Original Research Article

A comparative financial analysis of four crops based cropping pattern with existing cropping pattern in different locations of Bangladesh

Abstract

This study was undertaken to assess the comparative financial analysis of four crops based cropping pattern (FCP) with existing cropping pattern (ECP) in 35 upazilas of 25 districts under 7 divisions during the year of 2018-19 and 2019-20. Tabular technique and statistical analysis were done to achieve the objectives of the study. The Cobb-Douglas production function model was used for estimating the factors affecting FCP as well as ECP in the study areas. Within the 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 198% with the average increasing rate of 1.10% per year, at that time net cropped area decreased from 8248.16 thousand hectares to 8126.00 thousand hectares but grossed cropped area increased from 11785.55 thousand hectares to 16057.00 thousand hectares. This overall change in cropping intensity was due to increase in double cropped area (17.11%) and tripled cropped area (18.37%) and decline in single cropped area (35.76%). At present, four crops based cropping pattern was also introduced which occupied 0.28% of net cropped area. The major findings of the study were that cultivation of FCP was more profitable and feasible than ECP in terms of agronomic and economic point of view. The average total return per hectare for FCP was Tk. 529320.00 and Tk. 547896.00 and for ECP was an average Tk. 346788.00 and Tk. 348819.00 in 2018-19 and 2019-20 respectively. The total variable cost per hectare for FCP was Tk. 237134.00 and Tk. 238584.00 and for ECP was an average Tk. 175968.00 and Tk. 178294.00 in 2018-19 and 2019-20 respectively. Again the gross margin for FCP was Tk. 292186.00 and Tk. 309312.00 and for ECP was an average Tk. 170820.00 and Tk. 170525.00 in 2018-19 and 2019-20 respectively. The Benefit Cost Ratio (BCR) for FCP was 2.23 and 2.30 in 2018-19 and 2019-20 respectively. On the other hand, the BCR for ECP was 1.97 and 1.96 in 2018-19 and 2019-20 respectively. The average marginal benefit cost ratio (MBCR) in FCP over ECP was 2.98 and 3.30 in 2018-19 and 2019-20 respectively. Irrespective of locations, rice equivalent yield (REY), crop productivity, land use efficiency and profitability were higher in FCP than in ECP. The study also showed that FCP faced some problems mainly related to production and marketing of the

crops. It may be concluded that the farmers should be encouraged to grow four crops in a calendar year rather than existing two or three crops to enhance productivity and profitability.

Keywords: Cropping pattern, cropping intensity, productivity, profitability, BCR, Land use efficiency, rice equivalent yield, return.

Introduction

Bangladesh is one of the world's most densely populated countries, with a population of over 166.30 million and a growth rate of 1.03% per year (World population review, 2021). The county has an area of 147570 km2 and a net cultivated area of 8.126 million hectares. 2.11 million hectares are single cropped, 4.125 million hectares are double cropped, 1.867 million hectares are triple cultivated, and 0.023 million hectares are quadruple cropped, with a cropping intensity of 198% (Agri Stats, 2020). The population density per square kilometer is 1278 persons (World population review, 2021). As a developing country, it has strived for quick economic development. The agricultural sector dominates Bangladesh's economy. A satisfactory expansion of the agricultural sector is an essential requirement for accelerating the expansion of the overall economy. In recent years, agriculture's share of the nation's gross domestic product has declined, but it remains the greatest economic sector. Due to infrastructural development activities such as rapid urbanization, the construction of roads, highways, etc., the country's arable territory is diminishing gradually. Approximately 61.82 % of its population resides in rural areas, where agriculture is the primary industry and 40.6% (World Bank, 2020) of the labor force is engaged in agriculture. The majority of Bangladesh's inhabitants rely on agriculture for their livelihoods, either directly or indirectly.

A crop is defined as a collection of plants (of the same species) growing in a specific region that has some economic value to humans and/or livestock (Gaffer et al., 1996). Each season, crops are chosen based on soil-plant conditions. Bangladesh currently grows approximately 100 different crops due to its excellent climate for the development of a wide variety of crops. 32 of these 100 crops account for 96% of Bangladesh's total planted land. Crop production in Bangladesh has altered in recent years, both in terms of yields and crop distribution. Nonetheless, significant economic crops such as rice, jute, potato, legumes, and oilseeds may be found in Bangladesh. Rice accounts for around 77.12% of total cropped lands (Agri Stats, 2019).

Methodology

Selection of the study area

Considering the quadruple cropped areas of Bangladesh or where four crops cropping patterns are cultivated in a year, 35 locations of 25 district in 7 divisions were purposively selected for

collecting data regarding this study (Table 1). List of studied areas from where data were collected are given below:

Table 1. List of studied areas from where data were collected

Sl. No.	Division	District	Upazila
1.	Dhaka	Tangail	Modhupur
			Mirzapur
		Faridpur	Solakunda, Faridpur sadar
			Dicrirchar, Faridpur sadar
		Rajbari	Rajbari Sador
		Kishoreganj	Hossainpur
			Karimgang
		Narsingdi	Shibpur
		Gopalgonj	Gopalganj Sader
			Chandra Dighalia, Gopalganj Sader
		Gazipur	Dhirashram, Gazipur Sadar
		Manikganj	Manikganj Sador
2.	Khulna	Kushtia	Kushtia Sadar
		Meherpur	Gangni
		Satkhira	Satkhira Sador
		Jessore	Jessore Sadar
			Jhikargacha
3.	Mymensingh	Mymensingh	Mymensingh Sador
			Gouripur
		Jamalpur	Melandah
		Sherpur	Tarakandi, Sherpur Sador
4.	Rajshahi	Chapai Nawabganj	Amnura, Chapai Nawabganj Sadar
		Rajshahi	Mohanpur
			Bijoynagar
		Gaibandha	Dhaperhat, Sadullahpur
		Bogura	Sariakandi
			Sonatala
		Pabna	Pabna sadar
			Atgharia
5.	Rangpur	Dinajpur	Raniganj, Dinajpur Sador

		Rangpur	Rangpur Sador
			Gangachara
6.	Chattagram	Cox’s bazar	Cox’s bazar Sador
		Cumilla	Burichang
7.	Barisal	Bhola	Bhola Sador

