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Farm Planning for Short-term Optimal Food Crop Combination in the Southwest Region of Cameroon

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Abstract Cameroon's economy is on average agrarian. However, this subsector is plagued by a myriad of challenges with the most prominent one being that of misallocation of scarce resources. This study seeks to establish farm plans that will help food crop farmers efficiently allocate resources and maximise farm returns. Primary data was drawn from 60 farmers in Muyuka subdivision of the Southwest region of Cameroon. Six different food crop combinations were identified. Linear programming was used to formulate the farm problems with land, labour and capital being the constraints. The simplex algorithm, using the LINDO software was used to optimise the various combinations. In the various combinations only one was found to be the optimum combination. This combination includes maize and cassava enterprises. With this combination gross margin is optimized at 370,590 FCFA (US$ 617.65). This leads to an increase of 74,040 FCFA (US$ 123.4) from a non-optimal farm plan. Land and labour were found to be limiting constraints with shadow prices of 280,633 FCFA (US$ 467.7) and 468.5 FCFA (US$ 0.78) respectively. Capital on its part was binding with an associated unused capacity of 29,848.7 FCFA (US$ 49.7). It is recommended that farmers employ prudent method of resource allocation for optimal benefits.

Keywords: *Cameroon, food crops, farm plan, optimum combination*

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1. Introduction

Agriculture has remained a very important sector in the world through the provision of food and raw materials. Agriculture remains the most important sector of economies of African countries providing about 60% of employment. It accounts for about 40% of the continent's foreign earnings through the export of products such as cocoa, coffee and rubber. Over the years the government of Cameroon has been taking some measures to improve the food crop situation of the country. From the launching of the green revolution in 1973, to the policy agenda of second generation agriculture, the country has experienced improvements in food crop production. There has been an increase in the production of roots and tubers as well as an increase in cereal production by 3.7% [1].

Planning which results in optimal farm plans has remained a very important concept in farm production. It helps farmers identify the appropriate enterprises to be grown in the farm and how to efficiently allocate resources among these enterprises. Though farmers in their own simple ways try to allocate resources, they usually end up with suboptimal plans and inefficient of resource use. Through mathematical programming, optimal farm plans can be developed considering the resource constraints. Through this, arable crop farmers can better utilize their resources, increase their productivity and thus poverty will be reduced.

However, growing of food crops is constrained by many challenges. The amount of arable land is fast reducing as most of it is being used for non-agricultural purposes such as infrastructural development. Food crop farmers lack access to finance as their endeavour is considered unpredictable by lenders. This reduces the financial resources of farmers and thus limits their acquisition of inputs such as improved seeds, fertilisers and hired labour. Family labour serves as the main source of farm labour. The scarcity of these resources serves as a challenge to food crop farmers. Also, inadequate extension services and cultural believes of farmers affect the use of farm resources. Even though there is an increase in the scarcity of farm resources, there is an increasing demand in food stuff from the growing population. Cultural factors, inadequate extension services and low level of education of farmers may be the major causes of inefficient resource use. This results in increased cost of production, low productivity of resources, low farm incomes and consequently poverty which reduces farmers' welfare. Amidst these challenges, farmers try to improvise their own local ways of sustaining themselves. It is therefore

imperative that farmers in this area efficiently allocate the few available resources among their farming activities to be able to provide food and generate some revenue. Developing optimal farm plans that will help allocate resources for the farmers is necessary. This will help identify the appropriate enterprises for investment of resources.

This research sought to answer as principal question, what is the optimal cropping pattern for the study area? Hence, the goal is to develop a plausible optimal cropping plan for arable crop farmers that will maximize net returns. The result of this work provides empirical evidence to the situation of food crop farmers in Cameroon. The remainder of this paper is divided as follows: section 2 examines the methods employed. The results and discussion are in section 3. The paper concludes with some recommendations in section 4.

2. Materials and Methods

2.1. Conceptual Framework

Farm planning is a very important facet of agricultural production given the increasing demand for agricultural commodities for food and raw materials, yet the increasing scarcity of resources of production. The solution to these problems is through better farm planning which provides a means by which scarce agricultural resources can be allocated among enterprises. Farm planning problems are much more complex. Farmers do not only produce different crops and livestock, but also must choose among a variety of ways of producing them. Crop farming may involve choices about varieties, planting dates and pesticide treatment [2]. Planning thus consists essentially of a systematic search through all of the possible activity combinations for that combination which best meets the planning objective. This constitutes the optimal plan for the whole-farm system.

