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OPTIMUM LAND USE PATTERN AND RESOURCE ALLOCATION IN A GROWING ECONOMY: A CLOSED MODEL APPROACH

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ABSTRACT

The paper examines land use pattern for the small farmers at the farming systems research site, Jessore and attempts at developing optimum land use pattern considering available resources. Linear programming was used for optimizing resources. The results revealed a considerable divergence between the existing and optimum plans under both limited and borrowed capital situations. The resources were not found optimally allocated and after optimization, gross margin and employment of labour could be increased. Tractor/power tiller utilization increased under borrowed capital situation, while labour employment and tractor/power tiller utilization decreased under limited capital situation. This suggests that capital acted as a severe constraint. Cereal based cropping patterns showed dominance in both the existing and optimum plans. The optimum plans affected tenurial groups differently because of inter-tenurial variation in resource endowment and management. It is suggested that strengthening of the extension services and market network, besides a strong financial support, would go a long way in improving the prospects of the small farmers of the study area.

1. INTRODUCTION

Optimum allocation of land and other resources is defined as to what crop activities to undertake, how much land to allocate to each crop activity and what method and combinations of inputs to use on each crop so that net farm returns are maximized (Singh, 1978). Studies in optimum land use pattern, resource allocation and resource requirements, using the linear programming, have largely been attempted in many countries for different, usually synthetic or average categories of farms. In such studies for each farm situation, some resources are taken to be given, while others are hired or borrowed to the level where the marginal productivity of the resources gets equated to the marginal factor cost (price) of the respective resource (Dahiya, 1976; Singh, 1978; and Kahlon and Johl, 1978). It is assumed that the resources which are hired are available to the extent as to satisfy the estimated level. There is a limited

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stock of all such resources for the economy as a whole and each farm situation can draw upon it no more than its relative economic power in the economic system. For example, the labour supply during the peak periods may actually turn out to be less than the normative estimated requirement by an open model for each farm situation rendering the improved plans infeasible in the overall real economic system (Singh and Jain, 1981). However, in macro level inter-regional programming models, these aggregative constraints are explicitly considered (Ratnam, Rao and Viswandham, 1979).

This study makes an attempt to examine the land use pattern for the small farmers at the farming systems research site, Jessore in a closed economic system and would thereby develop optimum land use pattern considering their available resources. The planning was done at the micro level for farm-firms which were then aggregated to obtain the optimum cropping patterns for the study area. The results regarding resource requirements and the scope of increasing net return and employment of labour through optimum shifts in the cropping pattern were then related with the level of development and tenurial groups. Finally, the marginal value products of the different resources, namely land, human labour, bullock labour tractor/power tiller and capital were also computed.

The paper has been organized in four sections. The data and the model are discussed in section II. Some results pertaining to the optimum plans are presented in section III. Conclusions and policy implications of the paper are provided in the final section.

II. THE DATA AND THE MODEL

The analysis was based on the primary data collected through a comprehensive field survey. The farming systems research (FSR) site of Bagherpara thana of Jessore district was purposively selected. Then, 150 small farmers were chosen from a list of 301 small farmers (having land area from 0.51 to 2.49 acres) following systematic sampling method. Data pertaining to one agricultural year 1989-90 were collected from the sample farmers. The sample farms were classified into pure owner and owner-cum-tenant farms. Pure owner farms were those cultivating their owned land and owner-cum-tenant farms were those cultivating rented-in land along with whole or part of their owned land.

The profit maximization model of linear programming technique was used to find out the optimum solutions. The objective function was :

$$\text{Maximize } Z_0 = \Sigma_j G_j x_j - \sum_{t=1}^{8} W_h L_t - \sum_{t=1}^{5} W_b K_t - \sum_{t=1}^{2} W_d P_t - \sum_{t=1}^{4} rMt$$

Subject to

$$1.\ \sum_j l_{js}\, x_j \leq L_s \qquad \text{(Land)}$$

$$(s = 1, 2, \ldots\ldots, 72)$$

2. $\sum_j l_{jt} x_j - Lt \leq H_t$ (Human labour) (t =1, 2, 3, 4, 5, 6, 7, 8)

3. $\sum_j b_{jt} x_j - K_t \leq B_t$ (Bullock labour) (t = 1, 2, 3, 4, 5)

4. $\sum_j d_{jt} x_j - P_t \leq D_t$ (Tractor/ power tiller) (t = 1, 2)

5. $\sum_j C_{jt} x_j - M_t \leq C_t$ (Capital) (t =1, 2, 3, 4)

6. $\sum_k f_k x_k \geq F^{(min)}$ (Minimum cereal requirement)

Where,

Z_0 = total gross margin in taka
G_j = gross margin of the j^{th} crop activity
x_j = the level of the j^{th} crop activity
W_h = wage rate per unit of human labour
L_t = number of hired human labour in t^{th} period
W_b = wage rate per unit of bullock labour
K_t = number of hired bullock labour in t^{th} period
W_d = wage rate per unit of tractor/power tiller
P_t = tractor/power tiller hired in t^{th} period
r = rate of interest (Tk.) for six months
M_t = capital borrowed in taka in t^{th} period
f_k = cereal production in kg of k^{th} cereal crop activity
x_k = the level of the k^{th} cereal crop activity
$F^{(min)}$ = minimum cereal requirement of the farm family and non-negativity restrictions, $x_j \geq 0$, $L_t \geq 0$, $K_t \geq 0, \geq P_t \geq 0$, $M_t \geq 0$

The objective function was to maximize gross margin on each farm simultaneously within a closed economic system in an annual cycle. The gross margins were measured by deducting the variable expenses from the gross income. In order to maintain uniformity, the output prices were taken as the harvest prices and input prices as the actual market prices at the time of application of inputs.