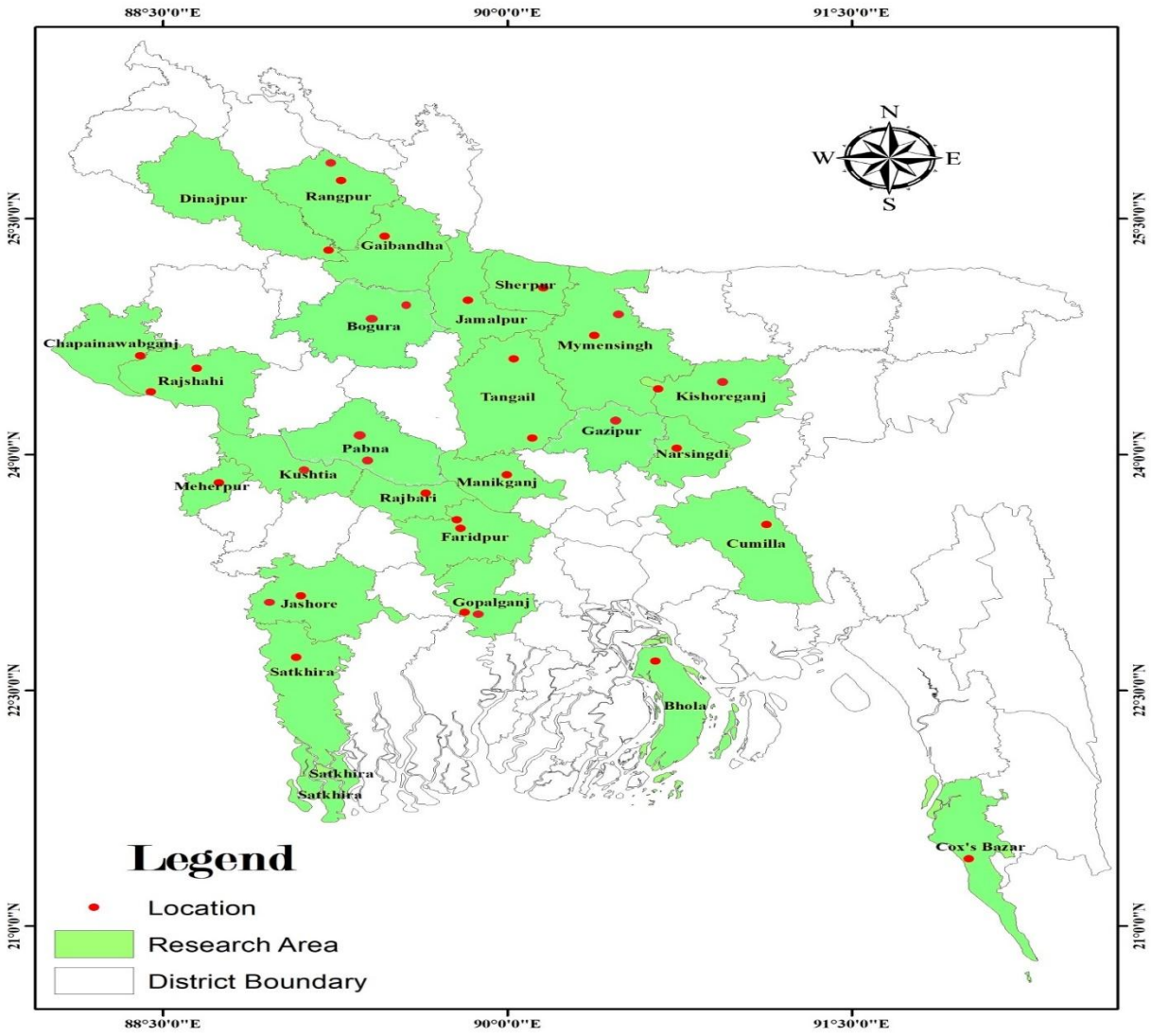


Figure 1 Map of research area (35 locations of 25 districts under 7 divisions)

Source of data

Secondary data were used for the study. Secondary data which related to document of cropping intensity were collected from different published sources including the statistical yearbook of Bangladesh (BBS, 2020), yearbook of agriculture statistics (Agri stats, 2020), food and agriculture data (FAOSTAT), world bank open data, annual report of Bangladesh agricultural research council (BARC) and annual report of soil resource development institute (SRDI). The future trend of various data until 2030 was projected based on BBS and historical data. Apart of that, field level data were collected from 35 locations of different farming system research and development (FSRD) and multi-locations trial sites (MLT sites) under on-farm research division (OFRD) of Bangladesh agricultural research institute (BARI) during the year of 2018-19 to 2019-20.

Processing of data

The collected data were manually edited and coded. Then all the collected data were summarized and scrutinized carefully.

Analytical techniques

Rice Equivalent Yield (REY)

The data of farmers practice was recorded from adjacent farmers' plots. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating their rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993), where

REY = {Yield of each crop (t ha-1) x price of respective crop (Tk. t-1)} / Price of rice grain (Tk. t-1)

Production efficiency

It was calculated by dividing the total main product in a cropping pattern by the total duration of crops in that pattern (Tomar and Tiwari 1990), using the formula:

Production Efficiency (kg ha–1 day–1) = {(y1 + y2 + y3 + y4) / (d1 + d2 + d3 + d4)} × 100

where y1 is yield of 1st crop of the pattern, y2 is yield of 2nd crop of the pattern, y3 is yield of 3rd crop of the pattern, y4 is yield of 4th crop of the pattern, d1 is duration of 1st crop of the pattern, d2 is duration of 2nd crop of the pattern, d3 is duration of 3rd crop of the pattern, and d4 is duration of 4th crop of the pattern.

Land use efficiency

Land Use Efficiency (%) = {(d1+d2+d3+d4) / 365} ×100

Where d1 is duration of 1st crop of the pattern, d2 is duration of 2nd crop of the pattern, d3 is duration of 3rd crop of the pattern, and d4 is duration of 4th crop of the pattern.

Calculation of returns

Total variable cost (TVC), gross return (GR), gross margin (GM), benefit-cost ratio (BCR) and marginal benefit-cost ratio (MBCR) of existing and four crops based cropping patterns were obtained from the prevailing market price of the products during the crop sowing and harvesting period. Marginal benefit-cost ratio (MBCR) was computed based on the formula:

Marginal benefit cost ratio = (GR of improved CP - GR of existing CP) / (TVC of improved CP - TVC of existing CP)

Predict a future value

The estimation of projected food requirement by the year 2030 is made by considering the population and minimum per head requirement. The estimation of projected production capacity in 2030 is prepared by analysing previous twelve year (2009-2020) production data.

The FORECAST function uses the following arguments:

FORECAST (x, known_y's, known_x's)

Where,

x = this is a numeric x-value (year 2030) for which we want to forecast a new y-value.

Known_y's = the dependent array or range of data (production data of individual crop).

Known_x's = this is the independent array or range of data that is known to us (years from 2009 to 2020).

The FORECAST function was calculated a new y-value using the simple straight-line

equation: $y = a+bx$

Where, $a = \bar{y} - b\bar{x}$ **and**

$$b = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2}$$

The values of x and y are the sample means (the averages) of the known_x and known_y values.

Factors influencing the existing and four crops based cropping pattern

The following type of Cobb-Douglas production function model was used for estimating the factors affecting 4 crops based cropping as well as existing in the study areas.

$\ln Y_i = \ln\alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + \beta n \ln X_{ni} + V_i$

Where, ln represents the natural logarithm, the subscript i represents the ith cropping pattern in the sample, Y represents the rice equivalent yield of cropping pattern(t ha^{-1}), Xi represents the variable factors of production, βi unknown parameters to be estimated, Vi assumed to be independently and identically distributed random errors, having N (0, σ_v^2) distribution.

Results and discussion

Document of cropping intensity in Bangladesh

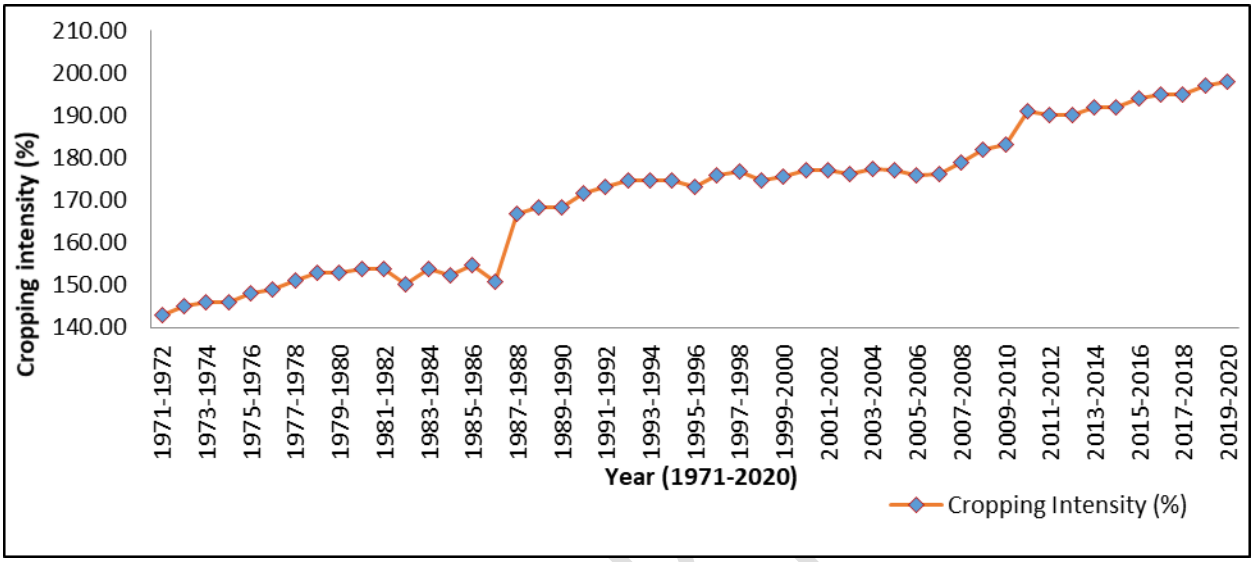
Cropping Intensity

Cropping intensity is expressed as the ratio of gross cropped area to net cropped area. Agricultural production can be increased either by bringing more and more land under cultivation or by increasing the cropping intensity and productivity of land or combination of both.

In Bangladesh, cropping intensity remained stagnant until late 1980s. There was a sharp rise in the years between 1987-88 and 2010-11 (Figure 2). In the first half of 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 173.06% with the increasing rate 1.20% per year, at that time net cropped area decreased 8248.16 thousand hectares to 7806.07 thousand hectares but total cropped area increased 11785.55 thousand hectares to 13518.64 thousand hectares (Figure 3), that's mean single cropped area converted to double and triple cropped area. Cultivation of modern crop varieties, improvising cultural operations, and crop protection measures collectively contributed to such achievement.

