Agriculture, Income Risks and Rural Poverty Dynamics:

Strategies of Smallholder Producers in Kenya

Joanne Wasswa Kuyiah[1*], Gideon Obare[2], Mario Herrero[3], Michael Waithaka[4]

[1] *Egerton University/International Livestock Research Institute, Agricultural Economics and Agribusiness Management, P O Box 536, Njoro, / 30709-00100, Nairobi, Kenya*

[2] *Egerton University, Agricultural Economics and Agribusiness Management, P O Box 536, Njoro Kenya*

[3] *International Livestock Research Institute (ILRI),P O Box 30709-00100, Nairobi, Kenya*

[4] *Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), Plot 15 John Babiiha Road, P.O.Box 765, Entebbe - Uganda*

Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

Agriculture, Income Risks and Rural Poverty Dynamics: Strategies of Smallholder Producers in Kenya

Joanne Wasswa Kuyiah[1*], Gideon Obare[2], Mario Herrero[3], Michael Waithaka[4]
[1] *Egerton University/International Livestock Research Institute, Agricultural Economics and Business Management, Kenya*
[2] *Egerton University, Agricultural Economics and Agribusiness Management, Kenya*
[3] *International Livestock Research Institute (ILRI), Kenya*
[4] *Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), Uganda*

Abstract

The 1st MDG of cutting by half the number of people living on less than a dollar a day by 2015 is proving difficult to achieve in many developing countries. In Africa, as elsewhere in the developing world, Poverty Reduction Strategies are increasingly being used at national level as vehicles through which governments seek to achieve this goal. In Kenya, the Poverty Reduction Strategy Paper (PRSP) policy document considers development of the agricultural sector as top priority in the process of poverty reduction. This sector is predominantly smallholder, characterised by poor farmers who seem to be caught in the vicious cycle of low investment, low productivity and low incomes. The farmers also face various exogenous risks emanating from the biophysical and socio-economic environment in which they operate. These risks, coupled with farm specific resource endowments and constraints affect the level and variability of household incomes. This study investigates how such risks affect farmers' production decisions in the crop-livestock systems of Vihiga and Kilifi districts in Kenya. Descriptive analysis gives an overview of the productivity of major staples in the study areas, including socio-economic profiles of the farm households. A comprehensive analysis using Linear Programming and Minimization of Total Absolute Deviation (MOTAD is applied to explore possibilities

[*] Corresponding author.
E-mail address: kuyiah@yahoo.com

of improving production and income on these smallholder farms. Results indicate there is scope to increase both production and income even in the presence of risk.

JEL classification: C61; D13; L23; Q18

Keywords: Smallholder farms; Income risk; Rural Poverty; Linear Programming; Kenya

Introduction

It is estimated that 56% of the total population in Kenya live below the poverty line, and most reside in rural areas where agriculture is the main source of livelihood. Smallholder farmers who account for 75% of the total agricultural output, and provide nearly all the domestic food requirements of the nation dominate Kenya's agriculture. In the PRSP policy document, development of the agriculture sector is considered vital in the process of poverty reduction because agriculture is the most important economic activity in which even the poor in rural areas engage. This sector is dominant in the country's economy as reflected by its contribution to income generation and employment creation. Currently, agriculture and agro-related activities account for over 50% of Kenya's GDP and contribute 62% of the total national employment. Through development of the agricultural sector, the government targets to reduce by half the number of people living below the poverty line by 2010, and reduce the number of people who are food insecure from the current 48.4% to below 10% by 2015. It is expected that raising agricultural productivity on smallholder farms will go a long way in helping achieve these two goals.

The relationship between poverty reduction and agricultural productivity has been studied in detail since the 1950's. More recent and comprehensive studies illustrate the potency of this relationship more clearly. For example, results from a study by Thirtle et al., (2003) show that a strong correlation exists between productivity gains in agriculture and poverty reduction. Agricultural growth provides vital spin-off activities that emerge from backward and forward production linkages with agriculture, as well as consumption and expenditure linkages with the rural non-farm sector. Similarly, other studies conducted in SSA consistently show that agricultural productivity gains have raised rural incomes by directly increasing farmers' incomes, and, of particular importance to poorer households, by increasing employment opportunities and wage rates (Dorward, 2003; Poulton and Dorward, 2003).

