Profitability Analysis of a Four Crop Based Cropping Pattern in Bogura Region of Bangladesh

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ABSTRACT

Farmers in the Bogura region benefit significantly from the systematic use of crop rotation. The experiment was performed at the Shibganj, Bogura, in 2015-16 and 2016-17 to create a potato-Boro-radish-T. Aman rice crop sequence that would compete with the potato-Boro-T. Aman rice crop sequence. Primary objectives of the experiment were to determine the cost of producing enhanced Potato-Boro-Radish-T. Aman rice and compare it to current potato-boro-t. aman rice. There were two patterns: Current Cropping Pattern Potato (BARI Alu-8)-Boro (BRRI dhan 28)-T. Aman (BRRI dhan-49) and Alternative Cropping Pattern Potato (BARI Alu-25)-Boro (BRRI dhan 28) -Radish (Rocky)-T. Aman (BRRI dhan-57). The research revealed that an alternative cropping pattern required average crop duration of 315 days to complete one cycle in a year, implying that a four multiple cropping sequence was economically viable to replace the current cropping pattern. In terms of mean REY, the total grain/tuber yield was 42.80 t/ha/year, which was 66% greater than the current pattern (25.76 t/ha/year). The overall production efficiency (185.14 kg/ha/day), usage of land (86.16%), and engagement in the population (660 man-days/ha/year) of the alternative cropping pattern were 45, 7, and 41% higher, respectively, than the current cropping pattern. Alternative cropping patterns had the gross benefit of 274911 Tk./ha/year, indicating that they were sparingly sustainable. The alternative crop sequence also improved crop strength, growers' real understanding, technique, profits, and engagement. Furthermore, by trying to incorporate T. aman straw into soil with an alternative cropping pattern, it promotes soil health. As a result, farmers in Bangladesh's Bogura region may employ a different planting pattern on their variable land in order to boost production and profitability while also creating jobs.

Keywords: Crop sequence, Crop rotation, Level of Productivity, Rice comparable yield, Usage of land.

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I. INTRODUCTION

Bangladesh is the most densely inhabited nation on the planet, through a land area of 1,47,570 square kilometers (approximately 1033 people per square kilometer). It currently has a people of approximately 152.40 million populaces and is rising at a proportion of around 1.37% per year [1]. By 2030, the populace will be roughly 186 million [2]. The whole cultivable land area in the state is around 8.44 million hectares, and it is depleting on a daily basis. Segment of the population pressures and increased urbanization have resulted in a 1% annual decrease in cropland. In the next 25 years, the country's food measures are expected to double [3]. Our finite and diminishing land resources must be used to meet the demand. There is little space available for cultivable land expansion, but there are opportunities to increase cropping intensity from 192% to 192% by improving existing cropping patterns and trying to incorporate short-duration crops into the paddy cropping system [4].

Bogura drops under Agro Ecological Zones (AEZ) 3, 4,

and 27. Non-calcareous gray and brown floodplain soils predominate in the Tista Meander Floodplain. The Karatoya-Bangali Floodplain has a variety of soil types, with non-calcareous gray and dark grey floodplain soils predominating. The Deep Red Brown Terrace soils and the Deep Grey Terrace soils make up the majority of the universal soil types found in the North Eastern Barind Tract. Approximately 79% of the land is classified as high or middle high land, with the potential to produce multiple crops per year. Potato-Boro-T. Aman is a main cropping pattern in Bogura's Shibganj upazilla, which spans approximately 18170 hectares. Shibganj has a cropping intensity of 271.47% right now [5]. Cropping intensity in this region may be enhanced by utilizing short-duration crop types produced by BARI and other research institutions. Bogura is Bangladesh's largest potato-growing district, and one of the most common patterns of cropping in the area is potato-boro-t. aman [5]. The land is left fallow after Boro rice harvesting. Radish can be easily added after the Boro rice has already been roasted. As a result, the addition of Radish to the potato-boro-t. aman cropping

techniques is expected to growth crop rotation strength and profitability in the Bogura state. Adopting this alternative cropping style of potato-boro-radish-t. aman dismiss assist rural poor farmers in the region in earning additional income and creating jobs. As a result of the current potato-based cropping pattern, farmers in Bogura face economic losses. As a result, farmers in the Bogura region will need to adopt a more beneficial cropping pattern.