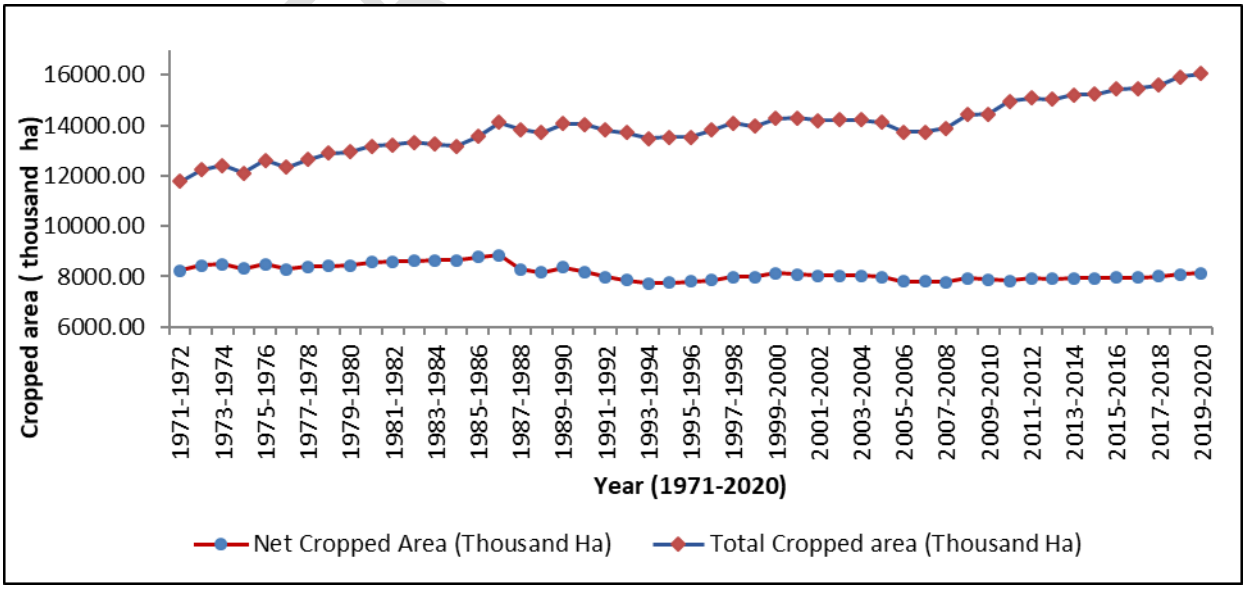
In the second half of 50 years, cropping intensity has increased from 173.06 to 198.00with the increasing rate 0.99% per year (Figure 2), in this time both net and gross cropped area are increased. In the year 2019-20, net area was 8126.00 thousand hectares and total cropped area was increased 16057.00 thousand hectares (Figure 3). Modern agricultural mechanization, irrigation facilities, year-round & short duration varieties and overall farmer's friendly policy helps to increase net and gross cropped area. But, it has not increased much in the last 25 years. In overall the 50 years of Bangladesh's independence, cropping intensity has increased from 143% to 198% with the increasing rate 1.10% per year, at that time net cropped area decreased 8248.16 thousand hectares to 8126.00 thousand hectares but total cropped area increased 11785.55 thousand hectares to 16057.00 thousand hectares. This overall increase in cropping intensity is due to increase in tripled cropped area and decline in single cropped area. The double

cropped area has not changed much over the last two decades, though it increased in 1990s. At the meantime, four crops were successfully cultivated in a calendar year. In the year 2019-20, four cropped area was about 23000 hectares (BBS, 2020). It should be noted here that the population of Bangladesh in 1971-72 was 65.53 million, but at this time the population of the country is 2.5 times higher.



(Source: BBS, FAOSTAT, World Bank)

Figure 2. Trend of changing cropping intensity (%) in Bangladesh since 1971-72 to 2019-20



(Source: BBS, FAOSTAT, World Bank)

Figure 3. Trend of changing net and gross cropped area in Bangladesh since 1971-72 to 2019-20.

Changes have been taking place in crop sector in terms of area allocation to different crops. Cropping pattern is dependent on physical, historical, social, institutional and economic factors as well as government policies (Agrawal and Kassam, 1976). The crop sector has experienced accelerated growth for almost a half century (1971-72 to 2020-21) after the emergence of Bangladesh. A change in quantity of output reflects growth performance in crop agriculture. The increase in crop output is the result of changes in several contributing factors like changes in area allocated to a particular crop and yield rates. Area allocation to a particular crop is being influenced by expected output prices relative to input prices, expected yield (based on the art of technology available), rainfall during the pre-sowing period, price and yield risk. Yield is postulated as being influenced by the technology of production, input costs and rainfall/water availability during the growing period.

Table 2 reveals that the trend of changing cropping intensity of Bangladesh from 1970-71 to 2019-20. It shows that continuously increasing cropping intensity in Bangladesh. In the year 1970-71 net cropped area was 8248.16 thousand hectares and gross cropped area was 11794.87 thousand hectares and 2019-20 in year net cropped area is 8126.00 thousand hectares and gross cropped area is 16057.00 thousand hectares increasing trend year by year. In the year 1970-71 the cropping intensity is 143% become increasing continuously i.e. 198% in 2019-20. The Table 2 indicates that the compound growth rate (CGR) of cropping intensity was 0.29 it shows that higher cropping intensity in Bangladesh. On the other hand, the Compound Growth Rate (CGR) of net cropped area and grossed cropped area were -0.07 and 0.22 respectively. That's means trend of net cropped area gradually decreasing but gross cropped area is increasing. The coefficient of variation for net cropped area, grossed cropped area and cropping intensity were 3.98%, 8.89% and 11.09 respectively. It indicates that, during 1971-2020 times, the trend of changing of cropping intensity and gross cropped areas showed higher variation but net cropped areas showed lower variation in Bangladesh.

Table 2. Change of net cropped area (NCA), gross cropped area (GCA) and cropping intensity every 5 years interval in Bangladesh

Year	**Net Cropped Area (NCA) (thousand Hectares)**	**Gross Cropped Area (GCA) (thousand Hectares)**	**Cropping Intensity (%)**
1971-72	8248.16	11794.87	143.00
*1975-76	8489.14	12563.93	148.00
1980-81	8565.93	13169.26	153.74
1985-86	8769.74	13570.30	154.74
1990-91	8177.33	14034.24	171.62
1995-96	7806.07	13512.61	173.10

2000-01	8085.02	14299.30	176.86
2005-06	7809.31	13736.39	175.90
2010-11	7838.00	14943.00	190.65
2015-16	7947.00	15438.00	194.26
2019-20	8126.00	16057.00	198.00
Mean	**8169.25**	**13919.90**	**170.90**
SD	**324.98**	**1237.55**	**18.96**
CGR	**-0.07**	**0.22**	**0.29**
CV(%)	**3.98**	**8.89**	**11.09**

SD = Standard deviation, CGR= Compound Growth Rate, CV= Co-efficient of Variance

Source: Yearbook of Agricultural Statistics (1980-81 to 2019-2020), Alam and Abedien (1996), World Bank open data

Table 3 indicates that division wise cropping intensity in Bangladesh in the last twelve years form 2008-09 to 2019-20. The cropping intensity shows great spatial variation in Bangladesh within twelve years, with higher levels in northern plains. In 2019-20 year, the highest cropping intensity found in Rangpur region (222%) followed by Rajshahi (216%) and Mymensingh region (206%). The difference between the two areas in terms of cropping patterns as well as cropping intensity is mainly caused by the timely availability of water for irrigation. The irrigation facilitated area under Rangpur, Rajshahi and Mymensingh region was 52.77%, 62.02%, 49.45% respectively (Agri stats, 2020). At the same time, the last 5 years average rainfall in Rangpur, Rajshahi and Mymensingh region was 2031.8 mm, 1290.0 mm and 2201.8 mm respectively (Agri stats, 2020). Although the average rainfall was low in Rajshahi but irrigation facilitated area was highest in this region. More irrigation facilities and rainfall, cropping intensity might be higher in this region compare to other region in Bangladesh. The cropping intensity in Chattagram and Dhaka region showed little lower than the national average (198%). The irrigation facilitated area under Chattagram and Dhaka region was 35.16% and 50.97%, respectively (Agri stats, 2020). The last 5 years average rainfall in Chattagram and Dhaka region was 3055.20 mm and 1998.40 mm respectively (Agri stats, 2020). Although irrigation facilitated area was low compare to other region in Chattagram but the average rainfall in Chattagram was highest. The lowest cropping intensity found in Khulna region (147%) followed by Sylhet and Barishal region. The irrigation facilitated area under Khulna, Sylhet and Barishal region was 64.02%, 34.152%, 15.96% respectively (Agri stats, 2020). The last 5 years average rainfall in Khulna, Sylhet and Barishal region was 1964.60 mm, 4401.00 mm and 2163.20 mm respectively (Agri stats, 2020). Although the average rainfall was high in this region but most of the areas are climatic vulnerable, that's why cropping intensity was might be low in this area. The Compound Growth Rate (CGR) of cropping intensity was positive for all regions except Barishal and

