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A Farm Resource Allocation Problem: A Case Study of Model A2 Resettled Farmers in Bindura, Zimbabwe

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ABSTRACT

Small-scale resettled farmers are often faced with the problem of how to allocate resources. The objective of the farmers is to generate maximum income for their households subject to resource constraints. These farmers often solve this problem using traditional methods like trial and error methods, instinct and past experience. This does not guarantee optimal solutions. In this paper linear programming is applied to address this problem. A linear programming model is developed. Optimal crop patterns and optimal number of breeding sows are determined. The results obtained from using the linear programming model are compared with the results that are obtained from the traditional methods of trial and error used by the farmers. The strategies obtained by using linear programming yields more income than strategies obtained from trial and error methods. Results obtained so far reveal the optimal strategies that the farmer could have considered to realize more income.

1.INTRODUCTION

Small-scale farmers in the Land Reform and Resettlement Programme (Model A2 Phase II) are often faced with the problem of how to allocate resources. Model A2 is a commercial settlement scheme comprising small-, medium-, and large-scale commercial settlements, intended to create a cadre of black commercial farmers in Zimbabwe (Zikhali, 2008). The objective of the farmers is to generate maximum income for their households subject to resource constraints. This can be achieved by developing optimal cropping patterns. These farmers often solve this problem using traditional methods like trial and error methods, instinct and past experience. This does not guarantee optimal solutions. Linear Programming (LP) can address this problem. Hassan, Raza, Khan and Ilahi (2005) applied a LP model to calculate the crop acreage, production and income of the Dera Ghazi Khan Division of Punjab Province in Pakistan. The optimal cropping pattern developed increased income by 2.91%. The results demonstrated that the LP model suggestions are worthy exercising (Hassan et al, 2005).

Igwe, Onye, Onyenweaku and Nwaru (2011), argue that “Linear Programming technique is relevant in optimization of resource allocation and achieving efficiency in production planning particularly in achieving increased agricultural productivity”. They applied LP technique to determine the optimum enterprise combination. The existing land use in terms of hectarage allocation and their optimum plans were tabled. The results from optimum plans were more superior.

Bamiro, Afolabi and Daramola (2012), examined the enterprise combination in cassava based food crop farming system in Ogun state in Nigeria. In their study the optimal cassava based combination was actualized by a LP model. Nedunchezhian and Thirunavukkarasu (2007) conducted a study to optimize farm plans in different farming systems in Orathanadu Block of the Thanjavur District in Tamil Nadu. They developed an LP model to arrive at the optimal farm plans for different categories of farms. The optimal plans show that they are significant potentials for increased income and employment generation. An LP technique was adopted to determine the optimum combination of crops and livestock production on small mixed farms in a newly reclaimed area in Egypt (Alsheikh and Ahmed, 2002). Results from the LP model were expected to improve farm income by 55%, 26% and 42% as compared to real situation in the three study locations.

The objective of this study is to develop an LP model that will maximize income subject to resource constraint for a resettled small-scale A2 model farmer in Bindura, Zimbabwe. The farmer produces maize and soya beans and rears pigs. The farmer has approximately 32.55 hectares of land for production. The goal of the farmer is to obtain breeding sows and to fatten their off -springs for pork using some of the maize and soya beans as feed. The problem is to determine the optimal number of breeding sows the farmer should carry and whether the farmer should rear or purchase replacements when needed. Linear Programming will address these issues in this study.

2. LINEAR PROGRAMMING FORMULATION

The farmer has 32.55 ha of land that is meant for pigs, maize and soya bean production. The expected income for production sale is; $66.00 per porker, $555.00/ha from soya beans and $295.00/ton from maize. The farmer is interested in buying breeding sows and to fatten their offspring for pork. The farmer would like to use some of the maize produced on the farm as feed. The model formulation in this study will pattern after Hazell and Norton (1986) where the problem was to determine the optimal number of breeding sows, and whether to rear or purchase replacements. The goal of the farmer is to obtain breeding sows and to fatten their off springs for pork using some of maize production as feed. The problem is to determine the optimal number of breeding sows the farmer should carry and whether we should rear or purchase replacements when needed. Before the optimization model was constructed, the farmer had made a plan to allocate 15 ha for soya beans, 5 ha for maize and to purchase 5 sows. His resources include land and labour. The farmer is interested in producing large white breed. The farmer must decide on the number of breeding sows to carry, and how many hectares that should be allocated to maize and soya beans production. So the decisions are:

$$x_1 = number\ of\ breeding\ sows.$$
$$x_2 = number\ of\ porkers.$$
$$x_3 = number\ of\ sows\ to\ be\ reared.$$
$$x_4 = number\ of\ sows\ to\ be\ purchased.$$
$$x_5 = hectares\ allocated\ for\ maize\ production.$$
$$x_6 = quantity\ of\ maize\ in\ tons\ to\ be\ sold.$$
$$x_7 = hectares\ allocated\ for\ soya\ beans\ production.$$

The goal of the objective function is to maximize the income subject to the given constraints.