BARI recently created several multiple cropping patterns that will be beneficial to farmers. Potato-Boro-Radish-T. Aman is single of them. This cropping style is desired to validate the current Potato-Boro-T. Aman cropping modes in the fields of Bogura farmers. It is possible to generate extra employment possibilities by growing multiple crops in a year on the same piece of land, as well as food and nutritional security for farmers. Simultaneously, cropping severity and output can be amplified [4], [6]. Furthermore, several reports on cropping patterns indicate that an added crop could be familiarized with minimal variations or substituted for current crops to significantly increase farmers' productivity and profitability [7]-[13]. Cropping intensity must be increased to crop more food on a limited volume of property, and thus more suitable crop(s) should be included in the cropping pattern. The objective of the research was to examine a multiple cropping pattern to a three-crop cropping style.

II. MATERIALS AND METHODS

During the cropping cycles of 2015-16 and 2016-17, the trial was conducted in the farmers' fields of the Shibganj, Bogura. Before and after the two cycles of the experiment, soil samples were collected from 0-15 cm depth to establish benchmark and post soil characteristics, respectively. As part of SRDI's soil analysis, separate soil samples were air dried, pulverized, and examined.

The experiment was designed in a block format to ensure that all activities occurred in the correct order. In each of the six farmers' cropping patterns, there were two one-hectare blocks. Potato was the alternative cropping pattern used on one block. Potato (BARI Alu-25)-Boro (BRRI dhan-28)-Radish (Rocky)-T. Aman (BRRI dhan-57) was bred against an existing pattern. Potato (BARI Alu-8)-Boro (BRRI dhan 28)-T.Aman (BRRI dhan-49).

The trial began with the cultivation of potatoes in both alternative and current cropping patterns. Rice seedlings were transplanted 20×15 cm apart, and potato seeds were sown in rows. Following best management practices, entirely fertilizers were treated twice, once as a base and once as a top dressing. Table II summarizes the agricultural factors and intercultural operations for crop development with upgraded and producer methods. Stem borer and sheath blight were found in some Boro and T. Aman rice plots. Follicur was applied at a rate of 0.5 ml/L to regulator sheath blight, and Virtaklo 40 WG was applied at a rate of 1.5g/10L to control stem borer. To control late blight disease, Acrobat MZ @ 2 g/L was sprayed on the potato, and Tido 20 SL (0.5 ml/L) was covered on the potato to control aphids and jassid. All enhanced and farmer-specific field operations and management techniques were carefully monitored, and data was gathered to assess agro-economic performance. 1m² of

each block was sampled for data on product and by-product yields.

Cropping patterns' agronomic performance was calculated, including Usage of land, Level of Productivity, and Rice comparable yield.

A. Usage of Land

It is calculated by dividing the overall period of each crop in an arrangement by 365 days [14] (Tomer and Tiwari, 1990) as follows:

$$\text{Usage of Land} = \frac{\sum d_i}{365} \times 100$$

where, d_i = period of i^{th} crop;
 $i=1, 2, 3$, and 4.

B. Level of Productivity

To calculate level of production in kg/ha/day, overall invention in a cropping style was distributed by total period of crops in that pattern [14].

$$\text{Level of productivity} = \frac{\sum y_i}{\sum d_i}$$

where,

y_i = Yield of i^{th} crop;

d_i = duration of i^{th} crop;

$i = 1, 2, 3$ and 4.

C. Rice Comparable Yield

To make a comparison of cropping patterns, the yields of all crops were converted to rice comparable yields using the current market price of the individual crop [15].

$$\text{Rice comparable Yield (t ha}^{-1}\text{)} = \frac{\text{Yield of each crop} \times \text{Current price of this crop}}{\text{Current price of T. Aman}}$$

D. Analysis of the Profitability

Economic guides such as total variable cost and gross return were also computed using product market prices. Using regular data from two crop circle, the financial evaluation of two cropping patterns was carried out. The taka value of the product and by-product per hectare was used to calculate the gross return. For different agricultural production processes and inputs, the total flexible rate of various collects was estimated using taka per hectare. To compare the benefits, fractional budgeting was utilized. The advantage was determined by subtracting the entire economic difficulty from the total economic benefit.

