International Scholars Journals

African Journal of Agriculture and Food Security ISSN: 2375-1177 Vol. 4 (3), pp. 161-166, March, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

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*Full Length Research Paper*

# Optimal resource allocation decision among women farmers in the Northern Region of Ghana

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Accepted 04 February, 2016

**Abstract**

**Food insecurity has been found to be high among households headed by female farmers in the northern region of Ghana as a result of poor access to agricultural resources. One approach to improve food insecurity is through increased on-farm income of women farmers through profit maximization. Hence this study was designed to determine the optimal farm plan that increases on-farm income among women farmers to ensure improved food security. A sample of 512 women farmers were randomly selected using simple random sampling technique for the study. Structured questionnaire was used to collect the data and data analysis was done using descriptive statistics and linear programming model. The study revealed that available resources were not efficiently allocated under the existing farm plan which led to over-allocation of capital and labor by 9.6% and 13% respectively. The study further showed a 13.6% increase in on-farm income by the optimal farm plan. Policy makers should develop and implement policies that emphasize and encourage optimal allocation of the limited resources available to women farmer to increase their income levels for improved food security.**

**Key words**: Food security, Linear programming, women farmers, optimal plan.

## INTRODUCTION

The role of women farmers in feeding the world and contributing to agricultural development across the world cannot be underestimated. The Food and Agricultural Organization has indicated that women are the main providers of household meals in many rural communities of many developing countries (FAO, 2011). In Africa, it is estimated that about three-quarters of the agricultural labor force is provided by women while women in the Middle-East and Latin America provide half of the labor force in agriculture (Prakash, 2003). In Ghana, it has been found that women are responsible for about 80 percent of the food produced in the country (Bortei-Doku, 1990).

Despite these important contributions women farmers make towards ensuring food security around the world, they are challenged by poor access to agricultural resources such as land, labor and capital especially in developing economies due to cultural and traditional laws. With regards to access to land, it has been shown that women farmers globally own less than 20% of agricultural land (FAO, 2012). Yemisi and Aisha (2009) observed that in agricultural production, women are more constrained in accessing resources than their male counterparts as a result of which most women have less access and higher costs for information technology, inputs and credit. The obvious consequence of the barriers to women in accessing agricultural resources is increased food and nutrition insecurity around the world. According to a previous study (Aidoo et al, 2013), food insecurity is more prevalent among female-headed households in the Ashanti region of Ghana.

Women farmers access to agricultural resources could be

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enhanced through resource acquisition reforms. In Ghana, a number of land reforms have taken place to ensure improved access to land by women, however, the implementation of these reforms has not favored women farmers and the problem of poor access to land and other resources by women persists (Fofie and Adu, 2013).

A number of studies (Aidoo et al, 2013; Otoo et al, 2015) have therefore suggested that, one approach to improve rural household food security is to increase households incomes by maximizing on-farm profit through the optimal allocation of the limited agricultural resources among women farmers. As a consequence, it is imperative that women farmers, especially those in developing countries allocate their limited resources efficiently to ensure increased farm incomes to improve food security among their households and communities.

Using Linear Programming model, this study was designed to determine the optimal farm plan that increases on-farm income among women farmers to ensure improved food insecurity condition in spite of their resource accessibility constraints.

## MATERIALS AND METHODS

### Study Area

The study was conducted in the Northern region of Ghana (Figure 1), which covers 29.51% of total land area of Ghana, and is often described as the food basket of Ghana (MoFA, 2010). The region has a population of 2,479,461 of whom 70% live in rural areas and are predominantly food crop farmers and has the largest number of female farmers in Ghana (GSS, 2010). The region is important in Ghana's fight against food insecurity as more than 60% of cereals, roots and tuber food crops in Ghana are produced in the region (MoFA, 2010).

### Data source

The study used a cross-sectional data collected from 512 randomly selected women farmers. The data was collected in 2012 from all the 20 districts in the region during the post-harvest period of the 2012 farming season.

### Data Analysis

### Demographic characteristics of respondents

The data was subjected to descriptive analysis with respect to the demographic characteristics of the respondents.