While overall agricultural growth is undoubtedly an effective engine for both economic growth and poverty reduction, the challenge for developing countries is to identify specific agricultural and rural development needs and opportunities so as to target interventions for successful intensification more appropriately. This process requires an understanding of the resources at the disposal of the smallholders, and factors influencing resource allocation decisions. Generally, farmers face price, yield and resource risks that arise from the biophysical and socio-economic environment in which they operate. These risks affect the level and variability of household resources and income. The lack of institutional innovations such as credit and insurance schemes in most developing countries makes individual risk management a significant issue to cash-constrained smallholders. In an effort to adapt to their risky environment, smallholders make certain production decisions and employ various risk mitigating strategies that may have serious negative implications for economic

development. It is therefore important to understand the role that risk plays in influencing these decisions as a way to help them better cope with its effects on their production, income and welfare. The objective of the study is to investigate how risk affects farmers' production decisions in the identified farming systems, and to explore the possibility of raising production and income on these smallholder farms through better allocation of resources.

Material studied

The analysis presented in this paper is based on both primary and secondary data. The sampling frames for the household surveys were the smallholder farmers from Vihiga and Kilifi districts who were interviewed during the PROSAM characterization survey. Simple random sampling was used to select a total of 240 households, who were interviewed using structured questionnaires to gather cross-sectional input-output data covering the 2003/4 agricultural year. This was supplemented with time series data on yields and market price data for the year 2003 from the two districts. This data was used in the subsequent descriptive and quantitative analyses.

Methods

Modelling smallholder farm household behaviour implies non-separability of consumption and production decisions. Non-separable models build upon the seminal works of Singh, Squire and Strauss (1986). Profit maximization alone is an inappropriate behavioural assumption when the outcome of production decisions made ex-ante is unknown with certainty. In the face of risk, the household allocates its resources to production optimally to manage trade-off between income level and variability (de Janvry and Sadoulet, 2003). Portfolio theory as developed by

Markowitz (1952) can provide a suitable framework for whole-farm risk analysis in the context of a household model. All efficient combinations of returns and risk can be found on the mean-variance frontier, which also guides diversification strategies suitable for minimizing risk. To empirically estimate the model, one must know a priori the mean gross margins for each farm activity. First, basic linear programming (LP) is done to determine a profit maximizing combination of farm enterprises that is feasible with a given set of resources and constraints. MOTAD analysis is then done by parametrically running the model with regard to mean income and minimizing deviation to develop the mean-variance frontier as described in Hazell and Norton (1986). The LP and MOTAD models used in this study are as follows, respectively:

Basic LP:

$$\text{Max INC} = \sum_{j=1}^{n} c_j X_j \text{ s.t. } \sum_{j=1}^{n} a_{ij} X_j \leq b_i \text{ and } X_j \geq 0$$

where INC is the value of the objective function in net cash income from whole farm enterprise plans (obtained from LP runs); c_jX_j is the enterprise gross margins for farm enterprise j (j= 1……..n); b_i's are land, labour, cash capital and subsistence constraints; α_{ij}'s are the respective input-output coefficients that capture the level of resource use in the production of enterprise j; and Xj is the j^{th} farm activity level

The MOTAD model is defined as:

$$\text{Min D} = \sum_{t=1}^{T} Y_t^-$$

s.t. $\sum_{t=1}^{T} (c_{jt} - c_j) X_j + Y_t^- \geq 0$ (risk rows);

$\sum_{j=1}^{n} \bar{c}_j X_j = \lambda$ (income from LP runs set as a scalar and parameterized);

$\sum_{j=1}^{n} a_{ij} X_j \leq b_i$ (LP constraints as indicated above); and

$X_j, Y_t^- \geq 0$.

where D is deviation in income from mean which is minimised; Y_t^- is the absolute value of the negative deviations in gross margin from its mean in the T years in analysis; c_{jt} are the respective enterprise gross margins in year *t*; $\bar{c}_j$'s are the average gross margins for the enterprise plans across the T years in analysis; and $(c_{jt} - c_j)X_j$ is the annual deviation of enterprise gross margins from average gross margin in year *t*. The description and measurement of variables used in the models is presented in table 1.

