INTERNATIONAL RESEARCHERS

OPTIMAL CROPPING PATTERNS FOR ENHANCING HOUSEHOLD FOOD SECURITY FOR CEREAL SMALL GRAIN FARMERS IN CHIVI, ZIMBABWE: A LINEAR PROGRAMMING APPROACH

Felix Majeke and Kasirayi Makaza

Volume No.7 Issue No.1 March 2018

www.iresearcher.org

ISSN 2227-7471

THE INTERNATIONAL RESEARCH JOURNAL "INTERNATIONAL RESEACHERS"

www.iresearcher.org

INTERNATIONAL RESEARCHERS is peer-reviewed, supported by rigorous processes of criterion-referenced article ranking and qualitative commentary, ensuring that only intellectual work of the greatest substance and highest significance is published.

INTERNATIONAL RESEARCHERS is indexed in wellknown indexing diectories

INDEX COPERNICUS INTERNATIONAL JOURNAL MASTER LIST with ICV value 5.90

ULRICHSWEB GLOBAL SERIALS DIRECTORY

JournalSeek

Directory of Research Journals Indexing

and moniter by

THOMSON REUTERS

OPTIMAL CROPPING PATTERNS FOR ENHANCING HOUSEHOLD FOOD SECURITY FOR CEREAL SMALL GRAIN FARMERS IN CHIVI, ZIMBABWE: A LINEAR PROGRAMMING APPROACH

Felix Majeke and Kasirayi Makaza

Gary Magadzire School of Agriculture and Natural Sciences, Great Zimbabwe University,
(ZIMBABWE)
fmajeke@gzu.ac.zw

ABSTRACT

Cereal small grain crops are a very important component of the agricultural sector in Chivi, Zimbabwe. The crops generate income and provide food security to the family households. Small scale farmers dominate the sector. These farmers are often faced by the problem of inefficient use of resources. There is thus a need to carry out a study on how to allocate scarce resources and develop optimal farm plans. They is a tendency by small scale farmers to determine their cropping patterns by trial and error, intuition and by copying cropping patterns from other surrounding farmers. The rainfall patterns in Chivi are also uncertain making the area prone to droughts. The farmers need to adopt coping strategies such as optimal crop combinations that will help them to achieve food security. Linear programming was in this study applied to obtain optimal cropping patterns for the small scale farmers in Chivi, Zimbabwe. The gross income increased by 14.91%. The results obtained by using Linear Programming were more superior to the ones obtained by using traditional methods.

Keywords: Resource Allocation; Cereal Small Grain; Rural Farmer; Linear Programming; Chivi.

1. INTRODUCTION

Cereal small grain crops are a very important component of the agricultural sector in Chivi, Zimbabwe. The crops generate income and provide food security to the family households. Small scale farmers dominate the sector. These farmers are often faced by the problem of inefficient use of resources. There is thus a need to carry out a study on how to allocate scarce resources and develop optimal farm plans. They is a tendency by small scale farmers to determine their cropping patterns by trial and error, intuition and by copying cropping patterns from other surrounding farmers. The rainfall patterns in Chivi are also uncertain making the area prone to droughts. The farmers need to adopt coping strategies such as optimal crop combinations that will help them to achieve food security. Linear programming (LP) has been applied in many studies to obtain optimal cropping patterns.

Ahmadzat, Nanseki and and Chomei (2016) used LP to obtain optimal farm plans in Afghanistan. The gross revenue increased by 37.9%. This indicated that the farmers existing plans were not efficient in resource allocation as compared to ones obtained by using the LP techniques. Salimonu, Falusi, Okoruwa and Yusuf (2008) modelled effiecient resource allocation patterns for food crop farmers in Nigeria using LP. They incorporated the risk element in their model. Frizzone, Coelho, Dourado-Neto and and Soliani (1997) developed an LP model which they used to optimize the water resource use in irrigation projectsin the Senator Nilo Coelho project. Their main objective was to develop an LP model given a set of technical factors which could infuence the profit of the irrigation project. A net return of 52.34% higher was obtained by using the LP model compared to the net return obtained by using traditional cropping patterns. An optimal cropping pattern was also obtained by Dahiphale, Singh, Kothari and Gharde (2015) for Jaisamand command of Udaipur district in Rajasthan, India by use of LP. The LP technique was also applied to farm data of a sample of farmers involved in crop farming in combination with livestock. The data were analysed using LP. The objective was to maximize the gross margin subject to available limited resources. The optimum gross margin was found to be 72.90 greater than that obtained by using the existing plan.