Input Coefficients

The input coefficients refer to the requirements of a crop activity in respect of the inputs of different resources measured in terms of per unit of land, i. e., per decimal. The input coefficients for all the crop activities on all the selected farms were calculated on the basis of the actual quantities of different resources used for those crop activities.

Resource Constraints or Resource Supplies

The resources which are fixed or scarce in supply on the farm at levels which limit, or are likely to limit the scale of the crop activities, are termed as resource constraints. In the context of Bangladesh farming, the most limiting resources in farm production are land and capital. In addition, human labour and draft power also become restrictive in certain periods of the year. It also seems plausible to assume that farmers would like to ensure minimum cereal requirement of the farm family out of their operation of the farm business. Having taken all these considerations into account, six restrictions were incorporated in the model. These were land, human labour, bullock labour, tractor/power tiller, capital and minimum cereal requirement constraints.

Land : For the present sutdy, three types of land restrictions, e. g. high land, medium high land and medium low land were considered. Each land type was further classified into land with and without irrigation. Twelve months of land restrictions were also considered in the model. Thus, 72 land restrictions were considered in the model.

Human labour : For setting up human labour restriction, seasonal operation wise requirements of labour for different crops were determined in consultation with the respondent farmers. There were certain peak operational periods for meeting the requirements and some casual labour had to be hired for accomplishing the required farm operations within time. These peak periods of labour hiring is a common practice in the study area. The restriction periods of human and bullock labour along with the operations performed on the sample farms are given in Table 1. The hiring in activity of labour was introduced for all the restriction periods.

Bullock labour : Bullock labour restriction was set in a similar way as for human labour. Five restriction periods were also identified. Hiring bullock labour as an activity has been included in the matrix table because bullock labour hiring is a common practice in the study area. The restriction periods of human and bullock labour along with the operations performed on the sample farms are discussed in detail by Alam (1994).

Tractor/power tiller : The availability of tractor/power tiller in terms of minutes was considered as a constraint for April and November when its demand rose at peak. Tractor/power tiller hiring is a common practice in the study area. It has been considered as a hiring activity in the matrix table.

Capital : For this study, capital has been defined as working capital required to meeting day to day farm or production expenses both in cash and kind. This consists of :

1) cost of hired human labour,
2) cost of hired bullock labour,
3) cost of purchased seed,
4) cost of purchased manures, fertilizers and insecticides,

5) irrigation charges, and

6) cost of hiring tractor/power tiller.

Capital coefficients include all the items listed above except hiring charges of human labour, bullock labour and tractor/power tiller because these items were taken as separate activities.

Capital availability in terms of taka was considered for 4 periods in a year which was taken as twenty percent (Rahman, 1984; Baksh and Ahmed, 1985) of the total income (agricultural income and non-agricultural income). The periods were as follows :

a) January, February and March : All expenditure for *boro* (plantation and intercultural operation) and harvesting cost of rabi crops had been included in this period. Income from *Kharif-II* crops +1/4 non-agriculturl income were considered as total income for this period. Twenty percent of this income was included as capital availability for this period. Irrigation cost and transport cost had been shared 50:50 for sowing/ plantation period and harvesting period. If manure not used, transport cost was considered only for harvesting period.

b) April, May and June : Harvesting cost of *boro* and all expenditure for *kharif-I* crops (sowing/plantation and intercultural operation) has been included in this period. Income from *rabi* crops + 1/4 non-agril. income were considered as total income for this period. Twenty per cent of this income was included as capital availability for this period. Irrigation cost and transport cost (if manure used) has been shared 50 : 50 for sowing/plantation period and harvesting period. If manure not used, transport cost was considered only for harvesting period.

c) July, August and September : All expenditure for *Kharif-II* crops (plantation and intecultural operation) and harvesting cost of *Kharif-I* crops had been included in this period. Income from rabi crops + 1/4 non- agril. income were considered as total income for this period. Twenty per cent of this income was included as capital availability for this period. Irrigation cost and transport cost (if manure used) had been shared 50 : 50 for sowing/plantation period and harvesting period. If manure not used, transport cost was considered only for harvesting period.

d) October, November and December : Harvesting cost of *kharif-II* crops and all expenditure for *rabi* crops sowing/plantation and intercultural operation) had been included in this period. Income from *kharif -I* crops and 1/4 non-agricultural income were considered as total income for this period. Twenty per cent of this income was included as capital avaibility for this period. Irrigation cost and transport cost (if manure used) had been shared 50:50 for sowing/plantation period and harvesting period. If manure not used, transport cost was considered only for harvesting period.

The borrowing activities for capital during four restriction periods were introduced to augment the capital available with the farmers.

Minimum Cereal Requirement : Family food supply, another possible constraint in farm planning, was also incorporated in the model. It was revealed from the field survey that farmers wanted to cover at least that much area by cereal crops that was needed to fulfill their home consumption requirement. For ascertaining minimum annual requirement of cereal (rice and wheat) for a typical family, each of the respondent farmers were asked to report the minimum cereal requirement of his own family. It was estimated that an average farm family would require a minimum of 366 and 389 kg of cereal (rice and wheat) per annum for home consumption for pure owner and owner-cum-tenant farms respectively. Therefore, minimum cereal production of 366 and 389 kg per annum for pure owner and owner-cum-tenant farms respectively was set as a constraint and was incorporated in the model.