### Optimal farm plan by women farmers

The Linear Programming (LP) model was used to determine the optimal crop allocation plan for women farmers under land, labor and capital constraints. Previous studies (Ibrahim et al, 2009; Nirragira et al, 2011) suggest the LP model as the appropriate approach to determine the optimal farm plan for profit maximization under resource constraints. The LP model was used for this study under the following assumptions;

1. Profit maximizing behavior of farmers
2. a single-period planning (prices of inputs and outputs do not vary within the period)
3. a certain environment

The optimization problem is a profit maximization problem; defined as

**Max** $\Pi = \sum_{n=1}^{n} NiXi, i = 1, 2, 3, \ldots\ldots\ldots, n$

Where;

Π = the total profit from all the crops (GH¢)

n = number of crops

Ni = the net returns from the ith crop (GH¢)

Xi = the total area under ith crop (acres)

**Constraints**

Land availability: L = $\sum_{n=1}^{n} Xi \leq TA$

TA is the total land area under cultivation to all crops

Labor availability:

Lb = $\sum_{n=1}^{n} Xi \leq TLb$

TLb is the total labor requirement for all crops

Capital availability: C = $\sum_{n=1}^{n} CiXi \leq TC$

Ci is the capital requirement for the ith crop

TC is the total capital requirement for all crops

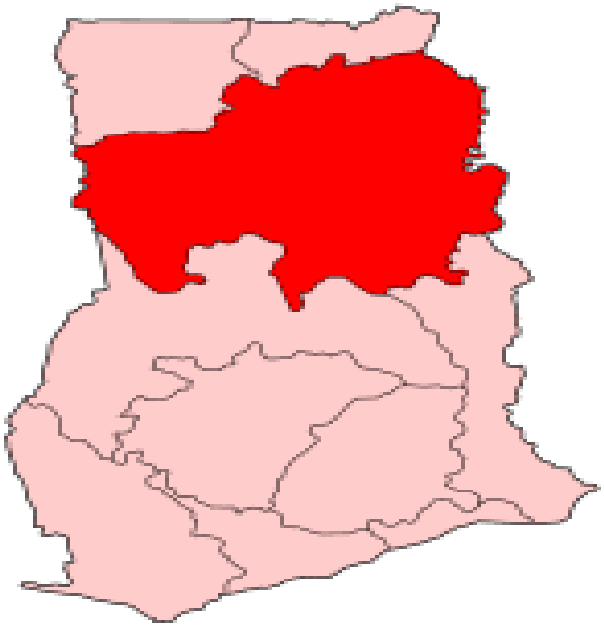
**Non-negativity:** $Xi \geq 0$ $fori$ = 1,2,3,...$n$.

## RESULTS

In Table 1, the results show the demographic characteristics of the respondents. The mean level of education was found to be 6 years. The mean values for access to land, creditor capital and labor were found to be 0.13, 0.26 and 0.34 respectively. The average income among female headed households in the region was found to be GH¢20 per week. These results meet the *apriori* expectation considering the fact that there is male dominance in controlling farm resources and revenue in many rural communities in the northern part of Ghana. The results also show a relatively young female farmers population with an average age of 38.7 years who cultivate various crops on small-scale basis with an average land area of 4.8 acres under cultivation to different food crops.

The results in Table 2 show a comparison between the existing crop selection plans and the optimal crop selection plans as far as the allocation of land, labor and capital are concerned and their levels of utilization. Under the existing selection plan, the results show that women farmers allocate 1.1 acres, 1.2 acres, 0.6 acres, 0.4 acres, 0.5 acres, 0.3 acres, 0.4 acres and 0.3 acres to maize, rice, soybean, cowpea, peanut, amaranthus *spp*, pepper and tomato respectively. The optimal selection plan or solution on the other hand suggests the production of 1.4 acre of maize, 1.0 acres of rice, 0.1