Ibrahim, Bello and Ibrahim (2009) in their study sought to determine the food security status of farming households and an optimal farm plan that could enhance the food security status of the households in Nasarawa State. Food security line as well as LP were used to analyse data that was collected from the 180 farmiing houeseholds using random sampling. The results indicated that an effective allocation of limited resources using LP can enhance the food security status of the farming households. Linear programming was also applied to household data inVihiga district by Nyangweso, Odhiambo, Odunga, Otieno and Korir (2009) to determine the optimal resource

levels and associated costs of meeting household food needs. Hassan, Maruod and Elteama (2014) successfully used LP to find the optimum cropping pattern that maximizes the gross margin in North Kordofan State. Hussain, Hussain, Sial, Akram and Hussain (2007) used LP to obtain an optimal cropping pattern for the Punjab canal. Their objective was to maximize water productivity through the reallocation of available resources. As a result of the use of LP, sugarcane water productivity was increased by as high as 20% on large farms and was increased by 12% on small farms. Thus, water productivity can be maximized by optimizing cropping patterns. Linear programming was also used by Bojang, Yu, Yang and Kuo (2016) to obtain an optimal cropping pattern for a farm in Njawara, Gambia. Their results indicated that 187% annual increase of the financial benefits can be achieved when using the optimum cultivation pattern.

The objective of this study was to develop an optimal cropping pattern for the small scale farmers in Chivi, Zimbabwe by using LP.

2. THE LINEAR PROGRAMMING FORMULATION

The family household considered in the study had 4 hectares of land that is meant for maize, sorghum, pearl and finger millet production. The household expected income was; $390 per ton from maize, $780/ha from sorghum, $390/ha from pearl millet and $390/ha from finger millet. The objective of the household is a cropping combination that helps them to maximize their gross annual income subject to land, labor, maize consumption and operating capital. Of prime importance is whether the household's existing crop combination is optimal and whether it yields maximum gross income?

The decision variables are:

$$x_1 = hectares\ allocated\ for\ maize\ production.$$
$$x_2 = tons\ of\ maize\ produced\ for\ sale.$$
$$x_3 = tons\ of\ maize\ stored\ for\ family\ consumption.$$
$$x_4 = hectares\ allocated\ for\ sorghum\ production.$$
$$x_5 = hectares\ allocated\ for\ pearl\ finger\ production.$$
$$x_6 = hectares\ allocated\ for\ finger\ millet\ production.$$

The objective was to maximize gross income at the end of the year and store maize for family consumption subject to land, labor and operating capital.

Table 1: Linear Programming Matrix

	Activities	Maize	Sell Maize	Transfer Maize	Sorghum	Pearl Millet	Finger Millet	
Resources	**Units**	ha	ton	ton	ha	ha	ha	RHS
Crop Land	ha	1			1	1	1	≤ 4
Labor	days	126			100	100	100	≤ 600
Maize Accounting	ton	-0.8	1	1				≤ 0
Maize Consumption	ton			-1				≤ -2
Operating Capital	dollars	630			480	240	240	≤ 2000
Gross Income	dollars		390		780	390	390	

The LP matrix is represented in Table 1 with the Right Hand Side (RHS) of the table representing the resource constraints.

The LP model is given by:

$$Max\ z = 390x_2 + 780x_4 + 390x_5 + 390x_6, \qquad (objective\ function)$$
$$subject\ to$$
$$x_1 + x_4 + x_5 + x_6 \leq 4, \qquad (crop\ land\ constraint)$$
$$126x_1 + 100x_4 + 100x_5 + 100x_6 \leq 600, \qquad (labor\ constraint)$$
$$-0.8x_1 + x_2 + x_3 \leq 0, \qquad (maize\ accounting)$$
$$-x_3 \leq -2, \qquad (maize\ consumption)$$

$$630x_1 + 480x_4 + 240x_5 + 240x_6 \leq 2000, \qquad (cash\ constraint)$$
$$x_1, \dots, x_6 \geq 0, \qquad (non-negativity\ constraint)$$

3. RESULTS AND DISCUSSION

The LP problem was solved using MS Excel 2010 and the solution is shown in Table 2. The solution suggested that the farmer's optimal plan should be to grow 2 ha of maize, 0.89 ha of sorghum, no pearl millet and no finger millet. The expected gross income was found to be $690.63.

