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Gross Margin Analysis of Irrigated Beans: A Case of Khosolo Extension Planning Area

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Abstract

Common beans are important food and cash crop in developing countries like Malawi. Khosolo EPA is well known for growing beans. However, productivity of beans is still low and far below potential hugely impacting profitability. The study conducted a gross margin analysis of irrigated bean production and assessed factors affecting its profitability in the EPA. Sampling was done on two stages: First, lists of farmers from Lupanda Producers and Marketing Cooperative and Kholoso EPA extension offices as sampling units was obtained. Secondly, random sampling was employed from where 60 cooperative smallholder farmers and 60 non-members farmers were drawn. Primary data on social economic characteristics, variable costs, crop output and sales were collected using semi-structured questionnaires through face to face interviews. Gross margin as a proxy of profitability was analyzed using Gross Margin Analysis method. Binary logistic regression analysis method was used to analyses factors affecting bean profitability in the EPA. The results showed that irrigated bean production is profitable in Khosolo EPA at above 60%. The level of profitability varied with non-members earning more than cooperative members. Farm size, variable costs, gross income and fertilizer application were significant influencers of bean profitability in the EPA. The study has provided empirical evidence that increasing bean profitability in the EPA requires increasing farm sizes, applying recommended fertilizers at the right calibrations to enhance productivity to the potential level and revamping extension services and training for effective extension delivery that will lead to adoption of new technologies. The study also points to the need for involvement of private sector businesses to increase availability of inputs and high value markets for beans.

Keywords: Cooperative members; Non-members; Profitability; Smallholder farmers

Introduction

Common beans (*Phaseolus vulgaris* L.) play significant roles in smallholder farmers' livelihoods. From a farmer's point of view, integration of beans in the farm enhances soil fertility and increases the amount and stability of household income streams [1]. On the consumption side, beans are the cheapest source of protein in a vegetarian's diet and supplement mineral and vitamin requirements [2]. However, bean production in Sub Saharan Africa (SSA) Malawi included is very low due to poor soil fertility and incidences of pest and diseases [3]. Zulu [4], states that the yields of beans in much of Africa are low (typically less than 1 ton/ha) despite their economic and food security importance. Mutegi and Zingore [5] noted that the average bean yields have stagnated to about 0.7-ton ha^{-1} against 3 tons ha^{-1} resulting into increased food insecurity in most parts of SSA. The situation is compounded by inadequate access to farm support services and insufficient attention by researchers to multi-functionality of beans as a crop [2]. In 2010, the National Smallholder Farmers Association of Malawi (NASFAM) introduced a bean promotion programme aimed at addressing declining productivity of beans in Kholololo Extension.

Extension Planning Area (EPA) [6] for such initiatives to succeed, the beneficiaries must fully contextualize the technologies within their farming systems and resource limits, accept and own them, especially when they are introduced by external organizations [7]. However, no empirical study has examined farmers' opinions on the profitability of the bean varieties introduced and the factors that affect such profitability.

Previous studies on beans have focused on agronomic issues such as effects to soil fertility and yield improvement by breeding [3]. However, agronomic results alone do not provide complete picture when assessing a given technology [2]. More insights from economic analysis are essential to enable comprehensive evaluation of bean profitability [8]. Also, other aspects concerning beans such as farmers' production objectives, markets and factors affecting profitability are of paramount importance [3]. It is against this background that the present study sought to conduct gross margin analysis of beans and investigate factors that explain the level of profits generated in Khosolo EPA.

Materials and Methods

Area of study

The study was undertaken at Khosolo EPA in Mzimba District in the Northern Region of Malawi. With 10.878 sq. km, the district is located at latitude 110 30' 00" and longitude 330 30' 00" with an altitude of 1362 covering an area of 10,382 km^2 and has a population of 610,944. Khosolo EPA lies in Eastern side of Mzimba with geographical coordinates of latitude: 12.4167°S and longitude: 33.7833°E. Smallholder farming covers 13,940 hectors of land. The EPA has two growing seasons; rainy season between November and March and irrigation between April and July. Climate change, however is gradually beginning to take toll in the EPA. Signs of this include

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unusually heavy rainfall, rise in temperature, drying of wetland areas and change in rainfall patterns among others.

Due to its unique geographical position, the EPA has favorable conditions for large number of crops including maize, Irish potatoes, sweet potatoes, tobacco, cassava, coffee, and beans. The EPA was selected for the study because almost all households grow maize and beans [7].

