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A Comparative Financial Analysis of Four Crops Based Cropping Patterns with Existing Cropping Patterns in Different Locations of Bangladesh

Kanis Fatema Ruma [a*], M. Kamruzzaman [a], Kaniz Fatima Jui [a], Kazi Tamim Rahman [a] and Jahidul Hasan [b]

[a] Department of Agricultural Economic, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.
[b] Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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. The major findings of the study were that cultivation of FCP was more profitable and feasible than ECP in terms of

**Corresponding author: E-mail: fatemakanis902@gmail.com;*

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; productivity; profitability; land use efficiency; return.

1. INTRODUCTION

Bangladesh is a densely populated country with lower per capita arable land (15 decimal head^{-1}) usage annual loss of agricultural land is about 0.30% per annum due to construction of houses, roads and industrial infrastructure [1]. Thus increase of cropping intensity in rice based cropping system is becoming important for food security and poverty alleviation. In near future, the main challenge is to increase 50% yield per unit land by manipulating limited land resources [2]. In order to produce more food within a limited area, the most important options are to increase the cropping intensity and to increase the production efficiency of the individual crop by using optimum management practices [3]. With the development of short duration varieties of rice, mustard, potato, pulse and jute, opportunities have been created to accommodate four crops in same piece of land in a year [2].

However, farmers select crops based on many factors, such as, availability of agricultural inputs, value of crops, family need, market demands and net returns and government policies. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing three or more crops over the same piece of land in a year and ii) to increase the productivity of the individual crop depending on how well it utilizes the basic resources especially, the limiting ones, like water and nutrients. The present cropping intensity is 198% [4] and that can be increased up to some extent by improving the present cropping pattern, incorporating short duration crops and through management of cultivation practices [5]. Most of the major cropping patterns practiced around the country are comprised of single, two to three crops a year. Recently four crop based cropping pattern has been introduced by Bangladesh Agricultural Research Institute (BARI) in many AEZs.

A lot of information on two or three crops based cropping pattern is available in Bangladesh but a little information is available from past studies on the relative financial profitability of four crops based cropping patterns and its impact on employment. Therefore, the present study is expected to add more information on four crops based cropping patterns as wells as on profitability and employment effects of different crop combinations. So, this study plays an important role in planning and policy making for both at micro and macro levels. Keeping all these factors in consideration, the present study was undertaken to ascertain financial feasibility of growing four crops in sequence for increasing cropping intensity and productivity and to study the comparative performance and financial return of four crop based cropping pattern with existing cropping pattern.

2. METHODOLOGY

2.1 Selection of the Study Area and Source of Data

At present, four crops based cropping patterns are cultivated in all divisions over the country except Sylhet division [4], though the intensity of area coverage and suitability for growing four crops is not equal in all locations of the country. 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 (Fig. 1). 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. The divisions wise study area and the cropping pattern list were given in appendix I & II.

2.2 Analytical Techniques

2.2.1 Rice equivalent yield (REY)

Production efficiency (kg ha^{-1} day^{-1}) indicates the system productivity in relation to duration of crop. 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}) = $\{(y_1 + y_2 + y_3 + y_4) / (d_1 + d_2 + d_3 + d_4)\} \times 100$

where y_1 is yield of 1st crop of the pattern, y_2 is yield of 2nd crop of the pattern, y_3 is yield of 3rd crop of the pattern, y_4 is yield of 4th crop of the pattern, d_1 is duration of 1st crop of the pattern, d_2 is duration of 2nd crop of the pattern, d_3 is duration of 3rd crop of the pattern, and d_4 is duration of 4th crop of the pattern.