Description of the research areas

Agriculture is the main source of livelihood, but farmers also engage in other income generating activities. Most farming activities follow the bimodal rainfall pattern. Farmers have a diverse range of crops grown at different times of the year, but the main staples are white maize, beans, cowpeas and cassava. The main cash crops are tea and coconut in Vihiga and Kilifi respectively. The main livestock enterprises are cattle (mainly local zebu), sheep, goats and local chicken. Use of purchased inputs is low; consequently productivity levels are quite low. Both districts face the challenge of increasing farm productivity with limited possibility of increasing the land frontiers. Vihiga district is a classic example of an area experiencing land scarcity due to high population density. Kilifi on the other hand has two thirds of its land lying on the Nyika plateau, an arid ad semi-arid area not suitable for rainfed agriculture.

Generally, farm sizes in Vihiga are smaller than those in Kilifi. Further, farms closer to rural towns are smaller and have a more diversified pattern of production. Opportunities to increase farm income exist due to good market prospects from rapidly growing populations in nearby rural and urban towns, and fair road infrastructure serving these rural towns and urban areas. Table 2 gives a summary of the socio-economic profiles of the study sites.

Results from econometric analyses

LP results show that households are not allocating resources efficiently to maximise cash income (see tables 3 and 4). Higher income would be realised by reallocating resources to better paying enterprises. The analyses reveal that subsistence needs, cash constraints and small land sizes are the most limiting constraints to optimal production at farm level. Further, conflicts between production of food, cash and fodder crops emerge as land size declines below 1 acre, as was observed in Vihiga. Since hiring of land is not a feasible option in Vihiga, farmers would benefit by changing to more paying enterprises. Analyses of these alternative enterprises show a substantial increase in income. On the other hand, farm production and income in Kilifi can be raised in two ways; by increasing cultivated land through hiring, or changing to high value production. However, cash capital limits further increase in the objective value as land sizes increases beyond 8 ha and 4 ha respectively.

The MOTAD results show farm plans are sensitive to the risk criteria. Further, the presence of high-value enterprises such as horticulture, tea and dairy in the risk-efficient farm plans indicate that there is scope to raise farm income even under conditions of risk. Enterprise mix in the farm plans varies as influenced by the risks

associated with the enterprises and feasibility of production as dictated by farm resource constraints. The near-flat frontiers imply that these smallholders are exposed to more risk to obtain higher income. The risk-efficient frontiers are given in figures 1 to 4.

Discussion

Farm production accounts for close to 60% of total household income in both study sites. However, overall farm income as given by the feasible income range from the risk-efficient farm plans is generally low. The low farm incomes are occasioned by food security concerns which necessitate a sizeable portion of available land to be allocated to low-value subsistence crops whose productivity is also low, to cater for household food security needs. Productivity growth of these staples is likely to free up more land for the production of other better paying enterprises. However, output levels remain tightly constrained by economic conditions, especially those affecting input and output prices and availability of credit. Results also show a gradual decline in income as farm size declines, irrespective of the underlying enterprise mix. This result gives an indication that small land sizes could be a limiting factor to raising farm income. Important spill-over effects to other rural sectors are affected by low farm incomes. There will be low demand for hired labourers (as these are substituted with family labour), low traded volumes of agricultural commodities and negative multiplier effects on income and employment among producers and traders of rural consumer goods and services.

The challenge of raising rural incomes requires some transformation out of the low-input, low-productivity farming systems, as well as shifting from low-return non-farm

activities that characterise most of the smallholder farming systems in the country. Given small land sizes and relatively abundant labour as seen from the analyses, land productivity must increase to increase labour productivity and farmers income. This can be achieved through diversification towards market-oriented production of high-value labour demanding enterprises such as horticulture, dairy and traditional export crops, produced for both urban and international markets. Such activities often take advantage of new market opportunities created by changes in the socioeconomic environment. Proximity to urban centres and the state of physical infrastructure play a major role in successful exploitation of such opportunities. Previous studies (Obare et al., 2003; Omamo, 1998) show infrastructure, via its influence on transportation costs of inputs and outputs between farm plots and markets to be an important determinant of production decisions and farm productivity of smallholders. Results from Vihiga verify that when commercial opportunities are present, high-value enterprises that provide higher returns to scarce land may be preferred by farmers to make their livelihood as opposed to subsistence agriculture based on traditional food crops.