Mymensingh region which was -0.47 and -0.22 respectively. That means last 11 years cropping intensity was not increase in this area. In case of Barishal region, cropping intensity decrease 169% to 164%, it might be occurs several natural calamities occurs last few years in this region. On the other hand, highest CGR was found in Rajshahi (2.30) followed by Khulna (1.53), Rangpur (1.21) and Dhaka (1.17), that means cropping intensity rapidly increased in this area. The highest Coefficient of Variation was found in Rajshahi regions (8.29%) followed by Khulna (6.03%) and Dhaka (5.07) respectively. It indicates that, during 2009-2020 times, the trend of changing of cropping intensity of these regions showed higher variation in Bangladesh.

Table 3. Division wise cropping intensity of Bangladesh during 2008-2020

Division	Barishal	Chattogram	Dhaka	Khulna	Mymensingh	Rajshahi	Rangpur	Sylhet
2008-09	169	183	167	128	206	173	199	148
2009-10	171	184	174	127	207	173	200	147
2010-11	176	199	172	134	215	180	202	154
2011-12	177	191	168	132	211	190	204	150
2012-13	175	190	168	132	209	190	188	151
2013-14	178	191	164	134	206	198	212	150
2014-15	173	193	181	147	205	199	214	153
2015-16	187	187	184	148	205	202	216	152
2016-17	165	187	184	145	205	215	220	152
2017-18	165	188	185	146	205	215	219	152
2018-19	164	193	188	147	205	216	220	163
2019-20	164	193	188	147	206	216	222	163
Mean	**172.00**	**189.92**	**176.92**	**138.92**	**207.08**	**197.25**	**209.67**	**152.92**
SD	**7.06**	**4.44**	**8.97**	**8.37**	**3.12**	**16.34**	**10.81**	**5.11**
CGR	**-0.47**	**0.17**	**1.17**	**1.53**	**-0.22**	**2.30**	**1.21**	**0.70**
CV(%)	**4.10**	**2.34**	**5.07**	**6.03**	**1.51**	**8.29**	**5.15**	**3.34**

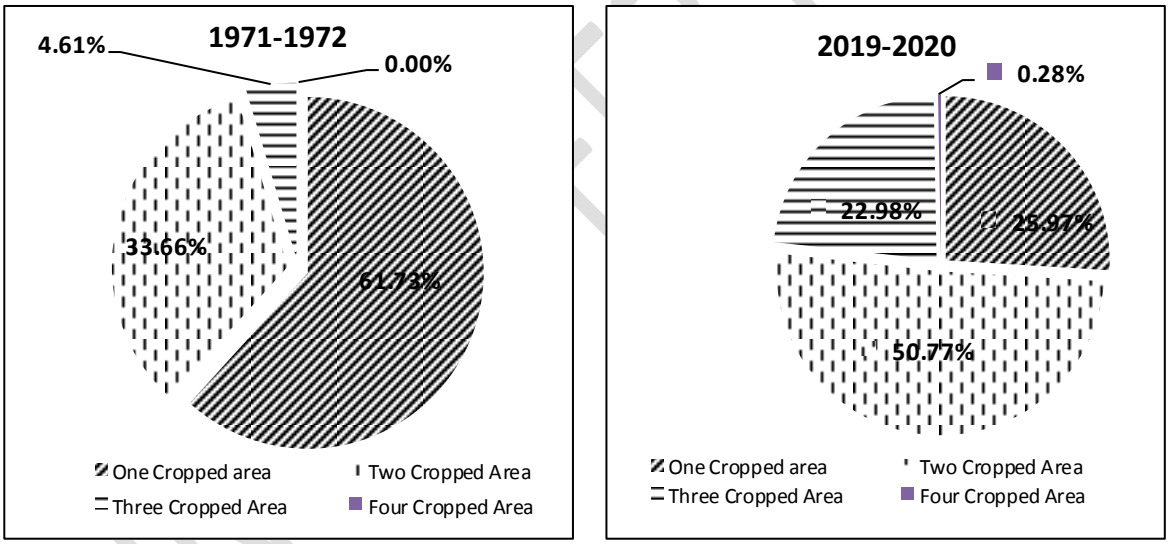
SD = Standard deviation, CGR= Compound Growth Rate, CV= Co-efficient of Variance

Source: Yearbook of Agricultural Statistics (2008-09 to 2019-20)

Trend of changing of cropped area in Bangladesh

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 77.12% of total cropped areas (Agri Stats, 2019). So all the other crops together, occupy the rest of the cropped. Generally there are three crop seasons in Bangladesh. Due to elevation of land and some other problems all the cultivable land is not suitable to use all the three seasons for crop production. Figure 4 presents the trends in agricultural land use change in Bangladesh over the 50 year period under consideration (1971-2020). In 1971-72, most of the cultivated land (61.73% of net cultivable land) produce crop once in a cropping calendar year but within 50 years the scenario is totally changed. At present, almost 50% of net cultivable land produce crop more than once in a cropping calendar year. It indicates there are high cropping intensity prevails during this time. This overall increase in cropping intensity is due to increase in double (17.11%) and tripled cropped area (18.37%) and decline in single cropped area (35.76%). Now a day, four cropped based cropping pattern also introduce in Bangladesh which occupied 0.28% of total cultivable area, which definitely will play a vital role to increase cropping intensity in future. Similarly, the more the multiple crop area, the more is the options in practicing crop diversification in the cultivable land.

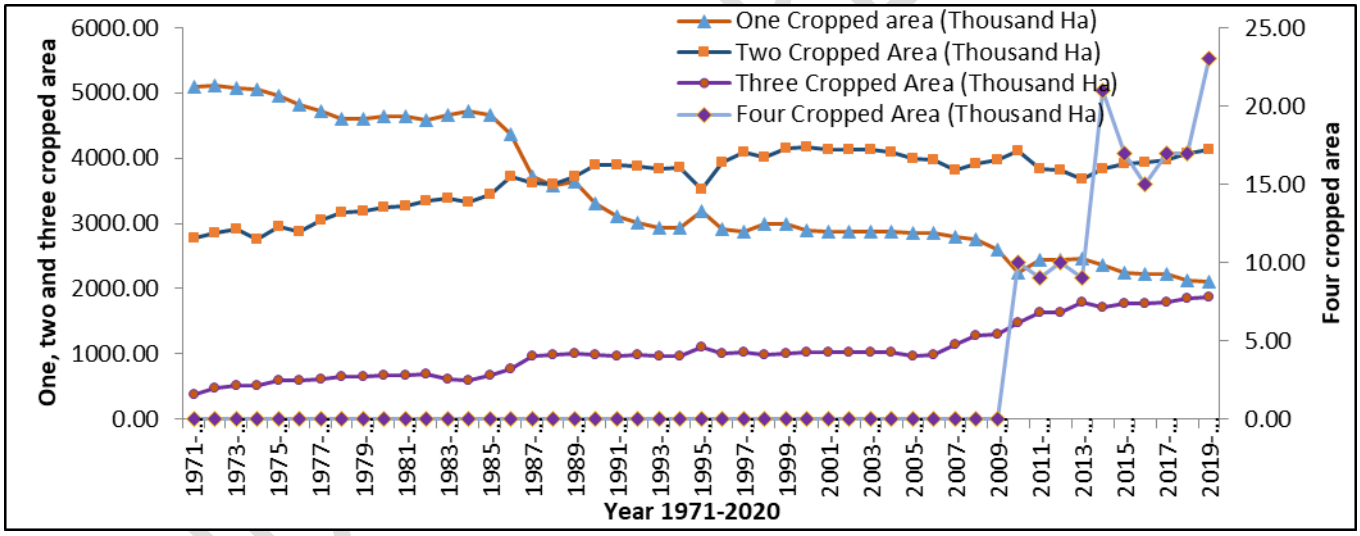


(Source: BBS, FAOSTAT, World Bank)