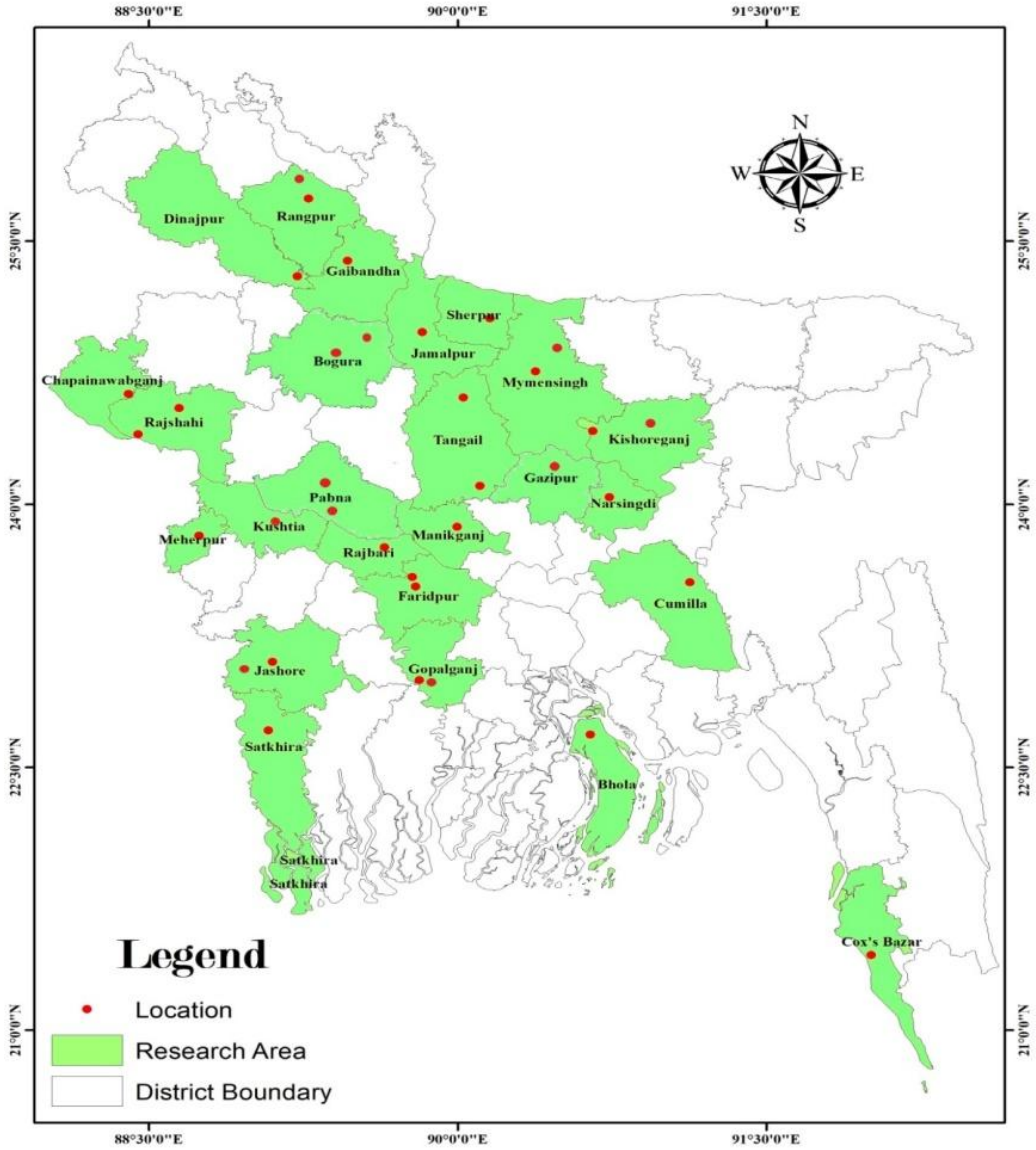

Fig. 1. Map of research area (35 locations of 25 districts under 7 divisions)

2.2.2 Land use efficiency

Land use efficiency (LUE) indicates the utilization of land with respect to time and space. Higher land use efficiency means land is occupied by various crops for a greater number of days in a year. Hence, the higher the land use efficiency, the higher is the chance to utilize larger amounts of natural resources. Land use efficiency was calculated by considering the total duration of crops in an individual cropping pattern divided by 365 d [6], based on the formula:

$$\text{Land Use Efficiency (\%)} = \{(d_1+d_2+d_3+d_4) / 365\} \times 100$$

Where d_1 is duration of 1st crop of the pattern, d_2 is duration of 2nd crop of the pattern, d_3 is duration of 3rd crop of the pattern, and d_4 is duration of 4th crop of the pattern.