Increasing farm income through farm production alone is a challenge given the continuing shrinkage of farm sizes. Off-farm and non-farm income provide viable options through which rural households can secure their livelihoods given small and declining land holdings. Various studies conducted in SSA (Reardon, 1997; Savadogo et al., 1998; Barrett et al., 2001) show such income to be beneficial to farm investment and productivity. Off-farm earnings and non-farm income allowed farm households to purchase cash inputs into production, or make farm investments. This cash also contributes to mitigating the seasonality problem of managing unstable income, and this in turn may help reduce risk-aversion in farm production decisions.

Particular attention should therefore be paid to ways in which these activities can be promoted in presence of agricultural growth.

Conclusions

Evidence indicates that where agro-ecological and infrastructural conditions are favourable, smallholders can raise their agricultural productivity and incomes by engaging in high-value crop and livestock production as well as diversifying their income sources. Uptake of such activities is conditional on incentives and capacity of farmers and other potential investors to undertake such opportunities, given input and output prices and risks associated with the activities.

Policies that stimulate the growth of the rural non-farm sector alongside other support institutions are necessary to increase income diversification options for farm households, and absorb excess labour from farm production. Research and extension should focus on improving efficient use of existing resources and also identify suitable enterprise mixes that suit diverse needs of farmers with heterogeneous resource endowments and ability to bear risks.

Acknowledgements

The research reported in this paper was funded by the PROSAM project (a collaboration between Wageningen University, ILRI, KARI, ICRAF and ICASA). PROSAM is funded by Ecoregional fund to support methodological initiatives of the Dutch government. Any errors of omission and commission are ours. Correspondence should be addressed to Kuyiah, J.W Email address: kuyiah@yahoo.com

References

Barrett C. B, Reardon T, Webb P. (2001). Non-farm Income Diversification and Household Livelihood Strategies in Rural Africa: Concept, Dynamics and Policy Implications. *Food Policy*, **26**: 315-331.

Dorward, A., (2003). Modelling Poor Farm-household Livelihoods in Malawi: Lessons for Pro-poor Policy. Report to DFID.

de Janvry, A. and Sadoulet, E. (2003). "Progress in Modeling Rural Household's Behavior under Market Failures" In de Janvry, A. and Kanbur, R. (ed). *Poverty, Inequality and Development*. Essays in Honor of Erik Thorbecke, Kluwer Publishing.

Hazell, P.B.R. and Norton, R.D. (1986). *Mathematical Programming for Economic Analysis in Agriculture*. New York: Macmillan.

Kuyiah, J. W. (2005). "Economic Analysis of Smallholder Agricultural Production Under Conditions of Risk: Case of Vihiga and Kilifi Districts in Kenya." Unpublished MSc. Thesis, Egerton University, Njoro.

Markowitz, H.M (1952) Portfolio Selection. *Journal of Finance*, 7: 77-91

Waithaka, M.M., Nyangaga, J.N., Staal, S.J., Wokabi, A.W., Njubi, D., Muriuki, K.G., Njoroge, L.N. and Wanjohi, P.N. (2002). *Characterization of Dairy Systems in the Western Kenya Region.* SDP Collaborative Research Report. December 2002. MoARD, KARI, ILRI and DFID.

Waithaka, M.M., Ouma, E.A., Kariri, J.M., Ikongo, D.O., Herrero, M., Thornton, P.K.and Shepherd, K.D. (2003). Systems Prototyping and Impact Assessment for Sustainable Alternatives in Mixed farming Systems in High Potential Areas of East Africa. Characterization of Kilifi Farming Systems. July 2003. Final Report.

Ministry of Agriculture and Ministry of Livestock and Fisheries Development (2004). *Strategy for Revitalizing Agriculture* 2004 – 2014. Government printers, Nairobi.

Obare, G.A., Omamo, S.W., William J.C. (2003). Smallholder Production Structure and Rural Roads in Africa: The Case of Nakuru District, Kenya. *Agricultural Economics* 28(3): 245-254.

Omamo, S.W. (1998). Transport Cost and Smallholder Cropping Choices: An Application to Siaya District Kenya. *Am. J. Agri. Econ.* 80(3)**:** 116-123.

Poulton, C., and Dorward, A.R. (2003) Modelling Poor Farm-household livelihoods in Zimbabwe: Lessons for Pro-poor Policy. Report to DFID.

Reardon, T. (1997). Using Evidence of Household income diversification to Inform Study of the Rural Non-farm Labor Market in Africa. *World Development*, 25(5):735-748.

