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Resource Use Efficiency in Vegetable Production under Irrigation: The Case of Marutle Agricultural Cooperative in the Limpopo Province of South Africa

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ABSTRACT This study was conducted to determine the effect of socio-economic variables on gross return of cabbage production in the Marutle Cooperative irrigation scheme of Limpopo Province, South Africa. In all, 395 cabbage farmers were selected for the study in 2013/2014 cropping season. By applying a modified Cobb-Douglas function, the study showed that although the selected socio-economic variables were correlated with gross returns nevertheless; they showed low percentage changes to gross returns. Variables included costs pertaining to labour, seedlings, fertilizer and tillage, irrigation, and insecticide. In all, the production function indicated decreasing returns to scale. It was recommended that the availability and low cost of the identified production inputs should be of great concern to both farmers and policy makers in the studyarea. Further studies were recommended to include more variables that are likely to affect gross returns in the model to increase the coefficient of multiple determination.

INTRODUCTION

The United Nations declared 2012 as the International Year of Cooperatives (IYC) on 18 December 2009 during the 64th Session of the United Nations General Assembly (UN 2010). The year was declared in the resolution "Cooperatives and Social Development". The IYC aimed at raising awareness on the socio-economic impact of cooperatives, and for promoting the autonomous formation and growth of cooperatives. It is for this reason that the cooperative sector has re-emerged forcefully in recent years as an important sector in South Africa's economy and the economies of other countries. In South Africa, the revival of this sector mostly occurred and still occurs in the rural areas, where most co-operatives across all sectors are found (DTI 2012).

The agricultural sector is one of the sectors that have identified co-operatives as a viable vehicle for sustainability of agricultural enterprises. Co-operatives provide economies of scale to influence and intervene in the supply chain of agricultural commodities for better remuneration and thereby contributing to wealth creation.In the past decade a vast increase in the establishment of agricultural co-operatives in the rural areas has been observed. This increase highlights the role of agriculture as one of the major economic drivers accessible to vast numbers of rural dwellers often without any alternative entry into economic activities. The increase that occurred mostly in the rural areas was certainly positive for the rural development objectives of the country that seeks to decentralize economic development and the redistribution of wealth (DTI 2004).

The intended objectives of the co-operatives development have not been realized, due to a number of challenges. The sector is faced withlow productivity, low profitability and unsustainable employment of the members. In addition, objectives for their establishment are misguided.There is a lack of management skills, corporate governance, and co-operatives not using business principles to operate. The co-operatives also experience lack of capital resources, inadequate training, extension and education programs, lack of communication and participation among members, feudalistic characteristics of communities and farmers, unclear and inadequate government policies on the development of agricultural cooperatives, high fragmentation of land holdings, and weak linkages among the activities of the cooperatives, for example, production, credit, marketing etc. Experience has also shown that there is institutional disharmony among institutions that act as developments agents (the various institutions involved in the sector have not achieved a level of synergy relevant for the viability of the sector).

South Africa has undergone many changes economically, socially and politically since its democratization in 1994. South Africa defines its agricultural policy objectives in the content of broad economic reforms, which entails sustainable and profitable participation in South African agricultural economy by all stakeholders. It recognizes the importance of maintaining and developing commercial production and strengthening international competitiveness, and at the same time it stresses the need to address the historical legacies and biases of apartheid (Delien 2010).

Umoh (2006) stated that the question of efficiency in resource allocation in traditional agriculture is not trivial. It is widely held that efficiency is at the heart of agricultural production. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources. Efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor.Increasing population and wealth are resulting in rising pressure on key resources to satisfy growing demand. The physical, economic and geopolitical accessibility of resources and the efficiency and sustainability of their use are of paramount concern worldwide (Van den 2011).

Vegetable farming systems differ significantly from one area to another (Arsanti and Bohme 2007). Capricorn district is considered a farming area. It has a lot of farming villages and small-scale farmers spread across its sub-districts. The small-scale farmers of Marutle Co-operative seem to be losing interest in the production of vegetables. The reasons for this are unknown yet, but the production of vegetable is becoming less each year. Farmers in the cooperative produce different crops throughout the year for crop rotation, but are still barely making profit and barely improving their living standard.