Hence, farm planning governs the survival, progress and prosperity of farm organisation in a competitive and dynamic environment. It is continuous and an unending process. It helps farmers make production decisions of what, when, how and for whom to produce. There are basically two types of farm planning: First, simple farm planning which is used when decisions are to be made on the part of a land or only on an enterprise. This is relatively easy to do and the process of change should always begin with simple planning. Second, complete or whole farm planning: this is the planning for the whole farming operation and it is used when decisions concerning the entire farm are to be made.

Whatever the goal of a farmer is, he needs a plan on how to achieve it. In this case a farm plan, which is a process for deciding in the present what to do in the future about the best of combination of crop through rational use of resources is needed. Farm planning does not only involve allocation of resources but also deals with selection of crops or enterprises, total area under cultivation and area for a particular enterprise. Farm planning also involves planning on how to market produce. This is an essential part of farm planning which little attention is given to. Therefore, effective planning should also incorporate timing in which market conditions will be best. Reference [3] analysed the resource allocation pattern for 120 crop farmers in Imo state Nigeria and their results showed a divergence between the existing and optimum farm plans under limited and borrowed capital situations as farm resources were not optimally allocated. They equally found out that increasing the area under cultivation by 2 hectares would result in optimum farm income increasing by N8,099 and N67,521.60 representing 87.94% and 54.18% under limited and borrowed capital situations respectively. The increase in income was as a result of utilizing those resources that were idle when land was a constraint to production.

Three relevant planning methods are available. In increasing order of their relative power, effectiveness and sophistication, but also - if done by hand - in order of their increasing clerical and tedious calculation requirements, these are allocation budgeting, simplified programming and linear programming (LP). All these methods are essentially formalized budget procedures. However, linear programming remains the most used technique in farm planning. Reference [4] showed a cropping pattern different from the farmers existing plan. The results gave a profit whereas the farmer's plan resulted in a loss. Some authors [5] developed an optimized planning model for sugarcane farming using a linear programming tool. The results support the LP model developed as a very useful tool for sugarcane management. Other researchers [6] used LP to develop optimal farm plan for farmers in Bafut sub division of Cameroon with land, labour and capital being the main constraints. He observed that cassava, yam and beans were the appropriate enterprises. This combination brought about an increase in the gross margin of 57,524.9 FCFA (US$ 95.87), about 95% increase in gross margin. He equally noted that capital was the most limiting resource and thus capital of 40,779.5 FCFA (US$ 67.97) was needed to achieve such gross margin.

The linear programming technique is similarly employed for this study. Specifically, the simplex method is used to arrive at optimal solution. Since its invention in 1946 by George Danzig it has been a widely used farm planning tool. Also, the by-products of the simplex tableau provide useful information such as shadow prices which also play a key role in decision making about resource acquisition. To be able to use this model, the assumptions of additivity, proportionality, divisibility and determinism are considered. In developing the matrix needed for this work, valuable information needed are resource requirements, output prices and available capacities of resources. This model works on the assumption that all farmers at least sell some quantity of their produce and thus the objective of the farmer is to maximise profit. For instance, [7] developed an LP model to determine the Optimum enterprise combination using data in Abia state, Nigeria. Their model incorporated constraints such as food consumption. The objective of the model was to maximize the gross margin of farmers involved in a combination of selected arable crops and fisheries. Out of the twelve production activities made up of ten cropping activities and two fishery enterprises, only two were recommended by the model for farmers which would help them achieve a gross income of 342,763.30 naira. They argued that this will attain food security in the area as well as the country at large.