Savadogo, K., Reardon, T., and Pietola, K. (1998). Adoption of Improved Land Use technologies to Increase Food Security in Burkina Faso: Relating Animal Traction, Productivity and Non-Farm Income. *Agricultural System*, 58 (3): 441-464.

Thirtle, C., Lin, L., and Piesse, J. (2003). The Impact of Research-led Agricultural productivity growth on Poverty reduction in Africa, Asia and Latin America. *World Development* 31(12): 1959-1976.

Table 1 Description and measurement of decision variables

Variable	Variable description	Unit of measurement
INC	Expected total farm income from enterprise plans	Ksh
$c_j X_j$	Respective enterprise gross margins	Ksh per hectare
$\bar{c}_j X_j$	Average enterprise gross margins across the T years	Ksh per hectare
X_j	Level of activity j	-
a_{ij}	Respective input-output coefficients that capture the level of resource use in the production of enterprise *j*	-
L	Land constraint	Hectares
H	Human labour constraint	Man days
K	Cash capital constraint (total variable costs)	Ksh
S	Subsistence requirement. Minimum land required for the production of main staples to ensure food security at household level	Hectares
c_{jt}	Respective enterprise gross margins in year *t*	Ksh per hectare
Y_t^-	Annual deviation of income from expected income in year t	Ksh
σ^2	MAD estimate of the variance of income over the T years in analysis	Millions

Table 2: Socio-economic profiles of the study sites

Attributes	District	
	Vihiga	Kilifi
Average household size (persons)	5.9	7.5
Average land size (ha)	0.876	2.2
Land access per capita	0.15	0.29
Market access	Medium	Medium
Soil fertility	Low	Moderate/low
Hiring labour (casual + permanent)	75.84	45.4
Sources of household income:		
Farming activities	58%	59%
Off-farm income	14%	16%
Non-farm income	28%	25%

Source: Survey results 2004; Waithaka et al., 2002, 2003

Table 3: LP results for Vihiga new enterprise mix

Variable	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Semi-commercial (*farm size 0.832 ha*)					
Objective value (ksh)	26410.00	28411.00	48764.93	50651.01	
Labour (m.d)	105.00	91.00	107.27	130.85	
Capital (ksh)	12044.00	20068.00	26137.21	28040.13	
Enterprise levels:					
Maize/beans (ha)	0.26	0.26	0.26	0.26	
Kales (ha)	0.58	0.16			
Tomatoes (ha)	-	-	0.416	-	
Onions (ha)	-	-	-	0.416	
Dairy goat (ha)	-	0.416	0.159	0.159	
Semi-subsistence (*farm size 0.642 ha*)					
Objective value (ksh)	19642	36122	37560	39038.4	40763.2
Labour (m.d)	81	84	102	87.31	108.9
Capital (ksh)	9312	18770	20221	19175.3	20915.5
Enterprise levels:					
Maize/beans (ha)	0.26	0.26	0.26	0.26	0.26
Kales (ha)	0.385	-	-	-	-
Tomatoes (ha)	-	0.321	-	0.385	-
Onions (ha)	-	-	0.32	-	0.39
Dairy goat (ha)	-	0.06	0.06	-	-

Notes: Alt is a shortened form for Alternative, representing the different farm plans
Source: Survey results 2004

Table 4: LP results for Kilifi

Variable	Existing plan (1.24 ha)	Alt 1 (4 ha)	Alt 2 (6 ha)	Alt 3 (8 ha)
Semi-commercial (*farm size 1.24 ha*)				
Objective value (ksh)	42008.15	145907.35	190610.82	229787.75
Labour (m.d)	131.78	523.7	543.96	517.815
Capital (ksh)	24009.25	93561.25	101105	101105
Enterprise levels:				
Maize/cowpeas (ha)	0.2	0.2	0.2	0.2
Coconut (ha)	0.15	0.15	0.15	0.15
Cassava (ha)	0.3	0.3	3.44	7.132
Bananas (ha)	0.59	3.35	2.21	0.518
Semi-subsistence (*farm size 2.08 ha*)				
Objective value (ksh)	62692.8	120523.65	123287.8	123287.8
Labour (m.d)	119.38	597.2	611.56	611.56
Capital (ksh)	39490.5	42893.25	43815	43815
Enterprise levels:				
Maize/cowpeas (ha)	0.2	3.55	3.641	3.641
Coconut (ha)	1.58	0.15	0.15	0.15
Cassava (ha)	0.3	0.3	0.3	0.3

