TECHNICAL EFFICIENCY IN A VEGETABLE BASED MIXED-CROPPING SECTOR IN TUGELA FERRY, MSINGA DISTRICT, KWAZULU-NATAL

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Abstract

Vegetable production constitutes an important sub-sector of the agricultural economy of KwaZulu-Natal. Most vegetables are cultivated in mixed-cropping types of farming systems. The technical efficiency of vegetable based cropping systems was estimated in order to identify the potential increase in production without incurring additional costs. The factors affecting technical efficiency and constraints and potential of the cropping system were also investigated. A field survey was conducted covering 120 vegetable farmers in the irrigated Tugela Ferry scheme and dryland farming sector in Msinga district during October to December 2003. According to a stochastic frontier production function using a Cobb-Douglas model, hired labour, organic fertilizer, inorganic fertilizer, area harvested and soil fertility maintenance cost showed significant positive effects on vegetable production. The mean technical efficiency of the vegetable based cropping systems was 84.32%. According to the inefficiency model the efficiency increased significantly as a result of farm visits by extension officers, participation in farmer training, less sloping lands, more experience, and higher diversity of the vegetable system. Technical efficiency decreased, however, with higher education level of the farmer and with higher off-farm income. Farm income is low due to low productivity, market constraints, lack of technology, and institutionally related constraints. Environmental conditions in the Msinga district are such that a high value crops can be grown with an adequate supply of irrigation water. There is a good possibility for stepping up production of these crops in marginal lands through appropriate crop diversification.

1. INTRODUCTION

Vegetable cultivation is widespread in the Tugela Ferry area in the Msinga district of KwaZulu-Natal province in South Africa. Msinga is semi-arid area with an average rainfall o f 600 mm per annum (varying between 400 and 900 mm). The area experiences two days of frost in winter on average and soils have a pH of 5.7 to 6.2 on average (CAP, 2003).The vegetable-based farming system in Msinga is largely divided into two, namely dryland and irrigated

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farming systems. Dryland farming in the area is considered as a livelihood "top-up" thus is not central to the farmers' livelihoods. The land under dryland farming in the area ranges between 0.4 to 1.3 hectares and these fields are attached to the family surname, thereby belong to the family permanently though this tenure is not necessarily institutionalized (Alcock, 2003). The main crops grown under dryland farming in the Msinga district are sorghum (grown for beer) and maize (grown for eating green, beer, feed for chickens, stover for cattle in winter. Sometimes this maize is milled for maize meal which is the staple diet of the local populace. Usually maize is intercropped with cowpeas, beans, different types of melons and imfe (sweetcane). There is low cash outlay in the dryland cropping system.

Irrigated farming, on the other hand, is more central to livelihoods as a source of income. The livelihoods of people in the area are adversely affected by crop failure as most people in the area depend on farming to a larger extend than in other areas in the province. The irrigation system practiced by farmers in the area is furrow irrigation. Farmers irrigate by making small furrows from the canal into their plots and flood the cropped area with water. Irrigated vegetable production in Msinga is based on plots size of 0.162 hectares (180m x 9 m) commonly known as 'beds' in local parlance. Some farmers have only one bed while others have more plots acquired through lease agreements with owners. The possession of such plots of land seems to depend on historical allocation to families and inheritance. Interestingly, one can lose the right to the land if he or she does not utilize it. Under irrigated cultivation in Msinga, farmers are able to produce two crops in each of two production seasons, the first roughly between January and June and the second from July to December. Vegetable crops grown during winter and summer include tomatoes, butternuts, spinach, sweet potatoes, potatoes, and onion in their order of importance. The main crop during summer is maize. Unlike under dryland, irrigated vegetable production incurs relatively high cash outlays.

Msinga is probably the leading district in small-scale commercial vegetable cultivation in KwaZulu-Natal partly because of its favourable climate and the long-established irrigation scheme. The local vegetable based cropping sector is crucial to the local economy, but it has faced severe problems during the last decades. Some of these problems are the prolonged fall in the production and productivity of vegetable based cropping systems, increasing cost of production, declining in market prices and drought. The Department of Agriculture and Environmental Affairs in KwaZulu-Natal with the mandate of small-scale farmers' development launched several programmes to develop this sector, including subsidy schemes for seed and seedlings, fertilizer subsidy schemes, and extension services. Despite such efforts, the performances of vegetable based cropping systems are not satisfactory. The average yield of pepper is 350-500 kg per hectare, but target yield is 1000 kg per hectare, for example. Even when farmers use same amount of farm inputs their outputs differ widely.