Real Activities

In order to determine optimum production programme, it is essential to incorporate such enterprises which are acceptable to the farmers. In this study, individual crop under different situations is considered as real activities. The crop activities included in the model are based mainly on survey results. The crop activities which are termed as "recommended" included from the experimental results of On-Farm research Division, BARI. The farmers produce rice (aus, aman and boro) wheat, mustard, pulses, vegetables, etc. which were considered as major land use alternatives. The analysis has not been carried out in terms of these crops as such. The crops were sub-classified into activities on the basis of the following production techniques : a) indigenous (*deshi*) variety and modern variety (MV) of a crop have been considered as separate crop activity; b) a crop has been considered as a separate activity due to different periods of sowing/transplanting; c) three levels of fertilization have been considered. These are : i) recommended dose, ii) local dose, and iii) unfertilized. Due to the level of fertilization, the same crop has been classified into separate activities; d) a crop grown under irrigated and non-irrigated conditions has been treated as being different activity; and e) a crop grown on high, medium high and medium low land has been considered as being different

activity. In this way, 125 crop activities for pure owner farms, 102 crop activities for owned land and 78 crop activities for rented-in land of owner-cum-tenant farms were identified.

Transfer Activity

To ensure fuller utilization of capital, capital transfer activity was incorporated in the model. This transfer activity ensures transfer of capital from one period to another period, provided it is profitable. The coefficients for capital transfer activities appear in the programming matrix with coefficients of (+ 1) for the capital to be transferred and (-1) for the capital receiving the transferred capital. The objective function coefficient for these activities were put at zero since the capital transfer did not affect the returns in any way.

III. ANALYSIS OF RESULTS

To examine the existing resource allocation pattern and to find out optimum cropping patterns to see how far the profitability of the farms can be improved if the resources are reallocated optimally, two sets of optimum plans were prepared for each case, one with limited capital and the other with borrowed capital.

Land Allocation under Existing and Optimum Plans

Existing land use pattern

The existing land use pattern together with the emerging optimum allocation of land with limited and borrowed capital situations for the pure owner and owner-cum-tenant farms are given in tables 1 and 2 respectively. An examination of the existing corpping patterns from Table 1 reveals that the pure owner farms devoted maximum area to B. *Aus*/Jute-Fallow-Pulses+Oilseeds which accounted for about 25% of the total cropped area in the high land under non-irrigated situation. Fallow-T. *Aman*-Chickpea was the next predominant cropping pattern which occupied nearly 18% of the total cropped area in the medium high land under non-irrigated condition.

It is clear from Table 2 that more or less similar cropping patterns were followed in the owned land and rented-in land by the owner-cum-tenant farms. The most predominant cropping pattern for this group appeared to be B. Aus/Jute-Fallow-Pulses+Oilseeds in both owned as well as rented-in land which accounted for roughly 31 and 42% respectively in the high land under non-irrigated situation. The next important cropping pattern was B. Aus/Jute-Fallow-Pulses/Oilseeds which occupied about 15% for both owned and rented-in land in the aforesaid land type. Fallow-T. Aman-Chickpea was also a predominant cropping pattern which occupied nearly 14 and 16% of the total cropped area in owned and and rented-in land, respectively in the medium high land under non-irrigated situation.

The cropping patterns followed by different tenurial groups are indicative of their resource availability and resource endowment. B. *Aus*/Jute-Fallow-Pulses+Oilseeds and B. *Aus*/Jute-Fallow-Pulses/Oilseeds occupied an important place in the cropping system for both the

groups of farms in the high land under non-irrigated situation. Vegetables occupied a significant percentage of area in the owned land that of rented-in land. Apparently, the farmers did not want to invest more in rented-in land. In the study area, the farmers grew vegetables in the high land under irrigated situation. The cropping pattern namely Fallow-T. *Aman*-Boro required maximum working capital which occupied about 7% of the total cropped area for both the groups of farms. In the medium low land under non-irrigated situation, single crop cropping pattern prevailed for both the groups of farms. However, in the case of the pure owner farms, about 84% of the area was occupied by the cropping patterns having cereal crops in the existing plan. About 86% of the owned land and 91% of the rented -in land had cropping patterns with cereal in the owner-cum-tenant farms; yet, the farmers were not self-sufficient in cereal. A comparative revealation of the cropping patterns followed by different tenurial groups clearly indicates that the pure owner farms practised more commercial crops as compared to the owner-cum-tenant farms. In the owner-cum-tenant farms, more commercial crops were noticed in the owned land as compared to the rented-in land.

Optimum Land Use Pattern With Limited Capital

Optimization and reallocation of available resources bring significant changes in the existing land use pattern. Due to optimization, Fallow-T. *Aman*-Sweetgourd found the prime place in the high land under non-irrigated situation which accounted for roughly 53% of the total cropped area. The next dominant cropping pattern was Fallow-Fallow-Chickpea which occupied about 25% of total cropped area in the medium high land under non-irrigated situation (Table 1). Due to capital scarcity, single crop cropping pattern appeared in the optimum plan. A similar situation was observed in the medium high land under irrigated situation where Fallow-Fallow-*Boro* prevailed. Optimum plan with limited capital indicates lower land use by keeping land seasonally fallow. The cropping intensity was 134% i. e. optimization suggested a decrease in the allocation of area.

In the case of the owner-cum-tenant farms, optimization of available resources suggested reallocation of land in terms of cropping patterns only on the owned land. Due to extreme capital scarcity and tenurial arrangement, the single crop activity could not appear into the plan on the rented -in land of the owner-cum-tenant farms. *Mukhikachu*-Sweetgourd was the predominant cropping pattern in the high land under non-irrigated situation which accounted for roughly 48% of the total cropped area. The same land type allocated another cropping pattern namely Fallow-T. *Aman*-Sweetgourd which accounted for only about 16% of the total cropped area. Due to optimization, the area under the cropping pattern, Fallow-T. *Aman*-Fallow increased by approximately three times over the existing land allocation in the medium high land under nonirrigated situation. In the medium high land under irrigated condition, the area under the cropping pattern Fallow-T. *Aman-Boro* increased by about one and a half times over the existing land allocation. Due to optimization however, the cropping intensity decreased from 175% to 152%.