Sampling and data collection

Sampling was done at two categories: Category one was obtaining a list of smallholder farmers (320) that are members of Lupanda Cooperative. Category two was obtaining a list of 400 smallholder farmers that grow beans on irrigation system but are not members of the cooperative from the EPA offices. Purposive sampling was applied to select sub sections where farmers grow their beans. Out of the seven sub-sections of the EPA, five sections of Kabiza, Khosolo A, Khosolo B, Msese A, and Msese B were purposively selected because of having high number of irrigated bean farms. Lastly, random sample of 60 smallholder farmers from each frame were selected through probability proportionate to size sampling technique. A total of 120 farmers were selected and interviewed.

Primary data was collected through face-to-face interviews during the irrigation season in 2017. Face-to-face interviews guarantee high response rates besides enabling clarification of survey questions in interviews [9]. Semi-structured questionnaires used in the survey captured information on input costs, yields per acre, market price and data on socioeconomic characteristics.

Empirical model estimation

Gross margin analysis and binary logistic regression model [10] were used in the analysis. Gross margin was used as a proxy for bean profitability. In analyzing farm profitability, gross margin has been suggested as the best method due to its simplicity and accuracy [11]. It serves as the unit of analysis in evaluating the economic performance of an enterprise and gives an indicator of the feasibility of an enterprise and its potential contributing to household income [12]. Gross margins are usually computed per year or per cropping season [4]. The gross margins were computed as the difference between total revenues and total variable costs as per equation 1 below:

$GM_i = TR_i - TVC_i$ (1)

Where, GM=Gross Margin, TR=Total (gross) Revenue, TVC=Total Variable Cost, For i=0,1 either the cooperative member farmers or the non-member farmers.

Data on factors affecting profitability of beans in Khosolo EPA was entered and analyzed using Statistical Package for Social Scientists (SPSS version 19). The binary logistic regression model was used for predicting the probability of a variable affecting profitability by fitting all the data to a logistic function [13]. Similar to other forms of regression analysis, the study used predictor variables that were either numerical or categorical in its analysis. This model was considered because of its ability to describe and test hypotheses about relationships between categorical outcome variable and one or more categorical predictor variables [14]. According to Agresti [15], logistic regression model solves the problems by applying the logit transformation to the dependent variable. It therefore predicts the logit of Y from X variables.

The realized gross margin as a dependent variable (Y) was dichotomized with the value of (0) if the farmer did not make profits and (1) if the farmer made profits. Fourteen predictor independent variables were regressed against a binary dependent variable of profitability. The model as specified in equation 2 was used to assess factors affecting profits accruing to bean producers in Khosolo EPA. All the parameters were estimated using Wald Criterion (W-C) method in SPSS version 19 in Microsoft Windows 13.

Xi	Variable	Code used
Y	Bean profitability	1=positive, 0=negative
X1	House Head sex	1=male, 0=female
X2	House Hold Age	Categorical (years)
X3	Marital Status	1=Married, 0=Single
X4	Literacy	1=Literate, 0=Illiterate
X5	Gross income	Categorical (amount)
X6	Experience	Categorical (years in bean farming)
X7	Farm size	Categorical (land in acres)
X8	Extension services	1=received, 0=did not receive
X9	Seed used	1=improved, 0=saved from previous
X10	Fertilizer	1=applied, 0=did not apply
X11	Labor	1=Household, 0=hired
X12	Total Variable Costs	Categorical (amount in MK)
X13	Farmer type	1=Cooperative, 0=Non-cooperative
X14	Total harvest	Categorical (Value in MK)

Table 1: Description of variables in the model.

Therefore, the model with multiple predictors was specified as follows:

$$Logit(y) = Ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 ... \beta_{14} x_{14} ....Equation\ 2$$

Where, Logit (P)=the natural log of the odds of success, the X's are the explanatory variables (X1 House head sex, X2 House hold age, X3 Marital status, X4 Literacy, X5 Gross income, X6 Experience in bean farming, X7 Farm size, X8 Extension services, X9 Seed used, X10 Fertilizer application, X11 type of labor used, X12 Total Variable Costs, X13 Farmer type, and X14 Total harvest realized (Table 1). All the explanatory variables were regressed against the gross margin obtained for each smallholder farmer.

Results

Descriptive analysis for irrigated bean farmers

The study sampled 120 irrigation-based farming households. Among the interviewed farmers, 84.2% were male and 15.8% were female. 78.2% were married and 86.5% of farmers were aged between 35-60 years with their average being 44 years similar to the findings of Venance et al. [16]. The average household size is at 5.65 just below the national average at 6.0 [6]. Based on Malawian education system, 61%

of the farmers had primary school education hence considered as literate. The average farm size was 1 acre with the lowest being 0.5 of an acre. Table 2 also shows that average farming experience was 15 years and that young people started to engage in irrigation farming as early as 22 years of age just as was the case with the findings of Samboko [17].