More often than not, more than one crop enterprise is found in a farm. African food crop farming is typically characterized by this. There are several reasons why farmers combine such enterprises. Some products on their part tend to result by default from the production of another enterprise. For example, the production of beef results automatically to the production of hide. This combination however is not planned by the farmer. On the other hand, farmers voluntarily combine enterprises. Reference [8] used linear programming to determine optimal farm plan to evaluate food security status of farming households. They observed that the production of cassava, maize /cowpea, benniseed and groundnut/yam enterprises at 0.64, 0.34, 0.35 and 0.22 hectares respectively would yield a return of 141,692 89 naira. They further discovered that maize, cassava and yam are the food security crops.

Similarly, [9] used linear programming to determine the optimal crop combination of a rural farmer in Zimbabwe. They realized the farmer was producing sub-optimally. Their model produced an optimal crop combination of maize, soybean and cotton and this gives higher income than that obtained from the farmer's plan.

In Nigeria, [10] applied LP technique to farm data obtained from thirty arable crop farmers in Abia state. The objective was to maximize gross margin from various combinations of arable crops and livestock enterprises. The developed plan was more profitable than the existing plan as there was an improvement of the gross margin by 61.35%. To achieve this, a farmer had to allocate 0.31hectare for yam/maize/melon, 0.33hectare to cassava/maize/cocoyam and 1.30hectares to yam/maize/melon with 0.14 of 500 birds of broiler 1 raised usually between January to May, 0.11 of 1000 fish of fish 2 done between July to December and 0.07 of 15 pigs be produced. Similarly, [11] determined an optimal enterprise combination for vegetable production under Fadama in North Central Nigeria. The model considered both economic and environmental goals simultaneously in a composite objective function. The optimal plan obtained achieved 88% of its goals. They concluded that increasing the area of land for vegetable cultivation would increase production. They further recommended that policies that will increase access to land should be put in place.

2.2. Study Area

This study was undertaken in Muyuka. Muyuka subdivision is found in Fako division of the southwest region of Cameroon. It is located at latitude 4.72°N and 9.64°E and some 31km from Buea the regional capital. The climate of this area is humid tropical. Temperatures range from 22°C to 32°C. The predominant vegetation is both primary and secondary forests. Both arable crops and field crops are cultivated in this area. The main arable crops are maize, melon, groundnut, cassava, cocoyam, yam and potato. These crops are mostly grown by women on small farms of average size being 1ha. The motive for production of such crops is for household consumption while surpluses are sold to cater for other needs. These crops are usually grown on a mixed cropping farming system.

2.3. Nature and Source of Data

Data for this research is primary data collected directly from the farmers. A cross section of the farmers was sampled. The sub-division was stratified into three strata. Each stratum consisted of six villages. Two villages were randomly selected from each stratum making a total of six villages. Ten farmers were randomly selected from each village and thus sixty farmers were sampled. The research instrument was questionnaire.

The variables analysed in this study include total crop output, total variable cost of farming operations and gross margins. The analytical techniques employed in this study are descriptive statistics, inferential statistics, farm budgeting analysis and linear programming. Only three constraints are considered, and they are land, labour and capital. Labour is measured in man-days while land is measured in square metres. Capital on its part is measured in Francs CFA (FCFA). The exchange rate was 1US$ = 600 FCFA. The simplex method was employed to obtain the optimal solution. Descriptive statistics are used for the socioeconomic information of the farmers. Inferential statistics are used to establish the relationship between gross margins, economic profit and compare the various enterprise combinations. The return on investment is equally computed. The Return on Investment (ROI) of the farmers is used to assess the crop enterprise combinations in the entire cropping system in the study area. The return on investment is a measure of the profitability of invested capital. It is the ratio of net income to the invested capital in the farm business.

3. Results and Discussion

3.1. Biographic Information of Food Crop Farmers

Males make up 31.6% of the farmers. This could be attributed to the perception that food crop farming is for females while the males are concerned with perennial crop farming. The results reveal that the old constitute most of food crop farmers. About 6.6% of the farmers are between 25-34 years while 18.3% and 75.1% of them are between 34-45 years and 46-51 years respectively. The average age of the farmers contacted is 45 years. This age justifies the low productivity of farmers as at this age, the strength (workforce) of the farmers is reduced. Also, most of them tend to be adamant to change and thus stick to their old techniques of crop production. The results are a clear indication that agriculture is still dominated by the elderly. The youthful populace migrates to urban centres where they are involved in non-farming activities and only see agriculture as a last resort. With the elderly being involved in agriculture, productivity remains low because of cultural factors and reluctance to adopt modern technologies.