A comparative analysis of seven optimum cropping patterns of the pure owner farms and six optimum cropping patterns of the owner-cum-tenant farms suggested a decrease in the allocation of land area. In the case of the pure owner farms, four new cropping patterns out of seven cropping patterns entered into the optimum plan with limited capital situation. In the case of the owner-cum-tenant farms, three new cropping patterns out of six cropping

Table 1. Existing and Optimum Cropping Patterns for the Pure Owner Farms

(Area in decimals)

Cropping patterns and cropping intensity	Existing plan	Optimum plans	
		With limited capital	With borrowed capital
Cropping Patterns			
High land (Non- irrigated)	47.60 (36.92)	52.74 (52.55)	56.14 (37.56)
1. B. *Aus*/Jute-Fallow-Pulses+Oilseeds	31.82 (24.68)	-	-
2. B. *Aus*/Jute-Fallow-Pulses/Oilseeds	8.84 (6.86)	-	-
3. Fallow-T. *Aman*-Fallow	4.05 (3.14)	-	-
4. Fallow-T. *Aman*-Sweetgourd	-	52.74 (52.55)	-
5. *Mukhikachu*-Pulses+Oilseeds	2.40 (1.86)	-	-
6. *Mukhikachu*-Sweetgourd	-	-	56.14 (37.56)
7. Turmeric	0.49 (0.38)	-	-
High land (Irrigated)	11.45 (8.88)	7.19 (7.16)	19.41 (12.99)
8. B. *Aus*-Fallow-Vegetables	1.60 (1.24)	-	-
9. Jute-Fallow-Vegetables	2.20 (1.71)	-	-
10. Vegetables-Vegetables	2.04 (1.58)	-	-
11. Cucumber-*Danta*-Radish	-	1.08 (1.08)	19.41 (12.99)
12. B. *Aus*/Jute-Fallow-Potato	1.28 (0.99)	-	-
13. Fallow-Bean	0.83 (0.65)	-	-
14. Fallow-Brinjal	0.66 (0.51)	6.11 (0.08)	-

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(Area in decimals)

Cropping patterns and cropping intensity	Existing plan	Optimum plans	
		With limited capital	With borrowed capital
Cropping Patterns			
15. B. *Aus*/Jute-Fallow-Wheat	2.04 (1.58)	-	-
16. Vegetables-Fallow-Pulses+Oilseeds	0.80 (0.62)	-	-
Medium high land (Non-irrigated)	45.02 (34.91)	24.61 (24.52)	49.22 (32.93)
17. Fallow-T. *Aman*-Chickpea	22.92 (17.77)	-	49.22 (32.93)
18. Fallow-T.*Aman*-Pulses+Oilseeds	3.00 (2.33)	-	-
19. Fallow-Fallow-Chickpea	-	24.61 (24.52)	-
20. Fallow-T. *Aman*-Lentil	2.08 (1.61)	-	-
21.B. *Aus*/Jute-T. *Aman*-Chickpea	10.16 (7.88)	-	-
22. B *Aus*/Jute-T. *Aman*-Fallow	4.76 (3.69)	-	-
23. B. *Aus*/Jute-T. *Aman*-Pulses+Oilseeds	2.10 (1.63)	-	-
Medium high land (Irrigated)	17.92 (13.90)	8.86 (8.83)	17.72 (11.86)
24. Fallow-T.Aman-Boro	8.98 (6.97)	-	1.48 (0.99)
25. Fallow-T. Aman-Wheat	5.42 (4.20)	-	-
26. Fallow-Fallow-Boro	-	8.86 (8.83)	-
27. B. Aus-Fallow -Potato	-	-	16.24 (10.87)
28. B. Aus/Jute-T. Aman-Wheat	3.52 (2.73)	-	-
Medium low land (Non-Irrigated)			
29. B. Aman-Fallow	6.53 (5.06)	6.53 (6.51)	6.53 (4.37)
Medium low land (Irrigated)			
30. Boro-Fallow	0.43 (0.33)	0.43 (0.43)	0.43 (0.29)
Total cropped area	128.95 (100)	100.36 (100)	149.45 (100)
Cropping intensity	172	134	199

Note : Figures in the parentheses are percentages to total cropped area.

Table 2. Existing and Optimum Cropping Patterns for the Owner-cum-tenant Farms

(Area in decimals)

Cropping patterns and cropping intensity	Existing plan		Optimum plans			
	Owned land	Rented in land	With limited capital		With borrowed capital	
			Owned land	Rented in land	Owned land	Rented in land
Cropping Patterns						
High land (Non-irrig.)	64.38 (49.35)	61.62 (56.70)	72.38 (63.73)	-	72.38 (50.38)	68.78 (57.14)
1. B.*Aus*/Jute-Fallow-pulses +Oilseeds	40.44 (31.00)	45.16 (41.55)	-	-	-	43.06 (35.77)
2. B. *Aus*/Jute-Fallow-pulses /Oilseeds	20.06 (15.38)	15.80 (14.54)	-	-	-	14.92 (12.40)
3. *Mukhikachu*-Pulses+ Oilseeds	3.88 (2.97)	0.66 (0.61)	-	-	-	-
4. *Mukhikachu*-Sweetgourd	-	-	54.54 (48.02)	-	72.38 (50.38)	-
5. Fallow-T. *Aman*-Chickpea	-	-	-	-	-	10.80 (8.97)
6. Fallow-T. *Aman*-Sweetgourd	-	-	17.84 (15.71)	-	-	-
High land (Irrigated)	7.24 (5.54)	5.27 (4.85)	3.83 (3.37)	-	7.66 (5.33)	6.66 (5.53)
7. B. *Aus*/Jute-Fallow-Potato	1.78 (1.36)	-	-	-	7.66 (5.33)	-
8. B. *Aus*/Jute-Fallow Wheat	1.42 (1.09)	1.38 (1.27)	-	-	-	-
9. Fallow-Bean	0.42 (0.32)	1.39 (1.28)	-	-	-	-
10. Fallow-Brinjal	-	-	3.83 (3.37)	-	-	-
11. *Danta-Bean*	-	-	-	-	-	6.66 (5.53)
12. B. *Aus*/Jute-Fallow-Vegetables	1.06 (0.81)	1.12 (1.03)	-	-	-	-
13. Fallow-T. *Aman*-Vegetables	2.56 (1.96)	1.38 (1.27)	-	-	-	-