2.2.3 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)

2.2.4 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.

$$\ln Y_i = \ln \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + V_i$$

Where,
Y = Rice equivalent yield of the i-th farm cropping pattern (t ha^{-1}); α = Constant or intercept of the function; X_1 = Human labor cost used by the i-th cropping pattern (Tk./ha); X_2 = cost of seed used by the i-th cropping pattern (Tk./ha); X_3 =cost of fertilizer used by the i-th cropping pattern (Tk./ha); X_4 = cost of irrigation used by the i-th cropping pattern (Tk./ha); X_5 = Insecticides and Pesticides cost used by the i-th cropping pattern (Tk./ha); X_6 = Miscellaneous cost (tillage, tools and equipment cost) used by the i-th cropping pattern (Tk./ha); ln = Natural logarithm; i = 1,2, 3……., n (n=35); β1, β2…......, β6 = Coefficient of respective variables; V_i = error term, V_i are assumed to be independently and identically distributed random errors, having N (0, σ_v^2) distribution.

This equation is individually applicable on four crops based cropping pattern and existing farmer practicing pattern because the same set of inputs as indicated in the model were used.

3. RESULTS AND DISCUSSION

3.1 Financial Feasibility of Growing Four Crops Based 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. In total, 316 cropping patterns were observed in Bangladesh [7] of which thirty two cropping patterns contain four crops with exclusive rice crop covers 0.28% of the NCA [8]. To boost up annual cropping system productivity, the four-crop-based improved cropping pattern can plays an important role.

3.2 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 [3]. 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 (ECP) required on average 276 days and 275 days in 2018-19 and 2019-20 respectively (Table 1). 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 (FCP) required on average 333 days and 334 days in 2018-19 and 2019-20

respectively (Table1). 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. 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.

3.3 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 2). 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 2) 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 [9]. 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.

3.4 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 3). 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 3). 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 [10]. 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 [10]. 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 [11,12].

Table 1. Duration of Existing cropping pattern and Four crops based cropping pattern in 2018-19 & 2019-20

Sl. No.	Division	Duration (days)			
		2018-19		2019-20	
		Existing CP	Four crops based CP	Existing CP	Four crops based CP
1	Dhaka	276	323	277	324
2	Khulna	281	348	277	352
3	Rajshahi	273	344	274	344
4	Rangpur	282	337	282	339
5	Mymensingh	234	328	235	329
6	Chattagram	289	302	290	303
7	Barisal	292	346	290	347
Mean		**276**	**333**	**275**	**334**
SD		**19.39**	**16.41**	**18.74**	**16.85**

Table 2. Rice Equivalent Yield (REY) of existing cropping pattern in different divisions in Bangladesh

Sl. No.	Division	Rice Equivalent Yield (REY) (t ha^{-1})			
		2018-19		2019-20	
		Existing CP	Four crops based CP	Existing CP	Four crops based CP
1	Dhaka	22.59	32.01	22.55	32.72
2	Khulna	12.08	21.11	12.07	21.75
3	Rajshahi	17.76	26.34	18.02	26.45
4	Rangpur	24.87	32.93	25.35	33.49
5	Mymensingh	14.70	29.52	14.59	31.48
6	Chattagram	22.79	43.43	22.48	40.65
7	Barisal	22.42	32.02	21.26	33.67
Mean		**19.60**	**31.05**	**19.47**	**31.46**
SD		**4.81**	**6.85**	**4.78**	**5.98**

Table 3. Production efficiency of farmer practices cropping pattern in different divisions in Bangladesh

Sl. No.	Division	Production efficiency (PE) (kg ha^{-1} day^{-1})			
		2018-19		2019-20	
		Existing CP	Four crops based CP	Existing CP	Four crops based CP
1	Dhaka	80.64	100.10	80.17	102.13
2	Khulna	43.71	60.43	44.83	61.60
3	Rajshahi	63.94	76.61	64.68	76.84
4	Rangpur	87.13	98.90	88.80	99.66
5	Mymensingh	60.12	99.22	59.44	101.50
6	Chattagram	81.16	144.03	79.75	134.32
7	Barisal	72.81	91.28	77.31	97.03
Mean		**69.93**	**95.80**	**70.71**	**96.15**
SD		**15.08**	**25.84**	**15.14**	**22.73**

3.5 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 4). 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 4) 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 1). The inclusion of new crop in the improved pattern occupied more field duration and led to higher land use efficiency.