Food crop farming is dominated by married people. Married people makeup 65% of the total farmers studied. About 10% of the farmers are single while 25% of them are widowed. Most of the married people are involved in arable crop farming mainly for semi subsistence motives of meeting household food needs and selling surpluses.

The couple alongside their children constitute the main source of farm labour.

From the results obtained, about 13% of the farmers had no formal education. Primary education is dominant in this area as it accounts for 58.3% of farmers sampled. About 21.7% of the farmers had attended secondary education while just 6.7% of them had attended a university. With no formal education and primary education dominating, cultural practices with respect to crops grown and techniques used is prevalent. It affects the rate of adoption of better techniques. Most farmers have been into arable crop farming for a very long period, cultivating these crops for an average period of 20 years. This justifies the effect of cultural factors on arable crop farming in this area.

3.2. Access to Resources in Food Crop Farms

Land is a crucial resource for agricultural endeavour. Food crop farming is not an exception as the type and nature of land affects output. Land tenure system also affects production decisions. Farmers in this area have four major ways of acquiring land; inheritance, purchase, rent and a combination of purchase and rent. About 21.7% of the farmers acquire land through inheritance and 5% of the farmers owned the land they were cultivating through its purchase. Rents account for 56.7% of farmers' land acquisition. Some farmers rent land to supplement either purchased or inherited land. This accounts for 13.3% of land acquisition. Through these various means, farmers acquired more than one piece of land and most of them do cultivate more than a plot of land at a season. With such dispersion of farmlands, the farmers do not concentrate their efforts. Machinery cannot be employed for such small and scattered pieces of land. All these affect farmers' productivity. With such constraints, farmers try to maximize the returns of the land by combining several enterprises on the same plot.

Farm sizes range from 0.5ha to 3ha. The average farm size in this area is 1ha. About 46.7% of farms have sizes between 0-1ha, 30% of farms are between1.1-2ha while farm sizes above 2ha makeup 23.3% of farms. Labour alongside land are the major production resources. The source and use of labour is primordial to the attainment of the farmers' goals. From the data collected, it is realized that there are three main sources of labour; family, hired and a combination of hired and family labour. About 21.7% of the farmers depend solely on family labour while only 6.7% of the farmers depend solely on hired labour. Most farmers depend on a combination of family and hired labour for their labour needs. About 71.6% of farmers depend on such source. Farmers, especially female ones only require hired labour for activities such as clearing. Averagely a farmer spends 4 days of the week in the farm. Organization of farmers into rotating-savings groups is another source of labour. However, this source is seldom used. There is division of labour between the men and women. Men are involved in activities such as clearing and transportation of produce. Women on their part are involved in activities such as planting, weeding, and harvesting.

Most farmers in this area use mainly unimproved seeds for production. There are three means by which they get planting material: purchasing from market, stored material from previous season's harvest and gift from friends and relatives. About 60% of the farmers get their seeds from previous season's harvest, 22% of them buy their seeds while 18% of them get seeds from friends and relatives. The use of previous season's seeds is dominant especially with crops like cassava and cocoyam. The use of such seeds which are usually less vigorous and have lost some of their agronomic properties are to some extent responsible for the low outputs.

It is further observed that there are two ways through which farmers sell their produce. Some sell at their homestead while others carry the produce to the market. About 80% of the farmers sell their produce at the market, while the remaining 20% sell at their houses. There are different means through which farmers carry their produce to the market. Motor bike is the main means of transporting produce to the market. About 83.3% of the farmers use motorbikes to transport produce to the market. 14% of the farmers use cars, while 2.7% of the farmers use head-portage to transport produce to the market. The main market in this area is the Muyuka market.

This study reveals that the main motive for combining such varieties of crops is to meet household food needs. However, surpluses are usually marketed. The surpluses sold generate income to buy other household needs such as soap, cooking oil, salt and clothing. Given the importance of extension services in agricultural development, it is important that farmers have access to extension services. From this study, it is revealed that only 14 of the 60 farmers get extension advices. This constitutes 24% of the farmers sampled. Even though these few have access to extension services, extension advice is directed towards improve production through use of improved seeds and phyto-sanitary products with no attention given to efficiency of resource use.