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(Area in decimals)

Cropping patterns and cropping intensity	Existing plan			Optimum plans		
				With limited capital		With borrowed capital
Cropping Patterns						
Med. high land (Non -irr.)	38.94 (29.85)	24.31 (22.37)	22.29 (19.62)	-	44.58 (31.03)	27.44 (22.80)
14. Fallow-T. *Aman*-Chickpea	18.20 (13.95)	17.82 (16.40)	-	-	44.58 (31.03)	27.44 (22.80)
15. Fallow-T. *Aman*-Fallow	6.67 (5.11)	1.39 (1.28)	22.29 (19.62)	-	-	-
16. Fallow-T. *Aman* Pulses+ Oilseeds	-	1.12 (1.03)	-	-	-	-
17. B. *Aus*/Jute-T. Aman - Chickpea	7.69 (5.90)	3.98 (3.66)	-	-	-	-
18. B. *Aus*/Jute- T. Aman- Fallow	6.38 (4.89)	-	-	-	-	-
Med. high land (Irrig.)	14.48 (11.10)	12.22 (11.24)	9.67 (8.51)	-	13.62 (9.48)	12.22 (10.15)
19. B.*Aus*-Fallow-Potato	-	-	-	-	13.62 (9.48)	-
20. Fallow-T. *Aman*-Boro	6.88 (5.27)	7.82 (7.19)	9.67 (8.51)	-	-	12.22 (10.15)
21. Fallow-T. *Aman*-Wheat	2.68 (2.05)	4.40 (4.05)	-	-	-	-
22. B *Aus* -Jute- T. *Aman*-Wheat	3.62 (2.78)	-	-	-	-	-
23. B. *Aus* -T. *Aman*-Potato	1.30 (1.00)	-	-	-	-	-
Med. low land (Non-irrigated)						
24. B. *Aman*-Fallow	5.42 (4.16)	4.58 (4.21)	5.42 (4.77)	-	5.42 (3.78)	4.58 (3.81)
Medium low land (Irrigated)						
25. *Boro*-Fallow	-	0.69 (0.63)	-	-	-	0.69 (0.57)
Total cropped area	130.46 (100)	108.69 (100)	113.59 (100)	- -	143.66 (100)	120.37 (100)
Cropping intensity	175	173	152	-	193	192

Note : Figures in the parentheses are percentages to total cropped area.

patterns under owned land entered into the optimum plan. The rest three cropping patterns in each case involved reallocation of land amongst the existing crops. However, in the pure owner farms, about 68% of the area was occupied by the cropping patterns including cereal crops. About 49% of the owned land was occupied by the cereal based cropping patterns in the owner-cum-tenant farms. Commercial crops such as vegetables were important for both the groups of farms. In the medium low land, there was no alternative of single crop cropping pattern. Due to optimization, the cropping intensity decreased for both the groups of farms as compared to the existing plans.

Optimum Land Use Pattern With Borrowed Capital

When capital restrictions are relaxed, the farm plan in the pure owner farms represent a slight increase in the area. The cropping pattern namely *Mukhikachu*-Sweetgourd was the most dominant cropping pattern in the high land under non-irrigated situation which occupied about 38% of total cropped area. The next dominant cropping pattern was Fallow-T. *Aman*-Chickpea which accounted for roughly 33% of total cropped area (Table 2). It is interesting to note that about 51% of the total cropped area was occupied by noncereal based cropping patterns. Therefore, it may be said that the cropping patterns under optimizing situation with borrowed capital were more cash-generating than those under existing or limited capital situation. The cropping intensity showed an increase from 172% in existing cropping patterns to 199% in cropping patterns with borrowed capital.

In the case of the owner-cum-tenant farms, *Mukhikachu*-Sweetgourd was also the most dominant cropping pattern in the owned land of the owner-cum-tenant farms with borrowed capital occupying about 50% of the total cropped area. The next dominant cropping pattern was Fallow-T. *Aman*-Chickpea whose area increased by approximately two and a half times in the owned land and about one and a half times in the rented-in land of the owner-cum-tenant farms in the medium high land under non-irrigated situation. Fallow-T. *Aman-Boro* occupied nearly 10% of the total cropped area in the rented-in land of the owner-cum-tenant farms (which was about 7% of the total cropped area in the existing plan) in the medium high land under irrigated condition. In this plan, owned land and rented-in land of the owner-cum-tenent farms occupied about 56 and 54% of the total cropped area based on non-cereal based cropping patterns, respectively. The cropping intensity of owned land stood at 193%, while in the case of rented-in-land, the cropping intensity was estimated at 192%.

Utilization of Human Labour

The utilization of human labour in different tenurial groups for the existing and optimum production plans in different peak periods selected for the study has been presented in Table 3. In the case of the pure owner farms, the total employment of labour declined in the optimum plan with limited capital situation by 15.43% as compared to the existing plan. This was due

to the utilization of lesser proportion of land. Therefore, lesser amount of labour required during April, May, July, August and November peak periods. However, due to more labour requirements in February and March for boro transplanting and harvesting of *rabi* crops, the total labour employment increased in those periods. On the other hand, the introduction of capital borrowing activity increased the total employment by 60.10% as compared to the existing plan. This was due to transfer of greater land area under local paddy to modern varieties. Besides, cultivation of non-paddy crops such as *mukhikachu, danta*, radish and potato also increased labour demand.