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.

3.6 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.

3.7 Cost of Existing and Four Crops Based Cropping Pattern

3.7.1 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 5). 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 6) and much higher than existing pattern.

3.7.2 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 5). 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 6).

3.7.3 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 5). 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 6).

3.7.4 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 5). 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 6).

Table 4. Land Use Efficiency (LUE) of farmer practices cropping pattern in different divisions in Bangladesh

SL. No.	Division	Land Use Efficiency (LUE) (%)			
		2018-19		2019-20	
		Existing CP	Four crops based CP	Existing CP	Four crops based CP
1	Dhaka	75.62	88.58	75.82	88.74
2	Khulna	76.93	95.41	75.89	96.66
3	Rajshahi	74.89	94.25	75.07	94.38
4	Rangpur	77.17	92.24	77.26	92.97
5	Mymensingh	64.18	89.93	64.32	90.00
6	Chattagram	81.16	82.74	79.32	83.01
7	Barisal	80.00	96.16	79.45	97.03
Mean		**75.71**	**91.33**	**75.30**	**91.83**
SD		**5.56**	**4.70**	**5.14**	**4.98**

Table 5. 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

Table 6. 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 equipment etc)	17832.00	7.52	18699.00	7.84
Total Variable Cost	237134.00	100.00	238584.00	100.00

3.8 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 5). 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 6).

3.8.1 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 5). 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 6).

3.8.2 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 7 and return per hectare for four crops based cropping pattern is shown in Table 8. 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. 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 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 7).

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. 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 8). 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. 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 7. 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		

Table 8. 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		

3.8.3 Factors influencing the four crops based CP and existing CP

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 9. The results are discussed below:

3.8.4 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 9).

3.8.5 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 9). That means labour may be effectively used in four crops based cropping pattern.

3.8.6 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 9).

3.8.7 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 9).

3.8.8 Pesticides cost (X_5)

In case of existing cropping pattern, it can be seen from Table 9 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%.

Table 9. 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 (Tk./ha)	-0.227	0.217	0.306	-0.624*	0.341	0.078
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		

3.8.9 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 9).

3.9 Value of R Square

For existing cropping pattern, the co-efficient of multiple determinations, R2 was 0.72 which indicates that about 72% of the total variations of the gross return of existing cropping pattern are explained by the explanatory variables included in the model. In other words the excluded variables accounted for 28% of the total variation in return of existing cropping pattern. On the other hand, the co-efficient of multiple determinations, R square was 0.52 which indicates that about 52% of the total variations of the gross return of four crops based cropping pattern are explained by the explanatory variables included in the model (Table 9).

3.10 F-Value

The F-value of the equation was highly significant for both cropping patterns and it implies that the included variables are important for explaining the variation in returns which indicate good fit of the model (Table 9).

4. 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. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX-I

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

APPENDIX-II

Location wise Existing cropping pattern and four crops based cropping pattern

Sl. No.	Location	Existing Cropping Pattern	Four crops based Cropping Pattern
1.	Modhupur, Tangail	Potato-*Boro*-T. *Aman*	Mustard-*Boro*-T. *Aus*-T. *Aman*
2.	Mirzapur, Tangail	Mustard-*Boro*-T. *Aman*	Black gram-*Boro*-T. *Aus*-T. *Aman*
3.	Solakunda, Faridpur sadar	Mustard-Jute-T. *Aman*	Mustard-Mungbean- T. *Aus*-T. *Aman*
4.	Dicrirchar, Faridpur sadar	Mustard-Jute-T. *Aman*	Mustard-Sesame-T. *Aus*-T. *Aman*
5.	Rajbari Sador	Wheat-Jute-T. *Aman*	Wheat-Mungbean- T. *Aus*-T. *Aman*
6.	Hossainpur, Kishoreganj	Potato-Chilli-T. *Aman*	Potato-Sweet gourd-T. *Aus*-T. *Aman*
7.	Karimgang, Kishoreganj	Potato-Chilli-T. *Aman*	Potato-Jute Shak-T. *Aus*-T. *Aman*
8.	Shibpur, Narsingdi	Vegetables-*Boro*-T. *Aman*	Potato-R. Amaranth-T. *Aus*-T. *Aman*
9.	Gopalganj Sader	*Boro*-T. *Aman*	Jute-T. *Aus*-Mustard-Mungbean
10.	Chandra Dighalia, Gopalganj Sader	*Boro*-T. *Aman*	Mustard-Mungbean- T. *Aus*-T. *Aman*