Notes: Alt is a shortened form for Alternative, representing the different farm plans
Source: Survey results 2004

Figure captions

Figure 1: Vihiga semi-subsistence risk- efficient frontier
Figure 2: Vihiga semi-commercial risk-efficient frontier
Figure 3: Kilifi subsistence risk- efficient frontier
Figure 4: Kilifi semi-commercial risk-efficient frontier

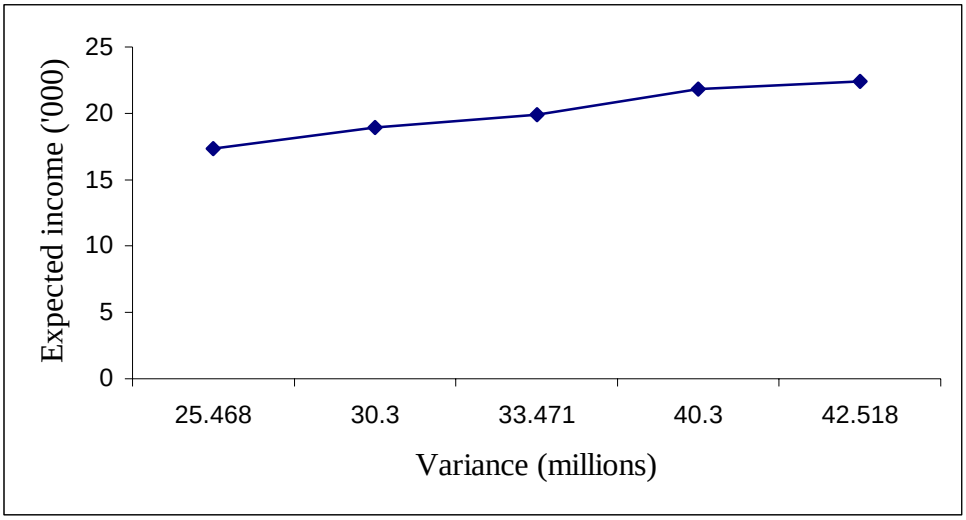

Figure 1: Vihiga semi-subsistence risk- efficient frontier

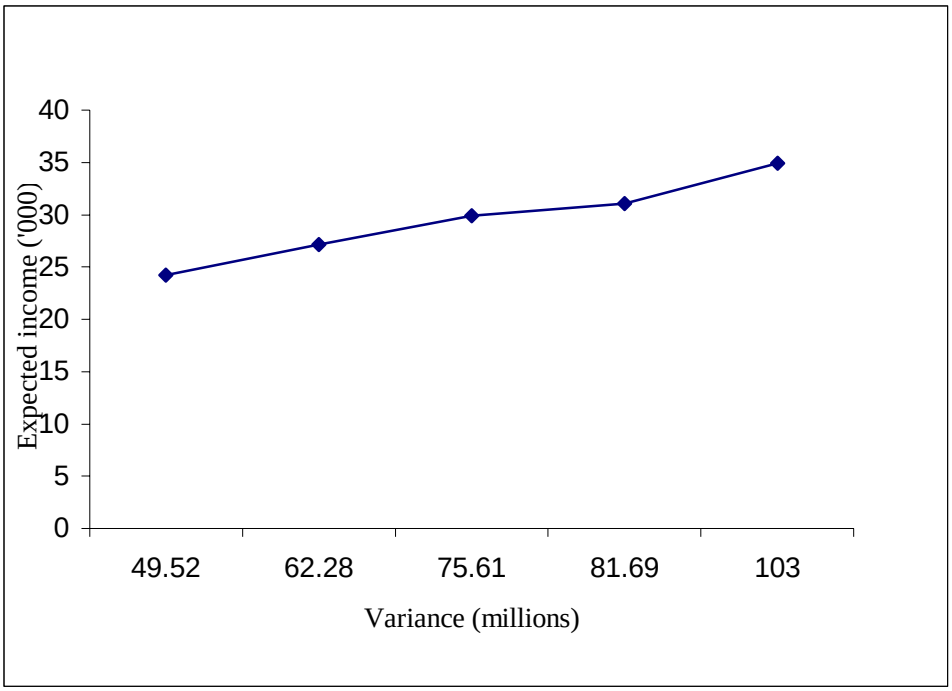

Figure 2: Vihiga semi-commercial risk-efficient frontier

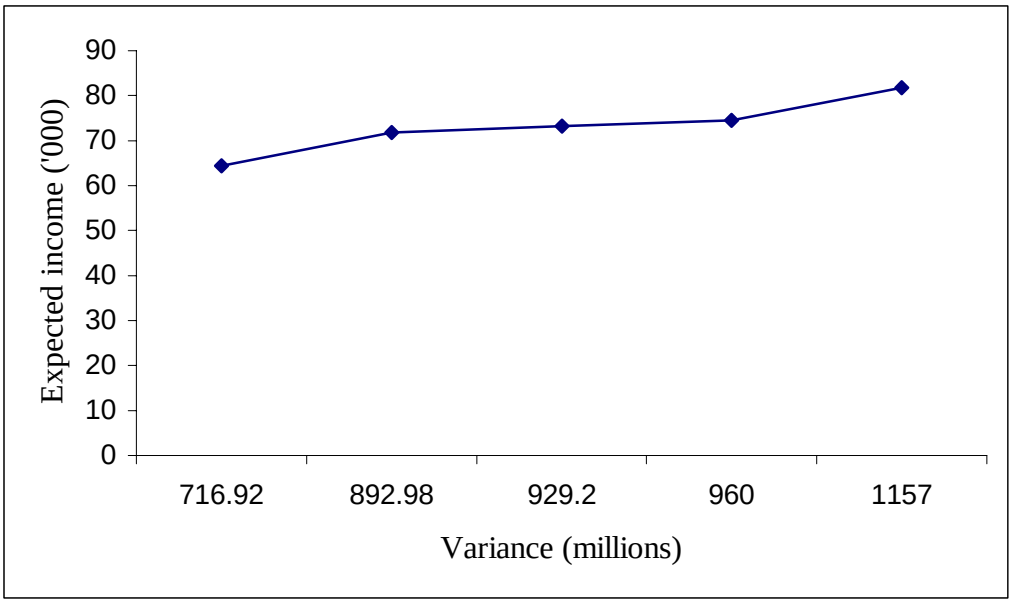

Figure 3: Kilifi subsistence risk- efficient frontier

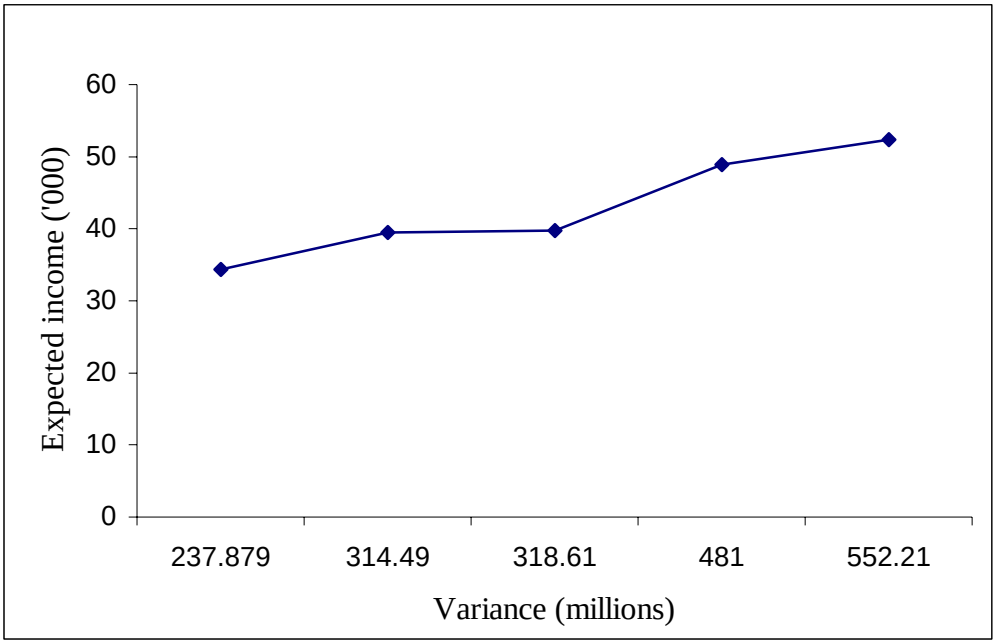

Figure 4: Kilifi semi-commercial risk-efficient frontier