**Figure 1.** Map of the Northern Region embedded in the map of Ghana.



Source: Google map, 2015

**Table 1**. Demographic Characteristics of respondents.

| VARIABLE | MEAN | STD. DEVIATION |
|---|---|---|
| Age | 38.7 | 3.33 |
| Educational level (years) | 6.31 | 0.38 |
| Marital status (Dummy: 1=married, 0=otherwise) | 0.38 | 0.48 |
| Average household size | 5.63 | 3.21 |
| Average land area (Acres) | 4.80 | 0.18 |
| Average household income (weekly) | 20.21 | 2.10 |
| Access to land (Dummy: 1=access, 0=otherwise) | 0.13 | 0.18 |
| Access to labor (Dummy: 1=access, 0=otherwise) | 0.34 | 0.16 |
| Access to capital/credit (Dummy: 1=access, 0=otherwise) | 0.26 | 0.27 |

acres of cowpea, 0.8 acres of peanut, 0.6 acre of Amaranthus sp, 0.4 acres of pepper and 0.2 acre of tomato and does not recommend the production of soybean and mixed cropping by women farmers. In terms of labor allocation, the traditional or the existing plan results show that women farmers allocate 20 man-days, 18 man-days, 16 man-days, 21 man-days, 19 man-days, 7 man-days, 21 man-days and 14 man-days to maize, rice, soybean, cowpea, peanut, amaranthus, pepper and tomato respectively. The optimal solution however, suggests the allocation of 22 man-days for maize, 19 man-days for rice, 21 man-days for cowpea, 15 man-days for peanut, 7 man-days for Amaranthus sp, 18 man-days for pepper and 16 man-days for tomato and does not recommend the allocation of labor to soybean production. With regards to capital allocation, the existing plan results show that women farmers allocate 52 Ghana cedis, 36 Ghana cedis, 24 Ghana cedis, 25 Ghana cedis, 28 Ghana cedis, 10 Ghana cedis, 35 Ghana cedis and 30 Ghana cedis to maize, rice, soybean, cowpea, peanut, amaranthus, pepper and tomato respectively. The optimal solution suggests the

**Table 2.** Comparison of Optimal Plan and Existing Allocation of Land, Labor and Capital.

| Crop Enterprise | Land Allocation | | | | Labor Allocation | | | | Capital Allocation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing plan | optimal plan | % of existing plan | level of utilization | Existing plan | optimal plan | % of existing plan | level of utilization | Existing plan | optimal plan | % of existing plan | level of utilization |
| Maize | 1.1 | 1.4 | 27.3 | under | 20.0 | 22.0 | 10.0 | under | 52.0 | 55.0 | 5.8 | under |
| Rice | 1.2 | 1.0 | -16.7 | over | 18.0 | 19.0 | 5.6 | under | 36.0 | 42.0 | 16.7 | under |
| Soybean | 0.6 | 0.0 | -100.0 | over | 16.0 | 0.0 | -100.0 | over | 24.0 | 0.0 | -100.0 | over |
| Cowpea | 0.4 | 0.1 | -75.0 | over | 21.0 | 21.0 | 0.0 | exact | 25.0 | 20.0 | -20.0 | over |
| Peanut (Groundnut) | 0.5 | 0.8 | 60.0 | under | 19.0 | 15.0 | -21.1 | over | 28.0 | 27.0 | -3.6 | over |
| Amaranthus spp | 0.3 | 0.6 | 100.0 | under | 7.0 | 7.0 | 0.0 | exact | 10.0 | 12.0 | 20.0 | exact |
| Pepper | 0.4 | 0.4 | 0.0 | Exact | 21.0 | 18.0 | -14.3 | over | 35.0 | 21.0 | -40.0 | over |
| Tomato | 0.3 | 0.2 | -33.3 | over | 14.0 | 16.0 | 14.3 | under | 30.0 | 25.0 | -16.7 | over |

allocation of 55 Ghana cedis for maize, 42 Ghana cedis for rice, 20 Ghana cedis for cowpea, 27 Ghana cedis for peanut, 12 Ghana cedis for Amaranthus sp, 21 Ghana cedis for pepper and 25 Ghana cedis for tomato and does not recommend the allocation of any amount of capital to soybean production.