Figure 4. Changing of cropped area in Bangladesh last 50 years

The overall land area has increased by 4% from 14.28 million ha in 1971 to 14.84 million ha in 2020 owing to reclamation of new lands rising from the river beds (known as char lands) (SRDI,

2020). The net sown area available for agriculture recorded an overall decline of 0.1% perhaps due to diversion of land for non-agricultural land uses (e.g., housing, road and industrial infrastructures). However, due to improvements in irrigation, the gross cropped area (GCA), which takes into account land area sown twice or three times in a year, has steadily increased during the early and take-off stages of Green Revolution (1971- 1995), as expected, but then stagnated during the mature stage of GR (1996-2020) finally reaching 16.05 million ha in 2020 (Figure 4). The main reason for such an increase is the development of irrigation which enabled farmers to grow three or four crops in a year. In figure 4, it is clearly visible that one cropped area is gradually declining over time but at the same time two and three cropped area is increasing. Due to improvement mechanization and modern short duration varieties four cropped based cropping pattern also introduced in Bangladesh and increase its area gradually.



(Source: BBS, FAOSTAT, World Bank)

Figure 5. Trend of changing of cropped area in Bangladesh

Things to do to increase cropping intensity

The estimation of food crops requirement by the year 2030 is made by considering the population and minimum per head requirement. The estimation of production capacity in 2030 is prepared by analysing previous twelve year production data (Table 4). All food crops except rice will be deficit as per projected requirements for the year 2030. However, horizontal expansion of crop area as well as vertical increase of crop productivity is to be explored and ensured through adoption of modern technologies. In addition, exploration of new areas especially in

unfavourable ecosystems and technological interventions through reducing knowledge-gap of farmers are some of the important areas to overcome the problem.

Table 4. Projections of food demand by 2030 in Bangladesh

Crop	Projected requirement in 2030 (million ton)	Current production in 2020 (million ton)	Additional requirement (million ton)	Production capacity in 2030 (million ton)
Rice	37.50	36.60	0.9	40.25
Wheat	4.20	1.25	2.95	1.01
Maize	8.30	4.70	3.60	7.24
Pulses	3.50	0.39	3.11	0.69
Oilseeds	1.70	0.97	0.73	1.13
Potato	12.30	9.60	2.7	11.39
Vegetables	6.40	4.58	1.82	6.33
Cropping intensity	-	198%	-	211.03%

Source: Author's estimation by using forecast formula and yearbook of agricultural statistics 2010-2020

A sum of 1.13 lakh ha agricultural land has been lost during the past 34 years from 1976 to 2010. Rate of cropland shifting to non-agricultural land (housing, industry, etc.) is alarming as it is associated with the food security of the country. Total cropland was estimated to be 9.76 million ha, 9.44 million ha and 8.75 ha in 1976, 2000, and 2010 with an average decrease of 0.14% during 1976 to 2000 and 0.73% during 2000 - 2010, respectively (SRDI, 2013). Hasan *et al.,* 2013 reported the rate of change cropland over the 34 years is 0.30% which is still declining. Despite that total gross cropped area has been increasing and will be increased in the future because of increasing cropping intensity. It was observed that cropping intensity increased from 143% (1971-72) to 198% (2019-20) at the rate of 1.15% and will be 211.03 % (projected) by 2030. It indicates that some single-cropped areas transformed to a double-cropped area, some double-cropped areas to the triple-cropped area, and some triple-cropped areas to quadruple cropped area by accommodating rice or non-rice crops in the cropping patterns. It can be noted that cropping intensity in Bangladesh substantially changed because of the development and dissemination of new generation short duration cultivars to fit into the fallow period in the existing single, two or three crops-based cropping patterns (Nasim *et al.,* 2021). Additionally, the availability of other green revolution technologies including chemical fertilizers, pesticides, irrigation facilities and modern farm mechanization also contributed to increasing cropping intensity. Therefore, it can be claimed that it is possible to increase total crop production through

the adoption of higher yield potential better genotype, improved cropping pattern through agronomic practices.

Financial feasibility of growing four crops based cropping pattern

There are many crop growing niches seen in Bangladesh to support a unique biodiversity of crops throughout the year. Types of crops cultivated in an area and round the year are 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 cropping pattern. The yearly sequence and spatial arrangement of crops or crops and seasonal fallow of a given area are known as cropping pattern. Cropping pattern 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. Cropping pattern is very important; it allows increase in intensity and hence total production in a year as well. Distribution of crops i.e., agricultural land occupied by different crops is an important consideration which is usually expressed by cropping pattern. In total, 316 cropping patterns were observed in Bangladesh (Nasim et al., 2017) of which thirty two cropping patterns contain four crops with exclusive rice crop covers 0.28% of the NCA (BBS 2020). To boost up annual cropping system productivity, the four-crop-based improved cropping pattern can plays an important role.

Field duration

The field duration of individual crop is very important in a four crops based cropping pattern as the four crops need to be planted and harvested within 365 days (Mondal et al. 2015). Short duration and location specific high yielding crop varieties are essential to plan four crops based cropping patterns. Field duration of a cropping pattern mainly depends on the individual duration of component crops. Farmers' cropping pattern or existing cropping pattern required on average 276 days and 275 days in 2018-19 and 2019-20 respectively (table 5). The highest crop duration found in Barishal division (292 days in 2018-19 and 290 days in 2019-20) followed by Chattagram and Rangpur division respectively and lowest crop duration found in Mymensingh division (234 days in 2018-19 and 235 days in 2019-20) followed by Rajshahi and Dhaka division. On the other hand, four crops based cropping pattern required on average 333 days and 334 days in 2018-19 and 2019-20 respectively (Table 6). The highest crop duration found in Khulna division (348 in 2018-19 and 352 days in 2019-20) followed by Barishal and Rajshahi division respectively and lowest crop duration found in Chattagram division (302 in 2018-19 and 303 days in 2019-20) followed by Dhaka and Mymensingh division. So it is clear that, this four crops based cropping pattern is very much feasible for our country where irrigation facility and other technologies are available. Recently, BRRI, BARI, BINA and other research institute as well as agricultural universities released many shorts duration HYV crop varieties which are easily fit in this cropping pattern.

To accommodate four crops in a cropping pattern, the farmers' existing crop variety(s) may need to be replaced by short-duration variety(s) especially if farmers use long-duration variety(s). Extension workers play a vital rule for replacing traditional variety by modern short duration

HYV variety. Demonstration plot and farmers training will be motivated farmers to cultivate four crops based cropping pattern.

Table 5. Duration of existing cropping pattern in different divisions in Bangladesh

Sl. No.	Division	Duration (days) 2018-19	Duration (days) 2019-20
1.	Dhaka	276	277
2.	Khulna	281	277
3.	Rajshahi	273	274
4.	Rangpur	282	282
5.	Mymensingh	234	235
6.	Chattagram	289	290
7.	Barisal	292	290
Mean		**276**	**275**
SD		**19.39**	**18.74**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Table 6. Duration of four crops based cropping pattern in different divisions in Bangladesh

Sl. No.	Division	Duration (days) 2018-19	Duration (days) 2019-20
1.	Dhaka	323	324
2.	Khulna	348	352
3.	Rajshahi	344	344
4.	Rangpur	337	339
5.	Mymensingh	328	329
6.	Chattagram	302	303
7.	Barisal	346	347
Mean		**333**	**334**
SD		**16.41**	**16.85**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area

Rice equivalent yield

The yield of a crop variety is the main indicator for acceptance or rejection of a crop or a variety by farmers. Rice equivalent yield **(**REY) is an indicator to compare the yield of the four crops based cropping pattern and the farmers' existing pattern. Here, farmers' cropping pattern or existing cropping pattern gave on average 19.60 t ha^{-1} and 19.47 t ha^{-1} rice equivalent yield in 2018-19 and 2019-20 respectively (Table 7). The highest rice equivalent yield found in Rangpur division (24.87 t ha^{-1} in 2018-19 and 25.35 t ha^{-1} in 2019-20) followed by Chattagram and