In the case of the owner-cum-tenant farms, the total labour employment decreased in the optimum plan by 32.08% with limited capital situation (Table 3). In the case of the owner-

Table 3. Human Labour Days Utilization by Different Tenurial Groups of the Small Farms

Period	Available	Existing plan	Optimum plans		Increase/decrease over existing plan			
			Limited capital	Borrowed capital	Limited capital	%	Borrowed capital	%
Pure owner farms								
1. February	15.36	4.86	7.03	5.11	+2.17	44.65	+ 0.25	5.14
2. March	15.36	6.09	8.03	9.57	+ 1.94	31.86	+ 3.48	57.14
3. April	16.64	4.21	1.57	12.62	-2.64	62.71	+ 8.41	199.76
4. May	16.64	8.88	5.26	13.63	-3.62	40.77	+ 4.75	53.49
5. July	16.64	7.62	2.39	13.35	-5.53	68.64	+ 5.73	75.20
6. August	15.36	10.59	8.41	4.97	- 2.18	20.59	-5.62	53.70
7. November	15.36	11.05	8.53	21.07	- 2.52	22.81	+10.02	90.60
8. December	15.36	3.54	6.85	10.68	+ 3.31	93.50	+ 7.14	201.69
Total	126.72	56.84	48.07	91.00	-8.77	15.43	+ 34.16	60.10
Owner-cum-tenant farms								
1. February	17.28	9.89	4.10	9.01	-5.79	58.54	-0.88	8.90
2. March	17.28	17.66	1.35	17.28	-16.31	92.36	-0.38	2.15
3. April	18.72	8.80	10.59	15.36	+ 1.69	19.20	+ 6.56	74.55
4. May	18.72	19.35	9.25	20.12	-10.10	52.20	+ 0.77	3.98
5. July	18.72	9.41	14.77	18.72	+ 5.36	56.96	+ 9.31	98.94
6. August	17.28	19.98	2.97	17.28	-16.92	85.07	-2.61	13.12
7. November	17.28	15.77	17.28	32.41	+ 1.51	9.58	+ 16.64	105.52
8. December	17.28	5.37	11.88	11.13	+ 6.51	121.23	+ 5.76	107.26
Total	142.56	106.14	72.09	141.31	-34.05	32.08	+35.17	33.14

cum-tenant farms, the optimized plan reduced the labour requirement in four peak periods viz. February, March, May and August. The remaining peak periods recorded higher labour requirement as compared to the existing plan. The relaxation of capital constraint increased the labour requirements. This was due to transfer of greater land area under local paddy to modern varieties which utilized more labour compared to local varieties. Therefore, during April, May, July, November and December, greater utilization of labour was noticed in the optimum plan with borrowed capital. The non-paddy crops such as jute, *mukhikachu* and potato further pushed up the labour requirements in those periods. Due to capital scarcity, the farmers kept their lands fallow in the optimized plans with limited capital. The farmers had to hire labours during November for the pure owner farms and during May and November for the owner-cum-tenant farms in the production plan with borrowed capital.

Utilization of Bullock Labour

The utilization of bullock labour in existing and optimum plans during selected peak periods for different tenurial groups is presented in Table *4*. The bullock labour utilization decreased in the optimum plan with limited capital by *40.27%* for the pure owner farms as compared to the existing plan. This was due to the lesser utilization of land. However, the use of bullock labour in the optimum plan for the month of July was higher than that in the existing plan because of greater ploughing requirements of transplanted *aman* and brinjal. The relaxation of capital constraint increased utilization of bullock labour due to transfer of land area from local (paddy) varieties to modern varieties. In this plan, the farmers had to hire bullock power throughout April because of ploughing of *aus* paddy, broadcast *aman* paddy, *danta* and *mukhikachu.*

In the case of the owner-cum-tenant farms, the total utilization of bullock labour decreased in the optimum plan with limited capital by *50.47%* as compared to the existing plan. This was due to the fact that the farmers kept land fallow under this plan owing to capital scarcity. Even in the case of relaxation of capital constraint, the owner-cum-tenant farms could not increase bullock labour utilization significantly over the existing plan. However, the farmers had to hire bullock labour during April for both the groups of farms in the optimum plan with borrowed capital.

Utilization of Tractor/Power Tiller

The utilization of tractor/power tiller for the existing plans and the optimum plans in the different peak periods for the selected tenurial groups of small farmers has been presented in Table *5*. In the case of the pure owner farms, utilization of tractor/power tiller increased in the optimum plan with limited capital by *0.79%* as compared to the existing plan. The relaxation of capital constraint further increased *(3.57%)* the utilization of tractor/power tiller.

Table 4. Bullock Labour Days Utilization by Different Tenurial Groups of the Small farms

Period	Available	Existing plan	Optimum plans		Increase/decrease over existing plan			
			Limited capital	Borrowed capital	Limited capital	%	Borrowed capital	%
Pure owner farms								
1. February	3.90	0.31	0.55	1.31	+ 0.24	77.42	+ 1.00	322.58
2. April	4.23	3.56	0.33	5.46	-3.23	90.73	+ 1.90	53.37
3. May	4.23	1.45	0.46	3.23	-0.99	68.28	+ 1.78	122.76
4. July	3.90	3.14	4. 13	3.83	+ 0.99	31.53	+ 0.69	21.97
5. November	3.90	2.49	1.07	3.24	- 1.42	57.03	+ 0.75	30.12
Total	20.16	10.95	6.54	17.07	- 4.41	40. 27	+ 6.12	55.89
Owner-cum-tenant farms								
1. February	7.68	0.40	0.00	0.38	- 0.40	100.00	- 0.02	5.00
2. April	8.32	9.64	4.04	8.82	- 5.60	58.09	- 0.82	8.51
3. May	8.32	4.14	2.61	3.56	- 1.53	36.96	- 0.58	14.01
4. July	7.68	5.18	5.45	7.68	+ 0. 27	5.21	+ 2.50	48.26
5. November	7.68	5.07	0.00	4.01	- 5.07	100.00	- 1.06	20.91
Total	39.68	24.43	12.10	24.45	-12.33	50.47	+ 0.02	0.08