III. RESULTS AND DISCUSSION

A. Changes in Soil Characteristics

The results in Table I illustrate and explain post-soil nutrient status. The soil was initially slightly acidic, had a moderate amount of organic matter, and was deficient in potassium, zinc, and boron. S content was moderate. The total

nitrogen content was extremely low, while the P content was optimal. Soil was also tested following the completion of two-year cycles. The soil's pH was marginally higher than the opening value, and the organic matter content was slightly lower, according to the post-analysis chemical analysis. P, S, and N reduced in post soil, but K, Zn, and B gained. The results of Mondal *et al.* [4] are in favor with the outcomes.

B. Crop Management

Crop management techniques include, among other things, sowing/transplanting date, harvesting date, the amount of fertilizer hand-me-down, irrigation, clearing, and pesticide application. The first and second cycles of the alternative cropping pattern (Potato-Boro-Radish-T. Aman rice) were completed in 317 and 312 days, respectively. Although the current cropping pattern (Potato-Boro-T. Aman rice) completed the first and second cycles in 295 and 293 days, the turnaround time for the first and second cycles of four crop-based alternative cropping patterns was 48 and 53 days, respectively, compared to 70 and 72 days for current cropping patterns. This demonstrates that a multiple-crop alternative pattern, as opposed to the current three-crop pattern, can easily fit on a plot of land in one year.

C. Grain/Tuber Yield

The mean grain/tuber yields of Potato, Boro, Radish, and T. Aman in alternative cropping patterns were 26.25, 5.45, 22.59, and 3.94 t/ha, including both, whereas in current cropping patterns, the imply grain/tuber yields of Potato, Boro, Radish, and T. Aman were 26.80, 5.57, and 5.11 t/ha, respectively (Table III). Table III presents the straw yields of the aforementioned crops. Boro rice produced a high yield, which could be attributed to the use of fertilizer in potato crops. Due to an initial flea beetle attack, the yield of radish in alternative cropping cycle (2nd cycle) was low. Grain/tuber yield of Potato, Boro, Radish, and T. Aman were 26.10, 5.44, 24.90, and 3.70 t/ha, including both, for the first cycle in the alternative cropping pattern, while grain/tuber yield of Potato, Boro, and T. Aman were 26.80, 5.56, and 5.12 t/ha, respectively, in the current pattern. Grain/tuber yield of Potato, Boro, Radish, and T. Aman were 26.40, 5.46, 20.29, and 4.19 t/ha, it's between, in the second cycle of alternative cropping pattern, while in the current pattern grain/tuber yield of Potato, Boro, and T. Aman were 26.81, 5.59, and 5.10 t/ha, in both. Rahman *et al.* [7] realized similar results.

TABLE I: FOUR CROP-BASED CROPPING PATTERN AREA AT MLT SITE SHIBGANJ, BOGURA HAD BOTH INITIAL AND FINAL SOIL CHARACTERISTICS IN 2015-16 AND 2016-17

Soil sample	Land type	pH	Organic matter (%)	Total N (%)	(meq/100g)	(µg g ⁻¹)			
					K	P	S	Zn	B
Initial	MHL	6.7	1.70	0.08	0.15	16.52	18.12	0.78	0.28
Final	MHL	6.8	1.68	0.07	0.16	15.76	17.87	0.96	0.32
Critical Limit	-	-	-	0.12	0.12	7.0	10.0	0.6	0.2

MLT= Multi-Location Testing, MHL= Medium High Land.

TABLE II: CROP CONTROL TECHNIQUES OF THE CURRENT (POTATO-BORO-T. AMAN) AND ALTERNATIVE CULTIVATION PRACTICES (POTATO-BORO-RADISH-T. AMAN) CROPPING STYLE IN THE FIRST AND SECOND CYCLES AT SHIBGANJ, BOGURA