This study assumes that limited resource mobilization and allocation is the main reason affecting vegetable productivity at Marutle Co-operative irrigation scheme. Therefore the study is aimed at investigating the current level of resource efficiency on the production of small-scale vegetables.

Objectives

(1) Determine the effect of socio-economic variables on gross return of vegetable (cabbage, spinach and onions) production.
(2) Determinethe responsiveness of output to changes in key socio-economic characteristics.
(3) Estimate the overall return to scale for vegetable production.

Literature Review

The question of efficiency in resource allocation in traditional agriculture is crucial. It is widely held that efficiency is at the centre of agricultural production. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources. Therefore efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor (Umoh 2006).The efficiency of vegetable production is very crucial in determining the returns on investment. Quite often the introduction of new technology has been used as a standard for distinguishing between a modern system and a traditional system, and for improving the efficiency of the production system. However in the developing world, some new technologies have been barely successful in improving production efficiency. This has often been blamed on the lack of ability and /or willingness on the part of producers to adjust input levels because of their familiarity with traditional agricultural systems and or the presence of institutional constraints (Amodu et al. 2011).

According to Loughrey et al. (2013), raising agricultural productivity involves making investment in the land itself. However, according to Nurah (1999)farm operators are not able to make much investment unless they are sure of the returns of their efforts and expenses they put into improving the land. In most countries, it has not been possible to increase production as land for cultivation is becoming effectively scarce. Land use changes impact the quality and availability of soils, water and biodiversity (Awoke and Okorji 2000). In most developing countries where there is land scarcity, it has not been possible to increase the scale of operation of vegetable production. According to Mengistu and De Stoop (2007), the growing population has led to shrinkage of land available for agriculture. This is further exacerbated by the loss of farmland due to land degradation. This leads to an increasing demand for agricultural land, which usually ends up in converting more forest land into farmland/grazing land. The study also indicates that many farmers (probably the poorest) use areas that are highly susceptible to degradation which should not be used for agriculture at all.

Nurah (1999) reported that commercial vegetable production is quite labour demanding and that many farmers will rely on family labour if the farm size is small.Most farmers therefore hire labour to supplement their own family labour supply.According to Ramaila et al. (2011) although land and labour productivity in South Africa have remained at 1.46 percent and 2.67 percent per year, this level remains high compared to other African countries. This is because the value of output per labour is considerably high in South Africa since 2007.Labour is the major factor of production in the traditional farming systems of West Africa and as such the utilization and productivity of labour is a key element in increasing the agricultural output and incomes of small farmers. To an extent that there is underemployment of labour in Agriculture, the potential exists for increasing output, employment and incomes.

According to Nurah (1999) vegetable production is capital intensive; equipment is needed to till the land, to irrigate the crops, to apply crop protection chemicals and to process the harvested products. Arsanti and Bohme (2007) indicated the varied sources of acquiring capital for farming were obtained from savings, gifts and inheritance, outside equity capital, leasing, contract production and borrowing. Food is needed all the time, so fresh clean water is also needed to produce our food. With the growing demand for food and climate change on the other hand, many regions especially in Africa struggle to find enough freshwater to meet their needs.In some parts pollution from pesticides and fertilizers used in agriculture alone remains a major cause of poor water quality (Ash 2011).

According to van Averbeke et al. (2011) irrigation refers to the artificial application of water to land for the purpose of enhancing plant production therefore irrigation water can be abstracted from the source and conveyed to the field by farmers individually or in a group as an irrigation scheme.Climatic conditions, soil type and structure, plant type, and the irrigation techniques applied are among the main factors that influence the efficiency and effectiveness of irrigation practices.According to Frank and Roland (2013) increasing water use efficiency should be one of the goals of vegetable producers. Vegetable crops require more total water and more frequent irrigation than most agronomic crops. Vegetable water requirements vary from each growing season, depending on kind of vegetable grown, production location and environmental conditions. Water use efficiency can also be increased through effective application scheduling.In South Africa, small-scale irrigation is seen as an important rural development factor, creating employment opportunities, generating income and enhancing food security. Huge investments are therefore made in the sector, rehabilitating existing schemes (Perret 2002). On the other hand, the growing water scarcity causes increasing pressure on farmers to allocate water more efficiently.