The average family size of Cameroon's farmers is 5persons. Family sizes ranging between 1-4 persons make up 43.3% of the farming families whilst 50% of family sizes are between 5-8persons. Family sizes above 8persons makeup 6.7% of the farming families. With such family sizes there is household labour to support farming from production to marketing. Through production of food crops, such family sizes can equally be sustained. There are other income generating activities besides farming that help sustain the farmers in this area. Some farmers have other income generating activities such as petty trading, building construction and commercial motorbike riding. However, only 35% of the farmers have other sources of income. The remaining 65% depend solely on farming as a source of livelihood.

3.3. Farm Enterprise Combination in Food Crop Farms

The major food crops cultivated are maize, melon (*egusi*), groundnut, yams, cocoyam and sweet potato. It is observed that all the farmers grow cassava as it is the major cash crop and found in all enterprise combinations. About 98% of the farmers grow maize. It is mostly cultivated for home consumption. Almost 89.9% of the farmers grow groundnut to supplement their diet. About 63.3% of the farmers grow melon. Only 12% of the

farmers grow potatoes. Another 3% of the farmers grow yams. These crops are grown in different combinations by different farmers according to their needs.

The major cropping system is mixed cropping. This is due to cultural factors and land constraint. This study reveals that an average of four crops is grown on the same piece of land. About 90% of the farmers grew four crops averagely, 5% grow three crops on the same piece of land; while the remaining 5% of the farmers cultivated an average of five crops on their farmlands.

For the different enterprise combinations in this area, this study revealed that 28.3% of the farmers had a combination of maize, cassava, groundnut and melon, 30% of the farmers grow maize, cocoyam, cassava and melon, 26% of the farmers have as crop combinations maize, cocoyam, cassava and groundnut and about 8.3% of the farmers grow cocoyam, cassava, groundnut and melon. Farmers who grow maize, cassava, groundnut and potato make up 8.3% of the farmers. The least practiced combination is maize, yam, cassava and groundnut as only about 6.7%of the farmers are involved in such combinations. As earlier noted, the selection of these enterprise combinations is in line with household food needs and the income requirement of the family. Land also serves as a major determinant of enterprise combinations. Table 1 shows the various enterprise combinations in this area.

Table 1. Various Enterprise Combinations

Enterprise Combinations	Frequency	Percentages
Maize, cocoyam, cassava, groundnut	16	26.7
Maize, cocoyam, cassava, melon	18	30
Maize, cassava, groundnut, melon	17	28.3
Cocoyam, cassava, groundnut, melon	5	8.3
Maize, cassava, groundnut, potato	5	8.3
Maize, yam, cassava, groundnut	4	6.7
Total	65*	109*

Note: *Farmers cultivate more than one combination at a time
Source: Field Survey (2017)

Farmers are plagued by a variety of challenges. About 93.3% of the farmers complained of lack of finance and poor road infrastructure as major challenges to farming. Pests and diseases are also a major challenge to farmers as 86.6% of the farmers are challenged by this. 88.3% of farmers complained of climate change as their main challenge. Due to this, they cannot properly plan their farm operations. Little government support and fluctuation of prices of produce remains a major challenge to the farmers. Inaccessibility to extension services are another challenge to farmers. Even to those who have access to extension services, the extension services are not readily available and thus when their services are needed, they are not available. From the results of this study, there is no use of machines in food crop farming in this area. It was equally realized that only about 1% of the farmers use chemicals (pesticides and inorganic fertilisers). Crop rotation is the main method of maintaining soil fertility and controlling diseases. The farmers are reluctant to invest in soil fertility activities due to the uncertainty in access to land.

