	Mustard-Boro- T. Aman	560	56	Coriander-Vegetab-Fallow	60
26	Mustard-Aus- T. Aman	510	57	Lentil-Aus- T. Aman	60
27	Chilli-Fallow- T. Aman	500	58	Chilli-Vegetab-Fallow	55
28	S.Potato-Fallow- T. Aman	475	59	Potato-Aus-Fallow	50
29	Wheat-B.Aman	435	60	Wheat-Vegetab-Vegetab	50
30	Potato-Vegetab- T. Aman	380	61	Wheat-Vegetab- T. Aman	40
31	Mustard-Boro-Fallow	340	62-87	Other 26 patterns (Table 7)	345