Dhaka division respectively and lowest crop duration found in Khulna division (12.08 t ha^{-1} in 2018-19 and 12.07 t ha^{-1} in 2019-20) followed by Mymensingh and Rajshahi division. On the other hand, four crops based cropping pattern gave on average 31.05 t ha^{-1} and 31.46 t ha^{-1} in 2018-19 and 2019-20 respectively (table 8) which was much higher than existing pattern. In case four crops cropping pattern, The highest rice equivalent yield found in Chattagram division (43.43 t ha^{-1} in 2018-19 and 40.65 t ha^{-1} in 2019-20) followed by Barishal and Rangpur division respectively and lowest crop duration found in Khulna division (21.11 t ha^{-1} in 2018-19 and 21.75 t ha^{-1} in 2019-20) followed by Rajshahi and Mymensingh division. REY is higher in four crops based cropping pattern due to the inclusion of a new crop in the improved pattern, use of modern high-yielding varieties instead of local varieties and improved management practices. It should be noted here that, the yield of an introduced short duration variety may, to some extent, be less than that of the farmers' long-duration variety. By replacing an existing long-duration variety with a short-duration variety, the yield of that crop may decrease. However, in a cropping system, the cumulative yield of component crops determines the total system productivity and not by a single crop (Timsina and Connor, 2001). The cumulative effect of the inclusion of a new crop and replacement of other crop varieties might increase total yield compared to the farmers' existing pattern.

Table 7. Rice Equivalent Yield (REY) of existing cropping pattern in different divisions in Bangladesh

Sl. No.	Division	REY (t ha^{-1}) 2018-19	REY (t ha^{-1}) 2019-20
1.	Dhaka	22.59	22.55
2.	Khulna	12.08	12.07
3.	Rajshahi	17.76	18.02
4.	Rangpur	24.87	25.35
5.	Mymensingh	14.70	14.59
6.	Chattagram	22.79	22.48
7.	Barisal	22.42	21.26
Mean		**19.60**	**19.47**
SD		**4.81**	**4.78**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Table 8. Rice Equivalent Yield (REY) of four crops based cropping pattern in different divisions in Bangladesh

Sl. No.	Division	REY (t ha^{-1}) 2018-19	REY (t ha^{-1}) 2019-20
1.	Dhaka	32.01	32.72
2.	Khulna	21.11	21.75
3.	Rajshahi	26.34	26.45
4.	Rangpur	32.93	33.49
5.	Mymensingh	29.52	31.48
6.	Chattagram	43.43	40.65
7.	Barisal	32.02	33.67
Mean		**31.05**	**31.46**
SD		**6.85**	**5.98**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Production efficiency

In case of existing cropping pattern, production efficiency was recorded an average 69.93 kg ha^{-1}day^{-1} and 70.71 kg ha^{-1}day^{-1} in 2018-19 and 2019-20 respectively (Table 9). Here, highest production efficiency found in Rangpur division (87.13 kg ha^{-1} day^{-1} in 2018-19 and 88.80 kg ha^{-1} day^{-1} in 2019-20) followed by Chattagram and Dhaka division respectively and lowest crop duration found in Khulna division (43.71 kg ha^{-1} day^{-1} in 2018-19 and 44.83 kg ha^{-1} day^{-1} in 2019-20) followed by Mymensingh and Rajshahi division. On the other hand, higher production efficiency was recorded in the improved four crops based cropping pattern which was an average 95.80 kg ha^{-1}day^{-1} and 96.15 kg ha^{-1}day^{-1} in 2018-19 and 2019-20 respectively (Table 9). Here, highest production efficiency found in Chattagram division (144.03 kg ha^{-1} day^{-1} in 2018-19 and 134.32 kg ha^{-1} day^{-1} in 2019-20) followed by Dhaka and Mymensingh division respectively and lowest crop duration found in Khulna division (60.43 kg ha^{-1} day^{-1} in 2018-19 and 61.60 kg ha^{-1} day^{-1} in 2019-20) followed by Rajshahi and Barishal division. Improved management practices and the use of modern varieties resulted in higher production efficiency in the four crops based cropping pattern over the existing farmers' cropping pattern (BARI, 2020). Production efficiency (kg ha^{-1}day^{-1}) in the farmers' pattern was lower than that in the improved pattern due to the absence of modern management practices and local varieties. It indicates the proper utilization of inputs supplied and the availability of natural resources in the field. Local varieties have low capacity to utilize the resources, whereas high yielding modern varieties are capable to utilize supplied inputs and natural resources (BARI 2020). That is why production efficiency was higher in the improved pattern. A similar result was also found in previous studies of rice-based improved cropping patterns (Nazrul *et al.*, 2013; Khan *et al.*, 2005).

Table 9. Production efficiency of farmer practices cropping pattern in different divisions in Bangladesh

Sl. No.	Division	PE (kg ha^{-1} day^{-1}) 2018-19	PE (kg ha^{-1} day^{-1}) 2019-20
1.	Dhaka	80.64	80.17
2.	Khulna	43.71	44.83
3.	Rajshahi	63.94	64.68
4.	Rangpur	87.13	88.80
5.	Mymensingh	60.12	59.44
6.	Chattagram	81.16	79.75
7.	Barisal	72.81	77.31
Mean		**69.93**	**70.71**
SD		**15.08**	**15.14**

Table 10. Production efficiency of four crops based cropping pattern in different location in Bangladesh

Sl. No.	Division	PE (kg ha^{-1} day^{-1}) 2018-19	PE (kg ha^{-1} day^{-1}) 2019-20
1.	Dhaka	100.10	102.13
2.	Khulna	60.43	61.60
3.	Rajshahi	76.61	76.84
4.	Rangpur	98.90	99.66
5.	Mymensingh	99.22	101.50
6.	Chattagram	144.03	134.32
7.	Barisal	91.28	97.03
Mean		**95.80**	**96.15**
SD		**25.84**	**22.73**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Land Use Efficiency

Land use efficiency (LUE) indicates the utilization of land in terms of time and space. Higher land use efficiency means that land is occupied for additional number of days by various crops in the cropping pattern. With higher land use efficiency, there is a higher chance of utilizing more natural resources. Land use efficiency (LUE) depends on crop duration and the number of crops cultivated during a cropping season. The study revealed that LUE of the farmers' cropping

pattern was 75.71% and 75.30% in 2018-19 and 2019-20 respectively (Table 11). On the other hand, LUE of four crops based cropping pattern was average 91.33% and 91.83% in 2018-19 and 2019-20 respectively (table 12) which was much higher than existing pattern. Land use efficiency in the improved four crops based cropping pattern was higher because this pattern occupied the field for a longer period year^{-1} (333 days and 334 days in 2018-19 and 2019-20 respectively) compared to the farmers' pattern (276 days and 275 days in 2018-19 and 2019-20 respectively) (Table 5 & 6). The inclusion of new crop in the improved pattern occupied more field duration and led to higher land use efficiency.

Table 11. Land Use Efficiency (LUE) of farmer practices cropping pattern in different divisions in Bangladesh

SL No	**Division**	**LUE % 2018-19**	**LUE % 2019-20**
1	Dhaka	75.62	75.82
2	Khulna	76.93	75.89
3	Rajshahi	74.89	75.07
4	Rangpur	77.17	77.26
5	Mymensingh	64.18	64.32
6	Chattagram	81.16	79.32
7	Barisal	80.00	79.45
Mean		**75.71**	**75.30**
SD		**5.56**	**5.14**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Table 12. Land Use Efficiency (LUE) of 4 crops based cropping pattern in different location in Bangladesh

SL. No.	**Division**	**LUE % 2018-19**	**LUE % 2019-20**
1	Dhaka	88.58	88.74
2	Khulna	95.41	96.66
3	Rajshahi	94.25	94.38
4	Rangpur	92.24	92.97
5	Mymensingh	89.93	90.00
6	Chattagram	82.74	83.01
7	Barisal	96.16	97.03
Mean		**91.33**	**91.83**
SD		**4.70**	**4.98**

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

In the above discussion it is clear that, four crops based cropping patterns are successfully grown in all divisions except Sylhet and in case of field duration, rice equivalent yield, production efficiency and land use efficiency it gave superior results than existing cropping patterns. So, it can say that, four crops based cropping pattern is very much feasible for our country where irrigation facility and other technologies are available.

Cost, return and profitability of four crops based cropping pattern

Profitability of every cropping pattern has been measured in terms of gross margin, net return, benefit cost ratio and marginal benefit cost ratio considering over total variable cost basis.