3.4. Profitability of Crop Enterprise Combinations

The various combinations have different gross margins. The gross margin of combining maize, cocoyam, cassava and groundnut is 263,070.4 FCFA (US$ 438.45) while that of the combination of maize, cocoyam, cassava and melon is 301,475.3 FCFA (US$ 502.46). It is the most profitable enterprise combination, and this justifies why it is the most cultivated enterprise. About 293,647 FCFA (US$ 489.41) is the gross margin of the combination of maize, cassava, groundnut and melon. The gross margin for the combination cocoyam, cassava, groundnut and melon is 264,450 FCFA (US$ 440.75) while that of combining maize, cassava, groundnut and potato is 286,147.2 FCFA (US$ 476.91). It is the least profitable combination. In addition, the gross margin of the combination maize, yam, cassava and groundnut is 296,549.5 FCFA (US$ 494.25). These enterprise combinations are presented below.

3.5. Optimal Feasible Combinations

Combination of Maize, Cocoyam, Cassava and Groundnut Enterprises (C_1): By following the algorithm of linear programming, the contributions of the various enterprises and the available resource quality were used to develop the model. The constraints identified are land, labour and capital. Land is expressed in hectares while labour and capital are expressed in man-days and FCFA respectively. X_1, X_2, X_3 and X_4 represent output of maize, cocoyam, cassava and groundnut respectively.

Maximise:

$$Z_1 = 362156.6X_1 + 228832.3X_2 + 379023.5X_3 + 221407.4X_4$$

Subject to

Land: $X_1 + X_2 + X_3 + X_4 \leq 1$

Labour: $174X_1 + 200X_2 + 210X_3 + 190X_4 \leq 192$

Capital: $191283.4X_1 + 209928.9X_2 + 207739.3X_3 + 205650.4X_4 \leq 229360.1$.

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$

Here, maize and cassava enterprises appear at the optimum plan. Therefore, these enterprises should be given priority by the farmer. By cultivating these enterprises, the gross margin generated will be 370,590 FCFA (US$617.6). Before optimization, this combination yielded a gross margin of 297,854.8 FCFA (US$496.4). By giving priority to this enterprise, the gross margin is increased by 90,735.2 FCFA (US$151.2). Land and labour happen to be the binding constraints with shadow prices of 280,633.2 FCFA (US$467.7) and 468.5 FCFA (US$0.78) respectively. This implies that a hectare increase in land will lead to an increase in gross margin by 280,633.18 FCFA (US$467.7) and a unit increase in labour will increase the gross margin by 468.5 FCFA (US$468.5).

Combination of Maize, Cocoyam, Cassava and Melon Enterprises (C_2): The contributions of the various enterprises are found in the objective function. The constraints include land, labour and capital; X_1, X_2, X_3 and

X_4, represent output of maize, cocoyam, cassava and melon respectively. The model is presented as;
Maximise:

$$Z_2 = 362156.6X_1 + 228832.3X_2 + 379023.5X_3 + 374669.7X_4$$

Subject to

Land: $X_1 + X_2 + X_3 + X_4 \leq 1$
Labour: $174X_1 + 200X_2 + 210X_3 + 205X_4 \leq 192$
Capital: $191283.4X_1 + 207739.3X_2 + 205650.4X_3 + 198300X_4 \leq 229360.1$

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$.

For this combination, two crops appear at optimum; X_1 and X_3 which represent maize and cassava respectively. The farmer should therefore produce only these two enterprises which will generate a gross margin of 370,590 FCFA (US$ 617.7). However, before optimization, the gross margin of the combination was 336,170.5 FCFA (US$560.3).By producing these enterprises, the gross margin is increased by 34419.5 FCFA (US$55.7). Land and labour are the limiting constraints with shadow prices of 280,633.2 FCFA (US$467.7) and 468.5FCFA (US$0.78) respectively. Therefore increasing land by one hectare will increase gross margin by 280,633.2FCFA (US$ 467.7) while increasing labour by one man-day will lead to 468.5 FCFA(US$0.78) increase in gross margin.