Table 5. Tractor/Power Tiller Utilization by Different Tenurial Groups of the Samall Farms

Period	Available	Existing plan	Optimum plans		Increase/decrease over existing plan			
			Limited capital	Borrowed capital	Limited capital	%	Borrowed capital	%
Pure owner farms								
1. April	0.00	14.20	6.07	7.86	- 8.13	57.25	-6.34	44. 65
2. November	0.00	50.22	58.86	58.86	+ 8.64	17.20	+ 8.64	17.20
Total	0.00	64.42	64.93	66. 72	+ 0.51	0.79	+ 2.30	3.57
Owner-cum-tenant farms								
1. April	0.00	20.29	0.00	14.30	-20.29	100.00	-5.99	29.52
2. November	0.00	84.85	40.89	148.30	-43.96	51.81	+ 63.45	74.78
Total	0.00	105.14	40.89	162.60	- 64.25	61.11	+ 57.46	54.65

In the case of the owner-cum-tenant farms, a slightly different result was observed. Table 6 reveals that the owner-cum- tenant farm registered a decrease of tractor/power tiller utilization by 61.11 % in the optimized plan with limited capital as compared to the existing plan. This was due to the non-utilization of tractor/power tiller of those crops which entered into that plan. The relaxation of capital constraint increased the utilization of tractor/power tiller by 54.65% in the optimum plan as compared to the existing plan. This was due to greater utilization of land area by *rabi* crops, namely sweetgourd, chickpea, mustard and lentil in the optimum plan.

Gross Margin Under Existing and Optimum Plans

An examination of Table 6 reveals that optimum plans with limited capital situation resulted an increase in gross margin by 32.79 and 31.80% on the pure owner and owner-cumtenant farms respectively. This clearly shows a marked mal-allocation of existing resources on all tenurial groups and a considerable scope for increasing farm income by reallocation of existing resources. The mal-allocation in the case of both the groups of farms was almost the same. The provision of borrowed capital further raised the income by 71.77 and 62.88% over the optimum plans with limited capital in the cases of the pure owner and owner-cum-tenant farms respectively indicating that both groups of farms were highly capital starved. The result of the analysis suggests that provision of adequate and timely credit would go a long way in popularising the adoption of modem varieties and cash crops, and in raising farm income.

The marginal value product of land varied considerably from situation to situation. An examination of Table 7 reveals that the use of borrowed capital increased marginal value product of land in all situations. The marginal value product of rented-in land was zero in the optimum plan with limited capital.

Marginal Value Products of Resources

The marginal value product of human labour for different months is given in Table 8. In the case of the pure owner farms, the marginal value product of human labour for different months in the optimum plan was zero (excepting the month of November). This indicates that the available human labour was uniformly surplus of the requirement in the optimum plan in the case of the pure owner farms. For the owner-cum-tenant farms however, a slightly different result was observed. The positive marginal value product of human labour was observed during the months of March, May July, August and November. This indicates that the available human labour was uniformly surplus of the requirement in the optimum plan in the case of the pure owner farms. Rationale for varying marginal value products of human labour was related to land reallocation to different crops and consequential readjustment in land-labour ratio in the cropping patterns under the optimum plans.

An examination of Table 9 reveals that on pure owner and owner-cum-tenant farms, the marginal value product of bullock labour was zero in most of the periods (excepting the months of April and July). This shows that the excess available bullock labour on these farms and the extent of under-employment prevailed in almost all the periods.

Table 10 indicates that the introduction of borrowed capital decreased maginal value product of tractor/power tiller. This might have been due to increase in the use of tractor/power tiller with access to capital. It is seen from Table 11 that the marginal value product of tractor/power tiller in the month of April was zero in the case of owner-cum-tenant farms with existing (limited) capital situation. This might be due to non-utilization of tractor/power tiller for those crops which entered into that plan.

The introduction of capital borrowing activity increased the use of capital on both groups of farms as evident in Table 11. The increase in the use of capital ranged from 23% to 34% in the case of the pure owner farms. This shows how badly the farmers need the credit for proper and better utilization of the available resources (with exception in tractor/power tiller). So, there exists an urgent need for providing special credit facilities for introducing the modern varieties and high valued cash crops as well as for optimum utilization of available resources. The marginal value product arising from limited capital was higher in owner-cum-tenant farms than that of pure owner farms. This indicates that in the case of the owner-cum-tenant farms, the capital investment pushed up even at a high rate of interest. For achieving economic efficiency the use of capital should be invested to the point where marginal value product equals interest rate.

IV. CONCLUSIONS AND POLICY IMPLICATIONS

The above discussions clearly demonstrate that under the existing plan, farm resources were not utilized optimally. There was significant increase in net return and employment of labour yielded by the optimum plans over the existing ones. Tractor/power tiller utilization increased under borrowed capital situation, while labour employment and tractor/power tiller utilization decreased under limited capital situation. This indicates that lack of capital acted as a severe constraint. Cereal based cropping patterns showed dominance in both the existing and optimum plans. The study found that the owner farmers were more efficient in allocating and utilizing available resources than those of the tenant operators. The variation in productivity was mainly due to variation in resource endowment and management. The information on optimum plans computed will be useful for policy makers to evolve regional schemes for development. The results of the study can be utilized by the credit agencies to assess the credit needs, both in short-term and long-term of the farmers. Based on our analysis, certain policy instruments may be identified and their implications can be stated as follows:

(i) the existing land use pattern was found to be sub-optimal, thereby indicating more scope of farm management extension.