In view of the growing competition in the vegetable market and high production costs, production efficiency will become an important determinant of the future of South Africa's vegetable industry. Developing and adopting new production technologies could improve productive efficiency. In addition the vegetable based cropping systems could maintain their economic viability by improving the efficiency of existing operations with given technology. In other words, the industry's total output can be increased without increasing the total cost by making better use of available inputs and technology.

The role that agriculture should play in economic development has been recognized for years. The adoption of new technologies designed to enhance farm output and income has received particular attention as means to economic development. Output growth is however not only determined by technological innovations but also by the efficiency with which available technologies are used. The potential importance of efficiency as means of fostering production has yielded a substantial number of studies focusing on agriculture (Bravo-Ureta and Pinheiro, 1993; Kalirajan, 1984; Rawlins, 1985). The importance of productivity and efficiency is likely to increase in the future. Since in this study farm level data is used rather than aggregate data, it provides important insights into the micro nature of the production, which could not be captured by aggregate data that largely ignores the behaviour of individual farmers.

Following the above discussion, this study examines the efficiency of vegetable based cropping systems. The general objective of the study is to examine technical efficiency for vegetable based cropping systems in Msinga district in KwaZulu-Natal, South Africa. The specific objectives of the study were 1) to estimate technical efficiency of the vegetable based cropping system; 2) to identify the factors causing technical inefficiency of the vegetable based cropping system; and 3) to identify the causes of unsustainability of the vegetable based cropping system.

2. LITERATURE REVIEW

Measuring efficiency is not straightforward and research efforts have been devoted to improvement and refinement of the techniques used in such pursuits over the past several years. Measurements of efficiency have a long and rich history dating back to Koopmans (1951), Debreu (1951) and Farrell (1957). More detailed discussions of the evolution of modern measurements of efficiency techniques are provided by Fare *et al* (1985, 1994), Battese (1992), Lovell (1993), Greene (1999) and more recently by Kumbhakar and Lovell (2000). Despite such a history, practitioners still confront several issues, like choosing between the parametric and nonparametric approaches, that is, stochastic production frontier (SPF) versus data envelopment analysis (DEA). If the former is chosen, the researcher must then choose a functional form as well as a distribution for the inefficiency index. Both approaches have distinct advantages and drawbacks.

2.1 Issues in efficiency measurement techniques

The SPF approach requires the specification of a production technology by selecting from a small pool of functional forms. In many studies the choice of the functional form appears to be arbitrary, but the Cobb-Douglas or a flexible form, like translogarithmic, is generally adopted. A number of flexible functional forms have been proposed, however, the translogarithmic is by far the most popular alternative despite the seemingly existence of a consensus that the dominance of one functional form over others is dataset specific (Kumbhakar and Lovell, 2000). Another requirement of the SPF approach is the choice of a distribution for the inefficiency scores. Again, it appears that most researchers do not invest much time and effort in choosing a particular distributional form. Finally, the SPF approach is suited only for single-output technologies. A multi-output case can only be studied if the various outputs can be aggregated into a single aggregate output (Coelli *et al*, 2002).

Although the DEA has its own limitations, it does not suffer from the above shortcomings of the SPF (Kalaitzandonakes *et al*, 1992). In addition, Gong and Sickles (1992) found that the DEA could outperform parametric frontier functional forms when selected functional form is significantly different from the actual Data Generating Process (DGP) and when inefficiency is heavily correlated with the regressors. Recent advances relying on bootstrapping make it possible to perform limited statistical tests on DEA results. Unfortunately, the bootstrap is too restrictive and difficult to implement. Secondly, the deterministic nature of DEA makes it also very sensitive to extreme values, which are crucial in the determination of the frontier. Thirdly, the results are greatly influenced by the arbitrary choice of explanatory variables. Tauer and Hanchar's (1995) Monte Carlo simulations suggest that measures of efficiency are more sensitive to changes in the number of products and inputs than to changes in the number of observations. Finally, Coelli *et al*

(2002) showed that many firms could spuriously appear on the DEA frontier when the sample is small and there are many inputs.