Cost of existing and four crops based cropping pattern

Cost of seed

Total seed cost for specific cropping pattern was calculated by summation of individual crop seed cost which was used in that cropping pattern. In case of existing cropping pattern, an average Tk. 30835.00 and Tk. 30693.00 required for seed purpose in 2018-19 and 2019-20 respectively which was 17.52% and 17.21% of the total variable cost (Table 13). On the other hand, four crops based cropping pattern required an average Tk. 41458.00 and Tk. 41406.00 in 2018-19 and 2019-20 respectively which was 17.48% and 17.35% of the total variable cost (Table 14) and much higher than existing pattern.

Cost of human labor

In case of existing cropping pattern, an average Tk. 69543.00 and Tk. 70914.00 required per hectare for hired labour purpose in 2018-19 and 2019-20 respectively which was 39.52% and 39.77% of the total variable cost (Table 13). On the other hand, four crops based cropping pattern required an average Tk. 92800.00 and Tk. 93643.00 in 2018-19 and 2019-20 respectively which was 39.13% and 39.25% of the total variable cost (Table 14).

Cost of fertilizer

In case of existing cropping pattern, an average Tk. 10213.00 and Tk. 10514.00 required per hectare for fertilizer purpose in 2018-19 and 2019-20 respectively which was 5.80% and 5.90% of the total variable cost (Table 13). On the other hand, 4 crops based cropping pattern required an average Tk. 13999.00 and Tk. 13772.00 in 2018-19 and 2019-20 respectively which was 5.90% and 5.77% of the total variable cost (Table 14).

Cost of irrigation

It was calculated based on how many times irrigation was needed per hectare and what was its cost. In case of existing cropping pattern, an average Tk. 26971.00 and Tk. 26514.00 required per hectare for irrigation purpose in 2018-19 and 2019-20 respectively which was 15.33% and 14.87% of the total variable cost (Table 13). On the other hand, four crops based cropping pattern required an average Tk. 36929.00 and Tk. 35720.00 in 2018-19 and 2019-20 respectively which was 15.57% and 14.97% of the total variable cost (Table 14).

Table 13. Per hectare average total variable cost of 35 existing cropping patterns during 2018-19 & 2019-20

Items	2018-19		2019-20	
	Cost of existing CP	Percent over total	Cost of existing CP	Percent over total
Seed cost	30835.00	17.52	30693.00	17.21
Labour cost	69543.00	39.52	70914.00	39.77
Fertilizer cost	10213.00	5.80	10514.00	5.90
Irrigation cost	26971.00	15.33	26514.00	14.87
Pesticides cost	24991.00	14.20	25600.00	14.36
Miscellaneous cost (tillage, tools equipment etc)	13415.00	7.62	14059.00	7.89
Total Variable Cost	175968.00	100	178294.00	100

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Table 14. Per hectare average total variable cost of 35 four crops based cropping patterns during 2018-19 & 2019-20

Items	2018-19		2019-20	
	Cost of 4 crops based CP	Percent over total	Cost of 4 crops based CP	Percent over total
Seed cost	41458.00	17.48	41406.00	17.35
Labour cost	92800.00	39.13	93643.00	39.25
Fertilizer cost	13999.00	5.90	13772.00	5.77
Irrigation cost	36929.00	15.57	35720.00	14.97
Pesticides cost	34116.00	14.39	35345.00	14.81
Miscellaneous cost (tillage, tools	17832.00	7.52	18699.00	7.84

equipment etc)				
Total Variable Cost	237134.00	100.00	238584.00	100.00

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area.

Cost of Pesticides

In case of existing cropping pattern, an average Tk. 24991.00 and Tk. 25600.00 required per hectare for pesticides purpose in 2018-19 and 2019-20 respectively which was 14.20% and 14.36% of the total variable cost (Table 13). On the other hand, 4 crops based cropping pattern required an average Tk. 34116.00 and Tk. 35345.00 in 2018-19 and 2019-20 respectively which was 14.39% and 14.81% of the total variable cost (Table 14).

Miscellaneous (tillage, tools and equipment cost)

In case of existing cropping pattern, an average Tk. 13415.00 and Tk. 14059.00 required per hectare for miscellaneous purpose in 2018-19 and 2019-20 respectively which was 7.62% and 7.89% of the total variable cost (Table 13). On the other hand, 4 crops based cropping pattern required an average Tk. 17832.00 and Tk. 18699.00 in 2018-19 and 2019-20 respectively which was 7.52% and 7.84% of the total variable cost (Table 14).

Profitability of four crops based cropping pattern

For every cropping pattern, return was calculated by multiplying rice equivalent yield with its price per kilogram. Return per hectare for existing cropping pattern is shown in Table 15 and return per hectare for four crops based cropping pattern is shown in Table 16. The variable cost included the seed cost, labour cost, fertilizer cost, irrigation, pesticides cost and miscellaneous cost (tillage, tools equipment etc). In the year 2018-19, the average per hector variable cost for existing cropping pattern and four crops based cropping was Tk. 175968.00 and Tk. 237134.00 respectively (Table 15). The average rice equivalent yield for existing cropping pattern and four crops based cropping was found to be 19.27 t ha^{-1} and 30.45 t ha^{-1} respectively. The gross return and gross margin for existing cropping pattern was Tk. 346788.00 and Tk. 170820.00 respectively. On the other hand, the gross return and gross margin for four crops based cropping pattern was Tk. 529320.00 and Tk. 292186.00 respectively. The average benefit cost ratio for existing cropping pattern and four crops based cropping was found to be 1.97 ha^{-1} and 2.23 ha^{-1} respectively. The average marginal benefit cost ratio (MBCR) was 2.98 ha^{-1} in four crops based cropping pattern over existing cropping pattern (Table 15) indicating that four crops based cropping pattern will produce more returns than the existing farmer's pattern. This was mainly due to the production potential accompanied with good monetary returns of components crops of four crops based cropping pattern. On the other hand, existing cropping pattern gave lower gross

return and gross margin. In case of every particular (rice equivalent yield, gross return, variable cost and gross margin) except benefit cost ratio, the P value was much lower than 0.01, that means the particulars for existing cropping pattern and four crop based cropping patter were significant at 1% level of significance. In case of benefit cost ratio, the P value was 0.083, which was significant at 10% level of significance for existing cropping pattern and four crops based cropping patter in 2018-19. (Table 15)

Table 15. Comparative profitability analysis of existing cropping pattern with four crops based cropping pattern during 2018-19

Particulars	2018-19		P value
	Existing cropping pattern	Four crops based cropping pattern	
Rice equivalent yield (t ha^{-1})	19.27	30.45	0.0002***
Gross return (Tk. ha^{-1})	346788.00	529320.00	0.0003***
Variable cost (Tk. ha^{-1})	175968.00	237134.00	0.0003***
Gross margin (Tk. ha^{-1})	170820.00	292186.00	0.0039***
Benefit cost ratio	1.97	2.23	0.083*
Marginal benefit cost ratio	2.98		

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area Note: *** and * indicates significant at 1% and 10% level of significance respectively

In the year 2019-20, the average per hector variable cost for existing cropping pattern and four crops based cropping was Tk. 178294.00 and Tk. 238584.00 respectively (Table 16). The average rice equivalent yield for existing cropping pattern and four crops based cropping was found to be19.38 t ha^{-1} and 30.34 t ha^{-1} respectively. The gross return and gross margin for existing cropping pattern was Tk. 348819.00 and Tk. 170525.00 respectively. On the other hand, the gross return and gross margin for four crops based cropping pattern was Tk. 547896.00 and Tk. 309312.00 respectively. The average benefit cost ratio for existing cropping pattern and four crops based cropping was found to be 1.96 ha^{-1} and 2.30 ha^{-1} respectively. The average marginal benefit cost ratio (MBCR) was 3.30 ha^{-1} in four crops based cropping pattern over existing cropping pattern (Table 16). In case of every particular (rice equivalent yield, gross return, variable cost and gross margin) except benefit cost ratio, the P value was much lower than 0.001, that means the particulars for existing cropping pattern and four crop based cropping patter were significant at 1% level. In case of benefit cost ratio, the P value was 0.0262, which was 5% level of significant for existing cropping pattern and four crops based cropping patter in 2019-20 (Table 16). On the basis of above discussions, it could thoughtfully be concluded here that both existing cropping pattern and four crops based cropping pattern were found profitable. However, four crops based cropping pattern estimated more profitable than existing in the studied areas.