Sl. No.	Location	Existing Cropping Pattern	Four crops based Cropping Pattern
11.	Dhirashram, Gazipur Sadar	Cauliflower-I. Spinach-T. *Aman*	Potato-Sweet gourd-I. Spinach-T. *Aman*
12.	Manikganj Sador	Carrot-Sweet gourd-T. *Aman*	Carrot-Sweet gourd-I. Spinach-T. *Aman*
13.	Kushtia Sadar	Lentil-Sesame-T. *Aman*	Lentil-Mungbean-T. *Aus*-T. *Aman*
14.	Gangni, Meherpur	Lentil-Sesame-T. *Aman*	Mustard-Mungbean- T. *Aus*-T. *Aman*
15.	Satkhira Sador	Mustard-*Boro*-T. *Aman*	Mustard-*Boro*-Jute-T. *Aman*
16.	Jessore Sadar	Mustard-*Boro*-T. *Aman*	Fieldpea-*Boro*-T. *Aus*-T. *Aman*
17.	Jhikargacha, Jessore	Mustard-*Boro*-T. *Aman*	Mustard-*Boro*-T. *Aus*-T. *Aman*
18.	Amnura, Chapai Nawabganj	*Boro*-T. *Aman*	Mustard-Sesame-T. *Aus*-T. *Aman*
19.	Mohanpur, Rajshahi	Potato-*Boro*-T. *Aman*	Potato-*Boro*-T. *Aus*-T. *Aman*
20.	Bijoynagar, Rajshahi	*Boro*-T. *Aman*	Mustard-*Boro*-T. *Aus*-T. *Aman*
21.	Dhaperhat, Sadullahpur	Potato-*Boro*-T. *Aman*	Potato-Cucumber-T. *Aus*-T. *Aman*
22.	Sariakandi, Bogura	Mustard-*Boro*-T. *Aman*	Mustard-*Boro*-T. *Aus*-T. *Aman*
23.	Sonatala, Bogura	Potato-*Boro*-T. *Aman*	Potato-Sweet gourd-T. *Aus*-T. *Aman*
24.	Pabna sadar	T. *Aman*-Onion-Maize	T. *Aman*-Mustard-Onion-Maize
25.	Atgharia, Pabna	Mustard-*Boro*-T. *Aman*	Fieldpea-*Boro*-T. *Aus*-T. *Aman*
26.	Raniganj, Dinajpur Sador	Maize-T. *Aman*	Potato-Maize(relay)- T. *Aus*-T. *Aman*
27.	Rangpur Sador	Potato-Jute-T. *Aman*	Potato-Sweet gourd-Jute-T. *Aman*
28.	Gangachara, Rangpur	Potato-*Boro*-T. *Aman*	Radish-Potato-Maize-T. *Aman*
29.	Mymensingh Sador	*Boro*-T. *Aman*	Potato-*Boro*-T. *Aus*-T. *Aman*
30.	Gouripur, Mymensingh	Potato-*Boro*-T. *Aman*	Cucumber-T. *Aman*-Potato-*Boro*
31.	Melandah, Jamalpur	*Boro*-T. *Aman*	Mustard-*Boro*-T. *Aus*-T. *Aman*
32.	Tarakandi, Sherpur Sador	*Boro*-T. *Aman*	Potato-Mungbean-T. *Aus*-T. *Aman*
33.	Cox's bazar Sador	Tomato-Okra-T. *Aman*	Mustard-R. Amarnth, Okra-T. *Aman*
34.	Burichang, Cumilla	Potato-*Boro*-T. *Aman*	Potato-Sweet gourd-T. *Aus*-T. *Aman*
35.	Bhola Sador	Dry Chilli-T. *Aus*-T. *Aman*	Onion-Dry Chilli-T. *Aus*-T. *Aman*

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