Combination of Maize, Cassava, Groundnut and Melon Enterprises (C3): Given gross margin and land, labour and capital as constraints, whereby ha, man-days and FCFA are their units of measurement respectively. Here, X_1, X_2, X_3 and X_4 represent maize, cassava, groundnut and melon respectively. The model is formulated as:
Maximise:

$$Z_3 = 228832.3X_1 + 379023.5X_2 + 221407.4X_3 + 374669.7X_4$$

Subject to

Land : $X_1 + X_2 + X_3 + X_4 \leq 1$
Labour : $174X_1 + 210X_2 + 190X_3 + 205X_4 \leq 192$
Capital : $191283.4X_1 + 207739.3X_2 + 205650.4X_3 + 2010500X_4 \leq 229360.1$

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$

Here, maize and cassava(X_1 and X_2) should be given priority. At optimum, this enterprise alone yields a gross margin of 370590.0 FCFA (US$ 617.7).This generates an increase in gross margin of 69,606.8 FCFA (US$ 116.0) as before optimization the gross margin was 300,983.2 FCFA (US$ 501.6). Land and labour are limiting and their corresponding shadow prices are 280,633.2 FCFA (US$467.7) and 468.5 FCFA (US$0.78), respectively.

Combination of Cocoyam, Cassava, Groundnut and Melon Enterprises (C_4): Given the gross margin and considering land, labour and capital as constraints; Here, X_1, X_2, X_3 and X_4 represent cocoyam, cassava, groundnut and melon, respectively. The model is presented mathematically as:
Maximise:

$$Z_4 = 228832.3X_1 + 379023.5X_2 + 221407.4X_3 + 374669.7X_4$$

Subject to

Land: $X_1 + X_2 + X_3 + X_4 \leq 1$
Labour: $200X_1 + 210X_2 + 190X_3 + 205X_4 \leq 192$
Capital: $209928.9X_1 + 207739.3X_2 + 205650.4X_3 + 2010500X_4 \leq 229360.1$

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$.

Here X_2 and X_4 enterprises which represent cassava and melon appear at optimum. The two enterprises should be produced as they will generate a gross margin of 346,637.6 FCFA (US$ 577.7). Before optimization, this combination generated a gross margin of 300,983.1 FCFA (US$ 501.6). By producing these enterprises, the gross margin is improved by 45,654.4 FCFA (US$ 76.1). Labour and capital are binding and their corresponding shadow prices are 1,802.3 FCFA (US$ 3.0) and 0.0025 FCFA, respectively. Therefore relaxing labour by one man day will lead to 1802.3 FCFA (US$3.0) increase in gross margin while a unit increase in capital will increase gross margin by 0.0025 FCFA.

Combination of Maize, Cassava, Groundnut and Potato Enterprises (C_5): Here, X_1, X_2, $X_3$and X_4represent output of maize, cassava, groundnut and potato respectively. Land, labour and capital are the constraints and they are measured in hectares, man-days and FCFA respectively. The model is presented mathematically as:
Maximise:

$$Z_5 = 362156.6X_1 + 379023.5X_2 + 221407.4X_3 + 207281.9X_4$$

Subject to

Land: $X_1 + X_2 + X_3 + X_4 \leq 1$
Labour: $174X_1 + 210X_2 + 190X_3 + 200X_4 \leq 192$
Capital: $191283.4X_1 + 207739.3X_2 + 205650.4X_3 + 198300X_4 \leq 229360.1$

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$.

Here, the maize and cassava enterprises (X_1andX_2) appear at optimum. These enterprises should be given priority as they will generate a gross margin of 370,590.0 FCFA (US$ 617.7). Before optimisation, the entire combination yielded a gross margin of 292,467.3 FCFA (US$ 487.4). Therefore by cultivating these enterprises, the gross margin increases by 78,122.6 FCFA (US$130.2). Land and labour are binding and their dual prices are 280,633.2 FCFA (US$ 467.7) and 468.5FCFA (US$ 0.78) respectively.

***Combination of Maize, Yam, Cassava and Groundnut Enterprises* (C_6):** Given gross margins and considering land, labour and capital as constraints, the model is presented mathematically as follows:
Maximise:

$$Z_6 = 362156.6X_1 + 234268X_2 + 379023.5X_3 + 221407.4X_4$$

Subject to

Land: $X_1 + X_2 + X_3 + X_4 \leq 1$
Labour: $174X_1 + 208X_2 + 210X_3 + 190X_4 \leq 192$
Capital: $191283.4X_1 + 274200X_2 + 207739.3X_3 + 205650.4X_4 \leq 229360.1$

Non-negativity: $X_1, X_2, X_3, X_4 \geq 0$

The enterprises X_1 and X_3 which are maize and cassava appear at optimum. The cultivation of these enterprises

generates a gross margin of 370,590.0 FCFA (US$ 617.7) which is higher than that of the entire combination before optimisation which is 299,213.9 FCFA (US$ 498.7).There is an increase in gross margin of 71,376.1 FCFA (US$119).The binding constraints are land and labour with associated shadow prices being 280,633.1FCFA (US$ 467.7) and 468.5 FCFA (US$ 0.78).