Variable	Mean	Std. Deviation
Age of farmer	44.33	11.75
Farming experience	15.39	11.031
Farm size in acres	1.231	1.1475
Average Household size	5.65	2.044
Level of Education (% literacy level)	61	0.49
Land ownership (%)	77	0.425
Extension services received (%)	0.07	0.25
Source of seed from shops (%)	0.33	0.473
Fertilizer applied	0.21	0.408
Hired Labor Used	0.5	0.502
Sex of respondent (%)	0.76	0.402
Marital status (%)	0.78	0.414

Table 2: Description of smallholder farmers' socio-economic characteristics.

The results also show that 77% of the irrigated land was owned by the sampled smallholder farmers with 33% of the farmers renting their land from other members in the villages. The findings indicate that only 7% of the smallholder farmers received extension services in the entire irrigation farming season. This is in line with the findings of Takusewanya et al. [18] which found that most of the extension officers disregard irrigation farming when providing services. 66.7% of the farmers used seed reserved from previous harvest as compared to 33.3% that used seed bought from shops. The adoption of new farming methods especially application of chemical fertilizers and spraying of other chemicals in irrigated bean production showed to be slow at only 20.8%. Finally, the study shows that household and hired labor was equally used at 50%.

Gross margins

The results of the gross margin analysis for irrigated bean broken by cooperative and non-member farmers for the entire season are shown in Table 3 below.

The results of the study show that irrigated bean farming recorded positive average gross margins for both members of the cooperative and non-members. These results are similar to the findings of Mogedi [19] who found that 67% of bean producing farmers received profits from their farm. Comparatively, the results show cooperative members having high average production costs (MK84, 319.33) per acre against MK71, 245.33 per acre for non-members, high average gross income (MK89, 374.17) against MK78, 368.33 for non-members. Interestingly, the results show that members of cooperative received less average gross margin (MK5, 054.83) per acre compared to non-members who received MK7, 123.00 in average gross margin per acre.

Variable	Cooperative members (MK)	Non-members (MK)
Land	13,453.33	9,268.33
Land clearing	7,808.33	7,317.50
Tilling	9,628.33	9,785.00
Digging	5,650.00	3,925.00
Equipment	380	373.33
Levelling	7,975.00	7,558.33
Cost of seed	2,366.83	2,565.00
Planting	5,291.67	5,641.67
Fertilizer cost	4,473.33	3,156.17
Weeding	9,721.67	7,520.00
Spraying	3,333.33	1,318.33
Harvesting	3,648.33	3,291.67
Transporting	3,315.83	3,562.50
Threshing	2,177.50	2,498.33
Winnowing	1,739.17	1,978.33
Fumigating	460	285
Marketing	1,585.00	550
Others	1,311.67	650.83
Average Variable costs (MK)	84,319.33	71,245.33
Average Gross income (MK)	89,374.17	78,368.33
Average Gross margin (MK)	5,054.83	7,123.00

Table 3: Results of the gross margin analysis in Malawi Kwacha.

Determinants of bean profitability

The results on factors determining irrigated bean profitability in Khosolo Extension Planning Area are presented in Table 4. From the fourteen variables fitted in the logistic regression model, four variables; gross income (^{5}), farm size (^{7}), fertilizer application (^{10}) and total variable costs (^{12}) have significant effects on profitability of irrigated beans in Khosolo EPA (P<0.05) while the other ten factors did not significantly influence profitability (P>0.005). The variables that were deemed insignificant were dropped from the final equation which contains four variables; gross income (^{5}), farm size (^{7}), fertilizer application (^{10}) and total variable costs (^{12}).

$$Logit(y) = Ln\left(\frac{p}{1-p}\right) = \beta_0 + x^5 + x^7 + x^{10} + x^{12} \text{....} Equation\ 3$$

Model evaluation

The results of the binary logistic regression analysis of the data showed that the full logistic regression model containing all the factors was statistically significant, ^{2}(14, =120)=222.97, <0.05 indicating that the independent variables significantly affected bean production profitability. Accuracy prediction of 97.9% was obtained and since the aim of the model was to identify factors affecting profitability of beans, the model is appropriate for the purpose considering its goodness of fit and very high predictive ability. The goodness of fit Hosmer and Lemeshow (H-L) test yielded c2 (8) of 5.499 and was insignificant at (p=0.605) showing that data fitted to the model very well.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Sex	-1.536	0.977	2.473	1	0.116	0.215
Age	0.008	0.032	0.063	1	0.801	1.008
Marital status	-0.77	0.932	0.682	1	0.409	0.463
Education	-0.659	0.617	1.139	1	0.286	0.517
Gross income	0	0	24.93	1	0.000*	1
Experience	-0.047	0.036	1.717	1	0.19	0.954
Farm size	0.001	0.001	20.55	1	0.002*	2
Extension	0.083	0.838	0.01	1	0.921	1.086
Seed used	-0.545	0.608	0.805	1	0.37	0.58
Fertilizer app	0.03	0.003	1.196	1	0.003*	3
Labor source	-0.868	0.653	1.771	1	0.183	0.42
Total V costs	0	0	28.02	1	0.000*	1
Farm type	-0.102	0.63	0.026	1	0.872	0.903
Total Harvest	-0.011	0.007	2.311	1	0.128	0.989