Båge (2002) stated that 75 percent of the world's poor people live in rural areas and make their living largely through the land on which they live. Their enterprises and households collectively account for much of the land, water and labour engaged in agricultural production. They have a wealth of traditional technical and organizational knowledge. The rural poor contribute greatly to the economic growth of their countries. They play a critical role in managing and conserving the world's natural resources. At the same time, farmers often have a challenge of degraded land that is increasing the problem to meet their needs, or to mismanage productive land because of the lack of appropriate tools or knowledge.In a study by Okoye et al. (2007) age, level of education and farm size were negatively and significantly related to economic efficiency, whereas farmer's farming experience and fertilizer use were positively and significantly related to economic efficiency. Adeyemoin and Kuhlmann (2009) stated that the main socio-economic factors which were assumed to have an influence on the productive efficiency of farmers and hence included in the model included the age of the farmer, availability of off-farm income, access to credit, access to extension services, educational level of farmer and years of experience in the vegetable production industry. Age of farmer; contact with extension agents; access to off-farm income and access to credit all had negative coefficients. The negative coefficients implied negative influence on technical inefficiency. Farming experience and level of education had positive effects on technical efficiency.

Mussa et al. (2011) stated agricultural productivity depended on how factors were efficiently used in the production process. Therefore the intensification of agricultural land and expansion of technology use must be accompanied by resource use efficiency that helpsproductivity of factors. Improvements in resource use efficiency hence increase in productivity will reduce encroachment of population to marginal agricultural lands. In turn, this will protect the resource base of the poor against degradation. More importantly, efficient resource use is the basis for achieving universal food security and poverty reduction strategies particularly in the rural areas. It is also crucial for policy makers to have adequate and evidence based policy options to increase efficiency and productivity to improve the livelihoods of the poor. Al-Said et al. (2012) stated that improving water productivity can make a sterling contribution to global food production and poverty alleviation. Groundwater has always been a critical resource for agriculture. Water productivity can help address water scarcity concerns through more productive use of scarce water resources and higher socio-economic benefits from available water.

METHODOLOGY

The study was conducted at Marutle Cooperative irrigation scheme on a smallholder surface irrigation scheme of 135.6 ha that was established in 2005. Marutle Cooperative is situated in the Limpopo Province of South Africaabout 6 km northwest of Polokwane, in the Aganang Local Municipality. Agro-ecological conditions at Marutle Cooperative are substantially homogeneous and the farms (plots) are identical in sizeof 1.28 ha per farm. A qualitative research design was used in this study. A questionnaire was designed so that a survey can be conducted. The questionnaire included the information required to answer all objectives. Simple random sampling technique was used to select the respondents from the population of Marutle Cooperative. A sample size of 395 was selected from a population of 1004 farmers. Primary data was collected using face to face interviews with the use of questionnaires.

Tredoux and Durrhei (2002) stated that recognizing whether a measure is continuous or discrete will help the researcher decide which kind of statistical test to use. The data collected using questionnaires were analysed with the Statistical Package for Social Sciences (SPSS Version 21.0) of 2012. An econometric model expressed in the non-linear Cobb Douglas type of production function was used to estimate cabbage production. In its most standard form for production of a single good with two factors, the function can be expressed as:

$$Y = A.L^{\beta}.K^{\alpha}.e^{\mu} \qquad (1)$$

Where:

- Y = total production (the real value of all goods produced in a year)
- L = labor input (the total number of person-hours worked in a year)
- K = capital input (the real value of all machinery, equipment, and buildings)
- A = total factor productivity
- α and β are the output elasticity's of capital (K) and labor (L), respectively. These values are constants and are determined by available technology.
- u= error term, with $E(e_i)=0$. $E(e_i e_j)=\Omega$ where the covariance matrix results from the first-order autoregressive process (Hayes 2005).

Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus. For example if $\alpha = 0.45$, a 1 percent increase in capital usage would lead to approximately a 0.45 percent increase in output.

In addition, if $\alpha + \beta = 1$,the production function has constant returns to scale, meaning that doubling the usage of capital (K) and labor (L) will also double output Y. If $\alpha + \beta < 1$,returns to scale are decreasing, and if $\alpha + \beta > 1$, returns to scale are increasing. Assuming perfect competition and $\alpha + \beta = 1$, α and β can be shown to be capital's and labor's shares of output. From equation 1, it is clear that the relationship between the output and the two inputs is nonlinear. However, if the non-linear equation is log transformed, a linear regression model is obtained which can be estimated by OLS (Tam 2008). Thus equation 1 can be written as:

$$\text{InY} = \text{InA} + \alpha\,\text{InL} + \beta\,\text{InK} + \mu \qquad (2)$$

In this study, the general Cobb-Douglas function was modified to determine the effect of socio-economic variables on gross return of cabbage per hectare.The selected Cobb-Douglas production function model (Gujarati 2003), in its stochastic form was expressed as:

$$Y = A.X_{1i}^{\beta_1} X_{2i}^{\beta_2} X_{3i}^{\beta_3} X_{4i}^{\beta_4} X_{5i}^{5} X_{6i}^{6} e^{u_i} \quad (3)$$

The function was transformed into the following double log or log-linear form i.e.

$InYi = InA + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \beta_3 InX_{3i} + \beta_4 InX_{4i} + \beta_5 InX_{5i} + \beta_6 InX_{6i} + u_1$............(4)

Where:

In Y = Gross return (R./ha);

In X_1 = Human labour cost (R./ha);

In X_2 = Irrigation cost (R./ha);

In X_3 = Seedling cost (R./ha);

In X_4 = Fertilizer cost (R./ha);

In $X_{5=}$ Tillage cost (R/ha)

In X_6 = Insecticides cost (R./ha);

i = l, 2, 3, ... n

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ = Regression co-efficient to be estimated

A= Constant term and u_i = Error term.

RESULTS AND DISCUSSION

Table 1: Descriptive statistics of variables

Variables	*Mean*	*Std.dev.*	*N*
InY	1003.6886	932.83601	395
InX_1	1.01	1.026	395
InX_2	1.48	0.500	395
InX_3	3.14	1.286	395
InX_4	2.15	1.220	395
InX_5	4.46	3.014	395
InX_6	2.73	2.413	395

Table 1 presents the descriptive statistics of the variables used in the equation. The results show that tillage cost (4.46) was the highest, followed by seedling cost (3.14), and insecticide cost (2.73). Fertilizer, irrigation and human labour costs were relatively low. A plausible explanation is that tillage using tractors, seedling and insecticides are all capital intensive and these production inputs which are not subsidised by the government cost farmers more than other inputs in cabbage production. The findings are consistent with those of Umoh (2006) who found out that in developing countries because farmers are resource-poor, irrigation and fertilizer costs are heavily subsidized. Therefore it costs less than other inputs for cabbage production in this study. Human labour is normally provided as family labour, hence costs are less.