Table 6. Gross Margin in the Existing and Optimum Plans by Different Tenurial Groups of the Small Farms

(in taka)

Tenurial groups	Existing plan	Optimum plans		Increase over existing plan				Increase in borrowed capital plan over limited capital plan	
		Limited capital	Borrowed capital	Limited capital	%	Borrowed capital	%	Taka	%
Pure owner farms	4138	5495	9439	1357	32.79	5301	128.11	3944	71.77
Owner-cum-tenant farms	6390	8422	12440	2032	31.80	6050	94.68	4018	62.88

Table 7. Marginal Value Product (MVP) of Land

(in taka)

Tenurial groups	High land				Medium high land				Medium low land			
	Non-irrigated		Irrigated		Non-irrigated		Irrigated		Non-irrigated		Irrigated	
	B	C	B	C	B	C	B	C	B	C	B	C
Pure owner farms	14.41	123.79	125.35	290.33	1.25	79.90	6.53	116.75	16.37	43.08	1.75	50.61
Owner-cum-tenant farms :												
Owned land	17.94	153.47	112.21	123.61	4.38	58.68	4.38	101.31	12.69	32.16	-	-
Rented in-land	0.00	13.68	0.00	28.16	0.00	13.68	0.00	26.44	0.00	8.94	0.00	21.21

B = Optiumum plan with limited capital.

C = Optimum plan with borrowed capital.

Table 8. Marginal Value Product (MVP) of Human Labour

(in taka)

Tenurial groups	February		March		April		May		July		August		November		December	
	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
Pure owner farms	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.80	0.00	0.00
Owner-cum-tenant farms	0.00	0.00	0.00	0.18	0.00	0.00	0.00	37.80	0.00	31.21	0.00	29.40	71.45	37.80	0.00	0.00

B = Optimum plan with limited capital.

C = Optimum plan with borrowed capital.

Table 9. Marginal Value Product (MVP) of Bullock Labour

(in taka)

Tenurial groups	February		April		May		July		November	
	B	C	B	C	B	C	B	C	B	C
Pure owner farms	0.00	0.00	0.00	59.40	0.00	0.00	177.35	0.00	0.00	0.00
Owner-cum-tenant farms	0.00	0.00	0.00	59.40	0.00	0.00	0.00	12.54	0.00	0.00

B =Optimum plan with limited capital.

C = Optimum plan with borrowed capital.

Table 10. Marginal Value Product (MVP) of Tractor/Power Tiller

(in taka)

Tenurial groups	April		November	
	B	C	B	C
Pure owner farms	5.46	2.16	5.46	2.16
Owner-cum-tenant farms	0.00	2.16	6.64	2.16

B = Optimum plan with limited capital.

C = Optimum plan with borrowed capital.

(ii) The optimim resource use, in addition to increasing farm income, was also more labour intensive. The development efforts which will encourage adjustments in the cropping pattern should be taken up. This will also help to create more employment in the economy.

(iii) The optimum plans suggest the adoption of modern varieties and remunerative cash crops which necessitate the dissemination of technical know-how by proper extension technique and training.

(iv) The use of capital intensive technology is being suggested by the optimum plans. Thus adequate supply of modern inputs at right time at fairly competitive price should be made available.

(v) The optimum plans did not include wheat. The study area was not a major wheat producing area because the available irrigation facilities were used for irrigating boro and thus there was little scope for ensuring irrigation for growing wheat. The present technology of wheat is not remunerative compared to irrigated rice. Therefore, breeding efforts would be needed to develop wheat varieties which tolerate heat and drought stress and which yield well under conditions of reduced fertility.

(vi) The optimum plans (cropping patterns) involved fewer crops, thereby indicating the trend towards specialisation. This is in conflict with the current emphasis on diversification of crops. Unless special attention is given to these minor crops in developing modern varieties with higher profitability, dissemination of technology among the farmers, and improvement in the post harvest processing and utilization aspects, the desired goal of crop diversification will be difficult to achieve. These measures are particularly needed for the minor crops especially wheat and turmeric for both limited capital and borrowed capital situation and for potato, pulses (except chickpea) and oilseeds under limited capital situation. When capital restriction was relaxed, potato, pulses and oilseeds were found to be included in the plan.

Table 11. Marginal Value Product (MVP) of Capital

(in taka)

Tenurial groups	Jan., Feb. & March				April, May & June				July August & September				Oct., Nov & Decmber			
	Plan B		Plan C		Plan B		Plan C		Plan B		Plan C		Plan B		Plan C	
	Fixed capital	MVP	Total capital	MVP	Fixed capital	MVP	Total capital	MVP	Fixed capital	MVP	Total capital	MVP	Fixed capital	MVP	Total capital	MVP
Pure owner farms	693	1.73	2117	0.08	970	1.73	2292	0.08	571	1.73	704	0.08	922	1.73	3757	0.08
Owner-cum-tenant farms	1010	2.32	2665	0.08	1718	2.32	3100	0.08	696	2.32	1679	0.08	728	2.32	3203	0.08

B = Optimum plan with limited capital.

C = Optimum plan with borrowed capital.

(vii) It is observed that assured irrigation had increased cropping intensity as well as income for both pure owner and owner-cum-tenant farms in the case of high land and medium high land. Therefore, extension of irrigation facility for non-irrigated high land and medium high land is suggested to increase cropped area and income of the farmers.

(viii) The results of the study demonstrate that lack of capital acted as a sever constraint for the farmers. Thus, availability of credit to farmers should be increased for increaing and stabilising the farm income.

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