Table 1: Livestock Investment Activities

	Breeding sow	**Porker**	**Rear sow**	**Buy sow**	**Maize (ha)**	**Sell Maize (ton)**	**Soya beans (ha)**	
Objective function ($)	-308.00	66.00	-218.00	-135.00	-1082.00	295.00	555.00	Maximize
Resources								**Available**
Land (ha)	0.20		0.30		1.00		1.00	32.55
Labour (months)	1.00	0.40	0.80		0.5		0.30	14.00
Replacement control	0.25		-1.00	-1.00				0.00
Litter balance	-16.00	1.00	1.00					0.00
Maize balance (ton)	0.16	0.16	0.25		-8.00	1.00		0.00

Table 1 shows the LP matrix.
The LP model is given by:

$$\max z = -308x_1 + 66x_2 - 218x_3 - 135x_4 - 1082x_5 + 295x_6 + 555x_7, \quad (objective\ function)$$

$$subject\ to$$

$$0.2x_1 + 0.3x_3 + x_5 + x_7 \leq 32.55, \quad (land\ constraint)$$

$$x_1 + 0.4x_2 + 0.8x_3 + 0.5x_5 + 0.3x_7 \leq 14, \quad (labour\ constraint)$$

$$0.25x_1 - x_3 - x_4 \leq 0, \quad (replacement\ control\ constraint)$$

$$-16x_1 + x_2 + x_3 \leq 0, \quad (litter\ balance\ constraint)$$

$$0.16x_1 + 0.16x_2 + 0.25x_3 - x_5 + x_6 \leq 0, \quad (maize\ balance\ constraint)$$

$$x_1, \ldots, x_8 \geq 0, \quad (non-negativity\ \ constraint)$$

3. RESULTS AND DISCUSSIONS

The LP problem is solved using Microsoft Office Excel (2007) a computer software package. Results obtained for optimal activity pattern and resource allocation are displayed in Table 2 and Table 3 respectively.

Table 2: Production Plan Suggested By LP Model

	Breeding sow	Porker	Rear sow	Buy sow	Maize (ha)	Soya beans (ha)
Production	0.00	0.00	0.00	0.00	28.00	0.00
Income ($)	35784.00					

Table 3: Resource Utilization

Resources	Available	Usage	Left Over
Land (ha)	32.55	28.00	4.55
Labour - (months)	14.00	14.00	0.00

The LP results show that the strategies for this farm, as specified in the model, are to produce 28 ha of maize, no soya beans and no pig project. All the labour is used, while 28 ha of the land are used and 4.55 ha are unused. The income is $35784.00.

Table 4: Production Plan Suggested By the Farmer

	Breeding sow	Buy sow	Maize (ha)	Soya beans (ha)
Production	5.00	5.00	5.00	15.00
Income ($)	17380.00			

Table 5: Resource Utilization

Resources	Available	Usage	Left Over
Land (ha)	32.55	21.00	11.55
Labour (months)	14.00	14.00	0.00

The farm plan obtained by the farmer through trial and error methods are displayed in Table 4 and Table 5 above respectively. The strategies for this farm, as specified in the plan, are to produce 15 ha of soya beans, 5 ha maize and buy 5 sows to be kept as breeding sows. All the labour is used, while 21 ha of the land are used and 11.55 ha are unused. The income is $17,350.00.

The results obtained from using the LP model are compared with the results that are obtained from the traditional methods of trial and error used by the farmer. The farm can make an income difference of $35,784.00 if they use LP. The difference in the incomes is 105.89%.
Data was also collected for the year 2009 to 2011 productions. The LP model was used to determine the "what if" land allocation plan. The percentage difference between results obtained from using the LP method and trial and error methods are summarized in Table 6 below.

Table 6: Percentage Income Differences

Year	% difference
2011	58
2010	64
2009	55

The strategies obtained by using LP yields more income than strategies obtained from trial and error methods. Results obtained so far reveal the strategies that the farm could have considered to realize more income.

The strategies obtained by LP, provides the farm with an opportunity to make more income from maize. Had the farmer used LP solutions before, more income from the same piece of land could have been realized. Since 2009, the farmer used instinct and experience to solve the resource allocation problem. This does not guarantee optimal strategies.

CONCLUSION

In this paper the problem of how to determine the optimal number of breeding sows and optimal crop patterns is addressed by LP. Results are tabled and compared with the results obtained by the farmer using trial and error methods. The strategies obtained by using LP yields more income than strategies obtained from trial and error methods. Results obtained so far reveal the strategies that the farmer could have considered to realize more income.

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