In Table 2, the estimated linear regression model is presented. All the six independent variables,which were selected on the basis of the best-fit and significance on gross returns, were significant. The results indicated that 1percent increase of human labour, keeping other factors constant, would increase the gross return by 15.8 percent. The coefficient of seedling cost was estimated to be 0.129. An indication that 1percent increase in seedling cost would increase seedling cost by 12.9 percent. The magnitude of the regression coefficient of fertilizer cost for gross return on cabbage production was 0.273. This coefficient was significant at the 1percent probability level which implied that 1percent increase in fertilizer cost caused by supply and demand, would lead to an increase of in the gross return of cabbage production by 27.3 percent keeping all other factors constant. The results in Table 2 also indicated that the production coefficient of tillage was 0.239 and significant at the 5 percent level of significance. This result implied that keeping all other factors con-

Table 2: Results from the estimated linear regression model

Variables	*Elasticities*	*Std. error*	*t-value*	*Sig.*	*Zero-order correlation*
Constant	-	210.711	0.840	0.402	-
InX_1	0.158	43.009	3.330	0.001	0.164
InX_2	-0.081	87.299	-1.736	0.083	-0.098
InX_3	0.129	33.758	2.775	0.006	0.094
InX_4	0.273	36.037	5.793	0.000	0.245
InX_5	0.239	15.636	4.733	0.000	0.229
InX_6	-0.157	19.433	-3.133	0.002	-0.021
R^2		= 0.171			
RTS ($\Sigma \hat{a}_i$) =	0.570				

Dependent variables= Gross Return (R/ha); Durbin-Watson=1.911; $^{***}P<0.01$ (1%); $^{**}P<0.05$ (5%); $^{*}P<0.10$ (10%).

stant, 1percent increase in tillage cost of cabbage production would result in an increase of 23.9 percent in the gross return from cabbage production. Although the variables described in Table 2 were positively correlated with gross returns , yet they displayed low percentage changes to gross returns. These findings confirm other studies from elsewhere which indicate that vegetable production is labour intensive, capital intensive and also need equipment and other inputs such as seed fertilizer for maximum production (Nurah 1999; Ramaila et al. 2011; Ash 2011).

Interpreting the negative coefficients, the coefficient for irrigation cost (-.081) meant that 1 percent increase in irrigation cost would decrease the gross return on cabbage production by 8.1 percent. Similarly, the coefficient of insecticide cost was -0.157, and it indicated that an increase of 1percent in insecticide cost would result in a decrease of 15.7percent in gross return on cabbage yield. The negative correlation between gross return and irrigation cost, and also insecticide cost confirmed other studies by Frank and Roland (2013) who indicated that vegetable crop production required frequent irrigation. An increase in the cost of irrigation coupled with insecticide costs is therefore likely to decrease production and eventually gross return.

The coefficient of multiple determination indicated by the value of R^2, was 0.171 and it indicated that only 17.1 percent of the variation of output of cabbage was explained by the independent variables included in the model. The indication was that other important variables which had effect on gross return, should have been included in the model but were excluded. The summation of the estimated coefficients (0.570) implied decreasing returns to scale and the vegetable enterprise was operating in the second stage of the production function.

CONCLUSION

The first objective of this study was to determine the effect of socio-economic variables on gross return of cabbage production. The study analysed the responsiveness of output to changes in key socio-economic characteristics and finally estimated the overall return to scale for cabbage production in the Marutle Cooperative irrigation scheme. The study concluded that although the selected socio-economic variables were positively correlated with gross returns, nevertheless; they showed low percentage changes to gross returns. These variables included labour costs, seedling, fertilizer and tillage costs. Irrigation costs, and insecticide costs showed negative correlation with gross return and also showed low percentage changes to gross returns. In all, the production function indicated decreasing returns to scale and also and the vegetable enterprise was operating in the second stage of the production function.

RECOMMENDATIONS

Since increase in the selected socio-economic variables (labour, irrigation, seedling, fertilizer, tillage, and insecticide costs) revealed low percentage changes to gross return, the availability of such production inputs should be of great concern to both farmers and policy makers. Further studies are also recommended to include more variables that are likely to affect gross return in the model. This is likely to increase the coefficient of determination.

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REFERENCES

Adeyemo R, Kuhlmann F 2009. Resource use efficiency in urban agriculture in Southwestern Nigeria. *Journal of Applied Tropical Agriculture*, 11:40-46.

Al-Said FA, Ashfaq M, Al-Barhi M, Hanjra MA, Khan IA 2012. Water productivity ofvegetables under modern irrigation methods in Oman. *Irrigation and Drainage*, 61: 477-489.