Parameters	Current Cropping Pattern			Alternative Cropping Pattern			
Crop	Boro	T. Aman	Potato	Boro	Radish	T. Aman	Potato
Variety	BRRI dhan - 28	BRRI dhan-49	BARI Alu-8	BRRI dhan - 28	Rocky	BRRI dhan-57	BARI Alu-25
1 st cycle							
Fertilizer dose (CD t/ha, NPKSZnBMg Kg/ha)	0,104-18-37-14-0-0-0	0,108-22-37-13-0-0-0	0,120-50-110-22-3-2-0	5, 120-18-75-18-5-2-0	0,160-40-82-15-0-0-0	0,70-11-25-10-2-0-0	0,110-30-100-16-3-2-10
Transplanting/ seeding date	01-03 Feb. 16	13-15 July,16	06-08 Nov. 16	1-2 Feb.16	3-5 June,16	30-31July, 16	01-03 Nov. 16
Harvesting time	17-19 May,16	28-30 Oct.16	26-28 Jan,17	17-18 May,16	22-25 July,16	17-20 Oct. 16	20-22 Jan.17
Intercultural Operation	Irrigation 15 times & weeding 2 times	Weeding 3 times	Irrigation 2 times & weeding 2 times	Irrigation 15 times & weeding 2 times	Irrigation 2 times & weeding 2 times	Weeding 3 times	Irrigation 2 times & weeding 2 times
	105	110	80	105	50	82	80
Longevity (days)	105	110	80	105	50	82	80
Turnaround period (days)	6	59	5	13	15	6	14
2 nd cycle							
Fertilizer dose (CD t/ha ⁻¹ , NPKSZnBMg kgha ⁻¹)	5, 140-20-50-9-2.5-0-0	0,70-19-35-10-0-0-0	0,170-25-130-15-2-1-10	5, 130-18-53-9-2.7-1-0	0,172-45-112-17-0-0-0	0,76-12-26-8.4-0-0-0	0,161-24-125-16-3-1.3-10
Transplanting/ seeding date	01 Feb. 17	12 July,17	08 Nov. 17	01 Feb.17	03 June,17	30 July, 17	03 Nov. 17
Harvesting time	16 May,17	30 Oct.17	27 Jan,17	15 May,17	23 July,17	19 Oct. 17	22 Jan..18
Intercultural Operation	Irrigation 15 times & weeding 2 times	Weeding 3 times	Irrigation 2 times & weeding 2 times	Irrigation 15 times & weeding 2 times	Irrigation 2 times & weeding 2 times	Weeding 3 times	Irrigation 2 times & weeding 2 times
	103	110	80	102	50	80	80
Longevity (days)	103	110	80	102	50	80	80
Turnaround period (days)	6	57	9	11	18	07	17

D. Rice Equivalent Yield

The alternative cropping pattern's mean rice equivalent yield (REY) was 42.80 t/ha/year, which was 66% upper than the current patterns of cropping (25.76 t/ha/year). The REY of the alternative cropping style was 48.89 t/ha/year in the first cycle, which was 67% higher than the REY of the current cropping pattern (28.93 t/ha/year). While the REY of the alternative cropping style was 36.71 t/ha/year, it was 42.5% higher than the current cropping pattern (25.76 t/ha/year) in the second cycle. The alternative cropping pattern resulted in a greater rice equivalent yield due to the addition of agricultural technologies and varieties. As demonstrated by the preceding results, changing patterns of cropping resulted in upper yield when linked to the established pattern (Table 4). This argument was maintained by Rahman *et al.* [5], Nazrul *et al.* [16], Nazrul *et al.* [8], and Khan *et al.* [11] in the example of alternative crop sequence.

E. Usage of Land

Land efficiency is calculated by taking into account the amount of time that land is utilized throughout a cropping year. This is mostly determined by the duration of the crops. The changed cropping patterns yielded a better land efficiency (86.16%) than the existing method (80.54%). The alternative cropping patterns utilized 86.85% and 85.48% of the land, respectively, for the first and second cycles, whereas the existing pattern utilized 80.82% and 80.27% of the land, respectively, for the first and second cycles (Table IV). Due to the pattern's increased component crop cultivation, the alternate cropping pattern had a higher land-use efficiency. Rahman *et al.* [5] and Nazrul *et al.* [16] cited the findings' similar trend.

F. Level of Productivity

Maximum productivity was obtained by substituting an alternative cropping pattern for the current cropping pattern (Table IV). The integration of four crops, current technological varieties, and improved management practices may have contributed to greater efficiency of alternative cropping patterns. The alternative cropping pattern's mean production value was found to be 185.14 kg/ha/day, 45.20% greater than the current cropping pattern (127.51 kg/ha/day). In the first cycle, cropping patterns produced 189.71 and 127.05 kg/ha/day, including both, while cropping patterns produced 180.58 and 127.98 kg/ha/day, respectively, in the second cycle (Table 4). Alternate cropping patterns produced 49% and 41% more than the current pattern in the first and second cycles, respectively. The analysis indicated that alternate cropping patterns against the current pattern were the most efficient cropping patterns in all cycles. In the case of alternative cropping patterns, Rahman *et al.* [5], Nazrul *et al.* [16] and Khan *et al.* [11] all cited similar findings.