In Table 3, the results show the levels of capital, labor and land utilization between the existing plan and the optimal farm plan. The results show 100% use of the available land by both the existing plan and the optimal plan. The existing plan used up all the capital available (100%) whilst the optimal solution made a savings of GH¢22.00 (9.6%) on capital. On labor use, the existing plan used all the available labor while the optimal plan made a 13% savings on available labor.

The results in Table 4 show total net returns of the optimal solution and the total

**Table 3.** Comparison of Resource Utilization under Optimal Solution with Existing Farming Plan.

| Resource | Existing Plan | Optimal Solution |
|---|---|---|
| **Land** | | |
| Available | 4.8 | 4.8 |
| Usage | 4.8 | 4.8 |
| % Usage | 100% | 100 |
| Unused | 0 | 0% |
| | | |
| **Labor** | 136 | 136 |
| Available | 136 | 118 |
| Usage | 100% | 87% |
| %Usage | 0 | 18 |
| Unused | 0% | 13% |
| %unused | | |
| | | |
| **Capital** | 230.00 (GH¢) | 23000 (GH¢) |
| Available | 230.00 (GH¢) | 20200 (GH¢) |
| Usage | 100% | 88% |
| % Usage | 0 | 22 |
| Unused | 0% | 9.6% |
| % Unused | | |

**Table 4.** comparison of results on total net returns (profit).

| | Total Net Returns (Profit) – GH¢ | | |
|---|---|---|---|
| | **Existing Plan** | **Optimal Plan** | **% change in Profit** |
| | | | |
| Amount | 342.43 | 389.14 | 13.64% |

net returns obtained from the existing plan. The results show that the existing plan realized a net return of GH¢342 whiles the optimal plan yielded a net return of GH¢389. This shows an increase of about 14% in net returns from the use of the optimal plan.

## DISCUSSION

The low average years of education suggests that primary school education is the main educational level majority of the respondents had attained. This low levels of education could be attributed to social and cultural norms such as early marriages which are predominant in the study area and serve as constraints to women with regards to education. The low level of education among women in the study area is confirmed by the 2010 Ghana Statistical Service census report which revealed that only 15% of women between the ages of 15 to 50 years in the northern region have had formal education (GSS, 2010). This results is in consonance with the results obtained by Jeiyol et al (2013) who found out that 52% of female farmers in Benue State in Nigeria had no formal education and no female farmer had attended any tertiary institution. This low level of education among women could hamper their ability to optimally allocate their resources to maximize profit.

The output of this research which suggests poor access to land by women farmers in the northern region is similar to the results obtained by previous research in the Volta region of Ghana by Duncan and Brants (2004), who found that though men and women had access to farmland, their degree of access differed with men often having full access rights to land and women often having partial or conditional access rights to land. The research output of Fofie and Adu (2013) in the Brong-Ahafo region of Ghana substantiate the result of poor access to land by women farmers in Ghana.

Access to agricultural credit or capital, which is very vital in any agricultural enterprise is shown to be generally low among women farmers in the study area. Similar result was obtained by Jeiyol et al (2013) who found that male farmers have more access to credit facilities than the female farmers in Benue State in Nigeria. The lack of many credit sources available to women farmers in the study area could be responsible for this situation. The study area is characterized by inadequate number of credit institutions and the few ones that are present require high collateral levels to provide credit facilities to farmers due to the high risk associated with agricultural production in the study area. Women farmers in the study area usually do not have access to such collaterals and as a result not able to access credit facilities. The long bureaucratic processes and policies adopted by many credit institutions could also be responsible for the low access to credit by women farmers in the study area. A study in the Upper East region of Ghana by Akudugu et al (2009) revealed that forty-nine (49) out of hundred (100) women farmers could not access credit from rural banks due to the savings before credit policy of the rural banks.