Amodu MY, Owolabi JO, Adeola SS 2011. Resource use efficiency in part-time food crop production: The Stochastic Frontier Approach. *Nigerian Journal of Basic and Applied Sciences,* 19:1.

Arsanti IW, Bohme MH 2007. Evaluation of Profitability and Competitiveness of Vegetable Farming Systems in Upland Areas of Indonesia. *Proceeding of the International Symposium on Improving the Performance of Supply Chains in the Transitional Economics*. Kuala Lumpur: Acta Horticulturae.

Ash K 2011. Risk Management in Agriculture in New Zealand, OECD Food and Agricultural Policy Analyst. *OECD Trade and Agriculture Directorate*. New Zealand.

Awoke MU, Okorji EC 2000. Analysis of constraints in resource use efficiency in multiple cropping system by smallholder farmer in Ebonyi State: *Global Journal of Agricultural Science* 2(2): 132-136.

Båge L 2002. Environment and Natural Resource Management, *Report No. 1*. Rome: IFAD.

Bembridge TJ 2000. Guidelines for Rehabilitation of Small-scale Farmer Irrigation Schemes in South Africa. *WRC Report No. 891/1/100.* Pretoria, South Africa.

Delian B 2010. *South Africa Yearbook*. Pretoria: Government Printers.

Department of Trade and Industries 2012. Promoting an Integrated Cooperative Sector in South Africa 2012-2022. *Policy Brief* No. 1: 1-12.

Department of Trade and Industries 2004. Cooperative Development Policy for South Africa. *Policy Brief* No. 4: 1-12.

Frank JD, Roland R 2013. *Vegetable Resources.* Chapter IV. London: Bakie Academic & Professional Publishers.

Gujarati DN 2003. *Basic Econometrics.* 2nd Edition.New York: McGraw Hill.

Hayes MR 2005. *Application of the Cobb-Douglas Production Model to Libraries*. New York: McGraw Hill.

Mengistu S, De Stoop C 2007. Environment for Survival – Taking Stock of Ethiopia's Environment. *Proceedings of the First Green Forum Conference* held in Addis Ababa, Green Forum Conference Proceedings No. 1, Addis Ababa, Ethioia, March 2007.

Mussa EC, Obare GA, Bogale A, Simtowe FP 2011. *Resource Use Efficiency of Smallholder Crop Production in the Central Highlands of Ethiopia.* Ethiopia.

Nurah GK 1999. A Base Line Study of Vegetable Production in Ghana. *Final Socio- economic Study Report, National Agricultural Project (NARP).* Accra, Ghana.

Okoye BC, Onyenweaku CE, Asumugha GN 2007. Economic efficiency of smallholder cocoyam farmers in Anambra State, Nigeria. *Research WebPub,* 1(2):12-17.

Perret S 2002. Water policies and smallholding irrigation schemes in South Africa.*Water Pol*, 4(3): 283-300.

Ramaila M, Mahlangu S, Du Toit D 2011. Agricultural Productivity in South Africa: Literature Review. *Report No. 1.* University of Pretoria, Pretoria.

Tam BH 2008. Cobb-Douglas Production Function. From <http://docents.fe.unl.pt/~jamador/Macro/cobb-douglas.pdf.> (Retreived on 24 July 2014).

Tredoux CG, Durrheim, KL 2002. *Numbers, Hypotheses and Conclusions.* Cape Town: Juta Publishers.

Umoh GS 2006. Resource use efficiency in urban farming: An application of Stochastic Frontier Production Function. *International Journal of Agriculture and Biology*, 10: 144-164.

Van Averbeke W, Denison J, Mnkeni PNS 2011. *Small Holder Irrigation Schemes in South Africa: A Review of Knowledge Generated by Water Research Commission*. Pretoria. Government Printers.

Van den BM 2011. *EU Resource Efficiency Perspectives in a Global Context*. The Hague: PBL Netherlands Environmental Assessment Agency.