G. Creative Employment

Labour was required to clear the land of obstructions, sow, and transplant crops, apply fertilizer, control weeds, spray pesticides, harvest, transport, thresh, dry, and clean the harvest. Compared to traditional cropping patterns, altered cropping patterns increase employment by 41% due to an increase in the number of man-days/ha/year requisite for crop growing (469 man-days/ha/year). Another benefit of including radish in the recipe is that it provides employment for women, children, and the elderly.

TABLE III: YIELD OF CURRENT (POTATO-BORO-T. AMAN) AND ALTERNATIVE (POTATO-BORO-RADISH-T. AMAN) CROPPING TECHNIQUES AT SHIBGANJ, BOGURA

Parameters	Current Cropping Pattern			Alternative Cropping Pattern		
	Boro	T. aman	Potato	Boro	Radish	T. aman
Variety	BRRRI dhan - 28	BRRRI dhan- 49	BARI Alu-8	BRRRI dhan - 28	Rocky	BRRRI dhan- 57
First cycle						
Grain/Tuber/Root Yield (t/ha)	5.56	5.12	26.80	5.44	24.90	3.7
Straw yield (t/ha)	6.31	6.09	-	6.12	-	4.30
Second cycle						
Grain/Tuber/Root Yield (t/ha)	5.59	5.10	26.81	5.46	20.29	4.19
Straw yield (t/ha)	6.21	5.82	-	6.03	-	4.31
Average						
Grain/Tuber/Root yield (t/ha)	5.57	5.11	26.80	5.45	22.59	3.94
Straw yield (t/ha)	6.26	5.95	-	6.07	-	4.30

TABLE IV: RICE EQUIVALENT YIELD, LEVEL OF PRODUCTIVITY, USAGE OF LAND, AND ENGAGEMENT IN THE POPULATION OF THE CURRENT (POTATO-BORO-T. AMAN) AND ALTERNATIVE (POTATO-BORO-RADISH-T. AMAN) PATTERNS OF CROPPING AT SHIBGANJ, BOGURA

Cycles	Patterns of cropping	Rice equivalent yield (t/ha)	Usage of land (%)	Level of Productivity (Kg/ha/day)	Engagement in the population (man- days/ha/year)
1 st	Current	28.93	80.82	127.05	472
	Alternative	48.89	86.85	189.71	664
	t-value	6.74	2.18	13.05	38.4
	Sx	**	*	**	**
2 nd	Current	22.60	80.27	127.98	466
	Alternative	36.71	85.48	180.58	656
	t-value	18.50	2.95	19.63	54.10
	Sx	**	*	**	**
Mean	Current	25.76	80.54	127.51	469
	Alternative	42.80	86.16	185.14	660
	t-value	5.34	4.89	21.89	63.20
	Sx	**	**	**	**

* Indicates significance at 5% level of probability and ** Indicates significant at 1% level of probability.

H. Analysis of Profitability

The estimated gross return on alternative and established cropping patterns was 842667 Tk./ha and 517077 Tk./ha, in both, according to the research (Table V). The estimated absolute return from alternative cropping patterns was 63% greater than the average gross return from current cropping patterns. The release of new crops and fast varieties may contribute to the increased gross return associated with alternate cropping patterns. The implied total variable cost of an alternative crop sequence and current cropping style were correspondingly 290281 Tk./ha and 239602 Tk./ha, including both (Table V). The alternative cropping pattern's overall average gross margin was 99% greater (552386 Tk./ha) than the current pattern's gross margin (277475 Tk./ha). It also included 22.59 t/ha of indicated yields in an alternative pattern of cropping due to the insertion of radish.

I. Economic Benefit

The average net economic benefits were 274911 Tk./ha/year, implying that alternative cropping patterns based on four crops were more economically viable than current cropping patterns (Table VI). 282777 Tk./ha/year and 267046 Tk./ha/year showed a similar trend in the first and second cycles, respectively.