Table 4: Results of factors affecting bean profitability. "*" indicates significance level at 0.05 probability level. The Goodness of fit Hosmer and Lemeshow (H-L) c2=5.499, df=8, P=0.605. -2 Log Likelihood=222.97 (p=0.001). Prediction of success=97.9%.

Discussion

The irrigated common bean farming in Khosolo EPA has preponderantly attracted male farmers (84.2%). Venance et al. [16] states that men are attracted to agricultural activities which generate sizeable income. This means men have seen the potential of bean in generating high incomes for their families. The average age of the farmers interviewed was 44 years similar to the findings of Onyango et al. [2] and Samboko [17]. This is within the ages defined as young and economically productive (15-64 years) as well as deteriorating productivity (65 and above) [17].

The study finds that age of farmers has a significant influence on decision making process of farmers with respect to risk aversion, adoption of improved agricultural technologies and other production related decisions. With most farmers being more experienced at 15 years, they are capable of obtaining higher yields compared to young and less experienced farmers. 61% of the farmers have completed primary education and can safely be considered literate. Education makes a farmer innovative and also easily understand concepts taught in different trainings consequently adopt new technologies with ease. While this may imply that farmers are better placed to adopt new information, the finding that only 7% of the farmers had access to extension services has not helped the cause. Pokhrel and Thapa [20] states that when service providers such as government and other private sectors do not provide extension services, farmers tend to use their traditional practices which at times do not improve crop output.

Farmers have therefore not been motivated to increase farm sizes maintaining an average of 0.5 to 1 acre. Low production has adversely affected output and profitability of the crop. Further limited extension services have resulted in only 20.8% smallholder farmers being reported using fertilizer and chemicals in their bean farming further plummeting productivity. The gross margin analysis shows that irrigated bean farming is profitable in the EPA regardless of whether smallholder farmers join farming groups or not. The gross margin model showed that the level of profitability was different with members of the cooperative slightly earning lower than and non-members.

The study found this to be because of cooperative members obtaining inputs on credit which pushed the cost of production (variable costs) higher compared to non-members. Mogedi [19] states that when farmers' access credit from their groups, the cost of production is also pushed high eroding their gross margins in the end. This may imply that farmers in a cooperative need to look for high value markets for their bean if they are to earn more from it. Current markets may not reward the hard work hence farmers will be demotivated to join the cooperative and may not repay the loans obtained.

The binary logistic regression analysis show that level of bean production profitability is affected by gross income (X^5), farm size (X^7), fertilizer application (X^{10}) and total variable costs (X^{12}). These results imply that smallholder farmers need to increase the size of their farms, reduce cost of producing beans, adopt new farming technologies such as start applying fertilizers to their beans and spraying chemicals in case of pest attacks. Samboko [17] states that increasing bean profitability requires agility from farmers in terms of sourcing cheaper inputs to reduce costs, increasing their farm plots and adopting new technologies. These combined with finding better and high value markets increases gross income farmers earn leading to better gross margins [5]. While the prices of irrigated beans were found to be slightly higher because of high demand and low supply, the smallholder farmers' yield was low to generate tangible income.

Conclusion and Recommendations

The study has showed that 60% of the irrigated bean production is profitable in Khosolo EPA. These results are similar to the findings of Mogedi [19] who found that 67% of bean farmers recorded profits from their farms. The profitability is mainly influenced by size of the farm, variable costs incurred, gross income and application of fertilizers. This study recommends that smallholder farmers should allocate more land to irrigation bean farming and use recommended fertilizers at the right calibrations to enhance productivity to the potential level. Policy wise, there is need for Ministry of Agriculture, Food Security and Water.

Development to take serious steps in revamping extension services and training for effective extension delivery that will lead to adoption of new technologies. The study also points to the need for involvement of private sector businesses to increase availability of inputs in the EPA. Increasing availability will in a way increase competition and reduce prices for farmers. Additionally, it would be beneficial to increase efforts in the development of high vale markets for the beans. Value addition for the beans should also be considered. Details of what kind of value addition and types of fertilizers that can be used were beyond the scope of this study.

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