From the above calculation it was found that four crops based cropping pattern is profitable in Bangladesh.

Table 16. Comparative profitability analysis of existing cropping pattern with four crops based cropping pattern during 2019-20

Particulars	2019-20		P value
	Existing cropping pattern	Four crops based cropping pattern	
Rice equivalent yield (t ha^{-1})	19.38	30.34	0.0002***
Gross return (Tk. ha^{-1})	348819.00	547896.00	0.00008***
Variable cost (Tk. ha^{-1})	178294.00	238584.00	0.0002***
Gross margin (Tk. ha^{-1})	170525.00	309312.00	0.0009***
Benefit cost ratio	1.96	2.30	0.0262**
Marginal benefit cost ratio	3.30		

Source: FSRD and MLT site, respective on-farm research division office, BARI in research area Note: *** and ** indicates significant at 1% and 5% level of significance respectively

Factors influencing the four crops based CP and existing CP

Table 17. Estimated values of coefficients and related statistics of Cobb-Douglas production function of four crops CP in 2018-19 and 2019-20 year

Items	Existing CP			Four crops based CP		
	Coefficient	Standard Error	p-value	Coefficient	Standard Error	p-value
Constant	-3.402	2.403	0.168	0.382	4.836	0.938
Seed (Tk./ha)	0.237***	0.049	0.0004	0.163***	0.058	0.008
Labour (Tk./ha)	0.069	0.238	0.774	0.003	0.492	0.995
Fertilizer (Tk./ha)	0.025	0.220	0.910	0.234	0.346	0.505
Irrigation	-0.227	0.217	0.306	-0.624*	0.341	0.07

(Tk./ha)						8
Pesticides (Tk./ha)	0.564**	0.276	0.050	0.386*	0.407	0.10
Miscellaneous (tillage, tools and equipment) (Tk./ha)	0.038	0.143	0.794	0.160	0.181	0.384
n	35			35		
F	**12.19*** **			**5.14*** **		
R square	72%			52%		
Standard Error	0.259			0.304		

Rice equivalent yield of farmer's pattern or existing cropping patterns much lower than the yield obtained from four crops based cropping pattern. This difference has resulted due to the variation in input use, different management and due to the additional yield of one or two new crops included in this pattern. To increase yield as well as total national production, the existing production practices at farmer's level needs to be increased first. With this view, the present study deals with comparative financial analysis of four crops based cropping pattern with existing cropping pattern in different location of Bangladesh. Adoption of modern technology and production practices vary across farms and locations for various reasons. To determine the effect of variable inputs, 6 important variables were included in a Cobb-Douglas production function to explain the effect on REY of cropping pattern. A correlation test was also conducted and variables with multi co-linearity were excluded from the analysis. The estimated values of the co-efficient and related statistics are presented in Table 17. The results are discussed below:

Seed cost (X_1)

In case of existing cropping patter, regression coefficient of seed cost was 0.237. This indicated that, if seed cost increase by 1%, keeping other factors constant, then the yield would be increased by 0.237%. On the other hand, in case of four crops based cropping patter, regression coefficient of seed cost was 0.163. This indicated that, an increase in seed cost by 1%, keeping other factors constant, would increase the yield by 0.163% (Table 17).

Labour cost (X_2)

In case of existing cropping patter, regression coefficient of lobour cost was 0.069. This indicated that, if labor costs increase by 1%, keeping other factors constant, yields will increase by 0.069%. On the other hand, the regression co-efficient of labour cost also was positively related to yield of four crops based pattern at studied areas it was insignificant. In case of four crops based cropping patter, regression coefficient of lobour cost was 0.003. This indicated that,

increase in labor use by 1%, keeping other factors constant, would increase yield by 0.003% (Table 17). That means labour may be effectively used in four crops based cropping pattern.

Fertilizer cost (X_3)

The regression co-efficient of fertilizer cost was positively related to yield of both cropping existing and four crops based cropping pattern at studied areas. The relationship was found to be insignificant in both patterns. In case of existing cropping patter, regression coefficient of fertilizer cost was 0.025. This indicated that, an increase in fertilizer use by 1%, keeping other factors constant, would increase the yield by 0.054%. On the other hand, in case of four crops based cropping patter, regression coefficient of fertilizer cost was 0.234. This indicated that, an increase in fertilizer use by 1%, keeping other factors constant, would increase the yield by 0.234% (table 17).

Irrigation water cost (X_4)

The regression co-efficient of irrigation cost was negatively related to yield of both existing cropping pattern and four crops based cropping pattern at studied areas. The relationship was found to be insignificant for existing cropping pattern and significant at 10% level of significance for four crops based cropping pattern. In case of existing cropping patter, regression coefficient of irrigation cost was -0.227. This indicated that, an increase apply of irrigation by 1%, keeping other factors constant, would decrease the yield by 0.227%. On the other hand, in case of four crops based cropping patter, regression coefficient of irrigation cost was -0.624. This indicated that, an increase apply of irrigation cost by 1%, keeping other factors constant, would decrease the yield by 0.624% (table 17).

Pesticides Cost (X_5)

In case of existing cropping pattern, it can be seen from Table 17 that, regression coefficient of pesticides cost was 0.564 that was positive was significant at 5% level of significance. This indicated that an increase 1% of pesticides cost, remaining other factors constant, would result in an increase in the gross return by 0.564%. On the other hand, in case four crops based cropping pattern the regression coefficient of pesticides cost was 0.386 that was positive was significant at 10% level. This indicated that, an increase in pesticides cost by 1%, keeping other factors constant, would increase the yield by 0.386%.

Miscellaneous (tillage, tools and equipment) Cost (X_6)

The regression co-efficient of miscellaneous cost (tillage, tools and equipment) was positively and the relationship was found to be insignificant. In case of existing cropping patter, regression coefficient of miscellaneous cost was 0.038. This indicated that, an increase in miscellaneous cost by 1%, keeping other factors constant, would decrease the yield by 0.038%. On the other hand, in case of four crops based cropping patter, regression coefficient of miscellaneous cost was 0.160. This indicated that, an increase in miscellaneous cost by 1%, keeping other factors constant, would increase the yield by 0.160% (Table 17)

Problems/Constraints related to four cropped based cropping pattern

- Irrigation is an important input for the production of crops and in case four crops based cropping pattern, the main precondition is to have irrigation facilities in that area. At present, 49.70% of total net cropped area of Bangladesh has irrigation facilities and its increasing gradually (Agri Stats, 2020).
- Although modem agricultural technologies have been currently using in Bangladesh but a large number of fanners have no adequate knowledge of right doses and methods of using modern inputs and technologies of producing their enterprises.
- During the production period price of some inputs tend to rise due to their scarcity and farmers had to purchase some inputs at a high price during the production period (Hossain, 2014).
- Most of the farmers had to sell a large portion of their product at the harvest period to meet various obligations like, household's expenditure and repayment of loan. But harvest time price of many crops like potato, rice, vegetables etc. remained low because of ample supply. So they could not get reasonable return for their products (Khatun, et al., 2020).
- Non-availability of human labour was found in different stages of production such as planting, intercultural operates and harvesting, for this reason many farmers are reluctant to cultivate four crops in a year.
- It was found that farmers faced some acute problems relating to the nature in their cultivation period. Natural calamities like drought hail storm, excessive rainfall, caused substantial damage to the crop in the field (Hossain, 2014).

Conclusion

From the results of the present study, it can be concluded that considerable scope apparently exists in the study area to increase the productivity of crop as well as to increase income of the growers by introduce four crops based cropping pattern. The study revealed that four crops based cropping pattern was relatively more profitable and feasible than existing two or three crops based cropping pattern in terms of agronomic and economic point of view. The findings of the study related to document of cropping intensity indicated that within the 50 years after Bangladesh's independence cropping intensity is gradually increased. Moreover, net cropped area is decreasing at an alarming rate because of high population pressure. Extension of agricultural land is not possible in Bangladesh. To explore the potential of four crops based cropping patterns, it is necessary to integrate the available technologies to increase the total productivity. Cropping intensity, and hence, the total annual system productivity and profitability, can be increased through the practice of four crops based cropping pattern. Increase production through utilizing fallow period can create scope for improvement of agricultural production system. Use of short-duration high-yielding variety can bring more area under this four crops based cropping pattern. Based on the productivity

and economic returns, the study suggests that the improved four crops based cropping pattern is financially viable and feasible for the medium-high land with irrigation facilities zone of Bangladesh.

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