IV. CONCLUSION

In this study, we evaluated the productivity level of a Potato-Boro-Radish-T. Aman rice cropping arrangement related to conventional crop production. After two cycles, the soil was also examined. The pH of the soil was somewhat higher than the starting value, but the organic content

decreased due to the cropping pattern of four crops. The average crop length for alternative cropping patterns was 315 days, suggesting that four crop cropping patterns are economically sustainable as a replacement for current cropping patterns. In terms of mean REY, total grain/tuber yield was 42.80 t/ha/year, which was 66% higher than the previous pattern (25.76 t/ha/year). The overall average production efficiency (185.14 kg/ha/day) of the alternative cropping pattern, land use efficiency (86.16%), and labour employment (660 man-days/ha/year) of the alternative cropping pattern were 45%, 7%, and 41% higher, respectively, than the current cropping pattern. Alternate farming patterns had a net economic benefit of 274911 Tk./ha/ year, suggesting that they were commercially feasible. The alternating cropping pattern also improved crop productivity, farmer knowledge, capacity, income, and employment. Farmers in the Bogura zone will benefit from better crop output per unit of ensuring food security. Additionally, it promotes soil health by incorporating Boro straw into soils with an alternate cropping pattern. Thus, it can be concluded that alternate cropping patterns benefit farmers in the Bogura region by providing a higher economic return. However, in this pattern, a strong marketing capability, particularly for radish, is critical.

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TABLE V: CROP CONTROL TECHNIQUES OF THE CURRENT (POTATO-BORO-T. AMAN) AND ALTERNATIVE CULTIVATION PRACTICES (POTATO-BORO-RADISH-T. AMAN) CROPPING STYLE IN THE FIRST AND SECOND CYCLES AT SHIBGANJ, BOGURA

Cycles	Patterns of cropping	Absolute return (Tk./ ha)	Variable cost sum (Tk/ha)	Gross profit (Tk./ha)
First	Current	507485	233210	274275
	Alternative	843770	286718	557052
Second	Current	526670	245995	280675
	Alternative	841565	293844	547721
Mean	Current	517077	239602	277475
	Alternative	842667	290281	552386

Market price of (first cycle) Potato @ 12 Tk.kg⁻¹, Boro @ 15 Tk. kg⁻¹, Straw @ 1.0 Tk.kg⁻¹, T. Aman@ 17 Tk. kg⁻¹, Straw @ 1.5 Tk.kg⁻¹Radish @ 15 Tk.kg⁻¹.

Market price of (Second cycle) Potato @ 10 Tk.kg⁻¹, Boro @ 22.5 Tk. kg⁻¹, Straw @ 1.5 Tk.kg⁻¹, T. Aman@ 22.5 Tk. kg⁻¹, Straw @ 1.5 Tk.kg⁻¹Radish @ 17 Tk.kg⁻¹.

TABLEVI: BUDGETING IN COMPONENTS OF CURRENT (POTATO-BORO-T. AMAN) AND ALTERNATIVE (POTATO-BORO-RADISH-T. AMAN) CROPPING STYLE AT SHIBGANJ, BOGURA

Cycles	Economic vulnerability	Tk./ha/year	Economic benefit	Tk./ha/year
1 st	(a)Absolute return of current cropping pattern	507485	(e)Absolute return of alternative cropping style	843770
	(b)Variable cost sum of alternative pattern of cropping	286718	(f)Variable cost sum of current cropping style	233210
	(c) Total (a+b)	794203	(g)Total (e+f)	1076980
	(d) The gross benefit (g-c)	282777		
2 nd	(a) Absolute return of current cropping pattern	526670	(e) Absolute return of alternative cropping style	841565
	(b) Variable cost sum of alternative patterns of cropping	293844	(f) Variable cost sum of current cropping style	245995
	(c) Total (a+b)	820514	(g)Total (e+f)	1087560
	(d) The gross benefit (g-c)	267046		
Mean	(a) Absolute return of current cropping pattern	517077	(e) Absolute return of alternative cropping style	842667
	(b) Variable cost sum of alternative patterns of cropping	290281	(f) Variable cost sum of current cropping style	239601
	(c) Total (a+b)	807358	(g)Total (e+f)	1082270
	(d) The gross benefit (g-c)	274911		

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