Table 2: Optimum Cropping Pattern

	Maize (ha)	Sorghum (ha)	Pearl Millet (ha)	Finger Millet (ha)
Production	2.00	0.89	0.00	0.00
Gross Income ($)	690.63			

From Table 3, we see that 0.62 ha of land are unused and 196 labour days are left over. All the operating capital, $2,000.00 was used up. If more capital was to be sourced, more land could be utilized resulting in increased gross income.

Table 3: Resource Utilization

Resources	Available	Usage	Left Over
Crop Land (ha)	4.00	3.39	0.62
Labour (days)	600.00	403.54	196.46
Operating Capital ($)	2,000.00	2,000.00	0.00

The results that we obtain from using the LP model yield a gross income of $690.63 as compared to $601.00 that we obtain by using traditional methods. The difference in the gross incomes was found to be 14.91%. The optimal plan obtained by using LP, yields more income than that from traditional methods.

The plan obtained by using LP, provides the farmer with an opportunity to make more gross income from maize and sorghum, and at the same time satisfy the maize consumption requirement for the family. The optimal solution obtained by using LP suggests that the small scale farmer should use LP to make cropping pattern decisions in order to make more income. Cropping patterns obtained by using traditional methods do not guarantee optimal strategies.

4. CONCLUSION

In this study, LP was applied to obtain an optimal cropping pattern for small scale farmers in Chivi, Zimbabwe. The gross income increased by 14.91%. The results obtained by using LP were more superior to the ones obtained by using traditional methods.

REFERENCES

Ahmadzat, N., Nanseki, T., & Chomei, Y. (2016). Cereal Crop Farming for Profit Maximization in Afghanistan. *J. Fac. Agr., Kyushu Univ*, 401-406.

Bojang, P. O., Yu, P.-S., Yang, T.-C., & Kuo, C.-M. (2016). Optimal Cropping Patterns for Profit Maximization using a Linear Programming Model: A Case Study in Njawara Village, The Gambia. *12th International Conference on Hydroscience & Engineering.* Tainan: Hydro-Science & Engineering for Environmental Resilience.

Dahiphale, P., Singh, P. K., Kothari, M., & Gharde, K. (2015). Optimal Cropping Pattern for Jaisamand Command of Udaipur District in Rajasthan, India. *Research Journal of Recent Sciences*, 1-7.

Frizzone, J. A., Coelho, R. D., Dourado-Neto, D., & Soliani, R. (1997). Linear Programming Model to Optimize the Water Resource use in Irrigation Projects: An Application to the Senator Nilo Coelho Project. *Sci. agric., Piracicaba, 54 (Numero Especial)*, 136-148.

Hassan, A. A., Maruod, M. E., & Elteama, M. S. (2014). Optimum Resource Use, Competitiveness and Food Security Nature of Crops Grown in Dry Land Areas in North Kordofan State. *International Journal of Education and Research*, 41-56.

Hussain, I., Hussain, Z., Sial, M. H., Akram, W., & Hussain, M. F. (2007). Optimal Cropping Pattern and Water Productivity: A Case of Punjab Canal. *Journal of Agronomy*, 526-533.

Ibrahim, H., Bello, M., & Ibrahim, H. (2009). Food Security and Resource Allocation among Farming Households in North Central Nigeria. *Pakistan Journal of Nutrition*, 1235-1239.

Igwe, K. C., Onyenweaku, C. E., & Tanko, L. (2013). A Linear Programming Approach to Combination of Crop, Monogastric Farm Animal and Fish Enterprises in Ohafia Agricultural Zone, Abia State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary Sciences*, 22-32.

Nyangweso, P. M., Odhiambo, M. O., Odunga, Otieno, D., & Korir, M. K. (2009). Optimal Resource Utilization for Enhancing Household Food Security in Vihiga District, Kenya: Linear Programmiing Approach. *17th International Farm Management Congress .* Bloomington/Normal: Farm Management.

Salimonu, K. K., Falusi, A. O., Okoruwa, V. O., & Yusuf, S. A. (2008). Modeling Efficient Resource Allocation Patterns for Food Crop Farmers in Nigeria: An Application of T- MOTAD Analysis. *International Journal of Agricultural Economics & Development*, 68-77.