The study shows low access to agricultural labor by women farmers. Women farmers in the study area lack the financial capacity to hire labor on their farm and rely mostly on family labor. The level of labor used in agriculture may be affected by farm size and other farm characteristics (Doss, 1999). In Zambia for example, it has been found that as farm size increases, women farmers allocate more labor to agriculture (Kumar 1991). The small land area available to women in the study area serves no motivation to access labor and could be responsible for their low access to labor.

The low income levels among women is attributed to low involvement of women in other off-farm employment. The low income levels among the respondents is substantiated by the 2008 Ghana Living Standards Survey report which showed that females in general earn about 30% less than their male counterparts in all sectors of the economy including agriculture (GLSS-5, 2008). In order to enhance food production and improve food security and income earnings among rural households in the northern region, women's access to and control over land within the context of natural resource management need to be enhanced. This could be achieved by promoting gender equity in access to and control over land and implementing policies to improve the socio-economic status of women in the region.

The results of the study suggest that there is over-allocation of land to rice, soybean, tomato, cowpea and under-allocation of land to maize, peanut and Amaranthus sp. The result also suggests the under-allocation of labor to maize, rice and tomato and under-allocation of capital to maize and rice cultivation. These are as a result of the inefficient allocation of land, labor and capital resources which have been found to be common among farmers especially in developing countries. Similar result was obtained by a previous study in the Fateakwa District of Ghana where farmers were found to be engaged in inefficient allocation of land, labor and capital (Otoo et al, 2015). A study conducted by Majeke and Majeke (2010) in Zimbabwe found similar results of inefficient allocation of resources among commercial farmers. In a study conducted among fish farmers in Uganda, Bukenya et al (2013) found similar results which revealed that small-scale farmers were inefficient in allocating their resources which lead to the over-utilizing labor and gross under-utilization of pond size, feeds and fingerlings.

The optimal crop selection plan used up 88% of capital available to women farmers as compared to the existing crop selection plan which used up all the capital available to the women farmers. The optimal selection plan allowed women farmers to increase their net returns by about 14% higher than the existing plan. A research by Otoo et al (2015) obtained similar results which showed that optimal farm plan resulted in a 16.25% increase in net farm returns among small scale farmers. Similar result was obtained by Majeke and Majeke (2010) who found that an optimal plan saved farmers more than 19% of their capital and provided farmers in Zimbabwe with an opportunity to realize more income from growing wheat, beans, potatoes, cabbages and tomatoes for the 2004 winter season. The 22% unused capital could be invested in other enterprises to increase household income. The results further show that the optimal plan saved women farmers 13% of the labor spent on crop production. This excess labor could be used on other off-farm employment to increase the income levels of households to ensure food security.

## CONCLUSION

This study was undertaken to determine the optimal farm plan that leads to an optimal selection of crops under land, labor and capital constraints to ensure profit maximization from crop production enterprises by women farmers in the Northern region of Ghana by using the linear programming model. The study revealed poor access to agricultural resources such as land among women farmers and also revealed low income levels among women farmers in the northern region of Ghana. The study further revealed that the existing farm plan resulted in an inefficient allocation of land, labor and capital to the various crop production enterprises among women farmers to maximize their crop production profits. Comparison of results obtained by using existing farming plan and the linear programming (LP) model show that the results obtained from the LP Model were significantly superior over the existing farming plan used by the respondents. The LP plan saved 9.6% of capital available to the women farmers. A 13.64% increment in profit was obtained by the LP Model over the existing plan. This

means that women farmers could increase their current net returns from crop production by about 14% if the optimal farm plan is adopted and practiced. These results show the importance of the application of formulated mathematical models like the LP model to planning and management of the limited resources by women farmers in Ghana who constantly face resource access constraints in their effort to increase their food production to ensure food security for their households and their communities.

**ACKNOWLEDGEMENT**

The author wishes to acknowledge the Regional Director of the Ministry of Food and Agriculture in the Northern Region, Mr. William Boakye-Acheampong for his support and making the data available to the researcher. I also wish to acknowledge Eleanor Araba Antwi of the University for Development Studies (UDS), Tamale, Ghana, for proof-reading the manuscript to improve its linguistic quality.

**Conflict of Interest**

The author has not declared any conflict of interest.

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