Optimal Farm Plan for Food Crop in study area: Given the gross margin and considering the various resources; land, labour and capital which are the constraints, the model for all combinations in the study area is presented below;

Maximise;

$$Z = 362156.6X_1 + 379023.5X_2 + 374669.7X_3.$$

Subject to

Land: $X_1 + X_2 + X_3 \leq 1$

Labour: $174X_1 + 210X_2 + 205X_3 \leq 192$

Capital: $191283.4X_1 + 207739.3X_2 + 201500X_3 \leq 229360.1.$

Non-negativity: $X_1, X_2, X_3 \geq 0.$

For farmers in this area to maximise gross margins, they should produce X_1 and X_2; maize and cassava as they are the ones that appear at optimum. These two enterprises will generate a gross margin of 370,590.0FCFA (US$ 617.7). Farmers in this area should therefore cultivate this combination. Before optimisation, this combination yielded a gross margin of 296,549.5 FCFA (US$ 494.2). There is therefore an increase in the gross margin by 74,040 FCFA (US$123.4) per hectare. Land is the major determinant of food crop farming in this area and it is thus limiting and has a corresponding shadow price of 280,633.2 FCFA (US$ 467.7). This implies that even though land is a major determinant of food crop farming in this area, it is very scarce. Therefore, a unit increase in the amount of land by one hectare will increase gross margin by 280,633.1 FCFA (US$ 467.7). More land should therefore be made available to farmers which when combined with the excess labour and capital may boost farm production in this area. Labour is also a binding constraint and its shadow price is 468.5 FCFA (US$ 0.78).Capital is a non-binding constraint and its unused capacity is 29,848.7 FCFA (US$ 49.7).

Table 2. Optimal tableau for Optimal Enterprise Combination for the study area

S.V	S_1	S_2	X_3	Y
X1	5	-0.02	0.14	0.50
X2	-4.83	0.03	0.86	0.50
S3	-0.13	0.86	0.18e7	29848.7
Z	280633.2	468.5	0	370590.0
Source: Computed from field survey (2017)				

4. Conclusion

Food crop farming is a vital subsector for an agrarian economy like that of Cameroon. It provides a double advantage of provision of food for the household and equally a source of income. Moreover, it acts as a major source of livelihood to the rural people, especially women. Given the multiple advantages of this subsector, it is plagued by a myriad of challenges with the most prominent of them being that of inefficiently allocating resources. Farmers in Cameroon are indifferent to these challenges. This study attempts to provide a solution to this problem. The study applies economic principles of resource allocation and use to develop an optimal farm plan for farmers in this area. It further identifies the various crop combinations to be cultivated in this area. With the results of this work, farmers' limited resources can be efficiently allocated and this may lead to an increase in productivity, reduction in the cost of production, increase in farmers' income and consequently a reduction in poverty. The study revealed that land and labour were the most limiting resources and therefore improving the access to these resources will boost food crop production in this area. It was revealed that the optimal combination that will maximise returns for the farmer is maize and cassava. The results have policy implication which will improve the subsector and make the stakeholders better off. If this subsector is to be improved, then farmers should combine maize and cassava as these will maximise the returns from their farm with rigorous training of extension agents who will guide farmers to better allocate resources. In addition, farmers' agricultural literacy rate should be improved. This can be done formally and informally. This will create awareness to farmers on efficient use of resources as well as encourage farmers to change some of their cultural practices and adopt better farming techniques. The government should make available financial support to farmers. This will help farmers acquire inputs such as improved seeds, fertilisers and hired labour to supplement family labour. The land tenure system in this area should be reviewed. Since land is the most limiting constraint in this area, if farmers have more access to land, their production could increase. Most importantly, farmers should change some of their cultural practices such as their choice of crops to be grown.

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