The DEA and SPF share some limitations. Specifically the technical efficiency/inefficiency score of an individual firm is defined as the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by that firm. Therefore, technical efficiency is a relative concept, not an absolute one, even when applied at the firm level. Furthermore, mean efficiency scores from two samples only reflect the dispersion of the firms' level of efficiency within each sample. Consequently, a comparison of two mean scores conveys no information about the efficiency of the firms in one sample relative to firms in the other sample.

2.2 Alternative approaches to technical efficiency modeling

2.2.1 Stochastic frontier models

The seminal contributions of Aigner, Lovell and Schmidt (1977) and of Meeusen and Van den Broeck (1977) have led to many studies on efficiency over the last two decades. The general stochastic frontier production function is specified as:

$$Y_i = X_i\, b + V_i - U_{i'}\ i = 1,\ldots, N \qquad (1)$$

where:

Y_i = the output of the *i*th farm
X_i = a (1 x *K*) vector of unknown parameters
V_i = iid~*N*(0,
$U_{i'}$s = independently distributed, nonnegative, unobservable random variables associated with technical inefficiency in production such as that, for a given technology and input levels, the observed output falls short of its potential. If Y_i and X_i were defined as the logarithms of output and the inputs respectively, then Equation. 1 would be a Cobb-Douglas production function.

Specific functional forms and inefficiency distributions must be chosen to estimate the model defined by Equation 1. The most common functional forms encountered in the literature are the parsimonious Cobb-Douglas (C-D) function and the translogarithmic (TL) form, which offers the advantage of being a second-order Taylor series expansions to an arbitrary technology. The C-D functional form has been frequently used because of its simplicity. This simplicity, however, comes at the cost of imposing strong restrictions on substitution possibilities (Griffin *et al*, 1987). Second-order Taylor series expansions or the flexible forms impose fewer restrictions on the technology but their estimations are susceptible to multicollinearity, and sometimes, to low degrees of freedom problems (Bendt, 1991). Like the TL, the generalized Leontief (GL) function is also flexible. It is commonly used in the estimation of efficiency frontiers.

3. MATERIALS AND METHODS

3.1 Site selection and sampling procedure

The research was carried out in Msinga district where vegetable garden cropping systems are frequently found and more than 1,000 people are involved in vegetable crops cultivation along the Thukela river banks. A sample of 120 households was used for data collection for this study. A stratified random sample was constructed by dividing the district into the following levels of sub-units: (1) Ematateni; (2) Nkaseni; (3) Dryland farming areas.

3.2 Data collection

Secondary information on the study area was obtained from extension officers in the study area, research officers in Department of Agriculture and Environmental Affairs in KwaZulu-Natal, and a locally-involved non-governmental organization (NGO) known as Church Agricultural Projects (CAP). Such information was in the form of publications and unpublished reports and files as well as personal communication with key staff.

A structured questionnaire was formulated for primary data collection. The questionnaire comprised seven main sections:

1) General household information like household size, age and education level.

2) Farming activities, experience with vegetable cultivation, extent of cultivation of various crops and reasons for crop selection.

3) Use of inputs including land (also covering land tenure and land management), labour (both family and hired labour), seeds and other planting materials, credit and subsidies, fertilisers and pesticides.

4) Yields and prices of all relevant crops, marketing channels and marketing problems.

5) Extension services in terms of number of visits as well as the quality of advice given.

6) Open ended questions regarding the farmer's perceptions on the profitability and the future of vegetable cultivation.

7) Farmer's perceptions on constraints to increased vegetable garden productivity.

The questionnaire was pre-tested on ten non-sample households. After the pre-test, the questionnaire was modified. The final questionnaire was used to interview all 120 sample households in face-to-face interviews conducted from October to December 2003. Diversity of vegetable gardens is one of the independent variables in the inefficiency model. While all other independent variables could be estimated from questionnaire data, diversity required a survey in the farmers' fields. Representative plots were selected, following the requirements suggested by Muller-Dombois and Ellenberg (1974) that the plot should be large enough to contain the most important species that belong to the vegetable gardens.

The diversity of vegetable gardens was investigated with the Counter-Plot analysis (Muller-Dombois and Ellenberg 1974). Plot sizes varied between 0.1ha and 1.3ha.

3.3 Data analysis

Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) independently proposed a stochastic frontier production function model with the following structure:

$$\text{Ln } Y = f(X_i; \beta) + \varepsilon_i$$
$$\varepsilon_i = v_i - u_i, \ i = 1, \ldots\ldots, N$$

where Y denotes production level, X_i is input level and β is a vector of unknown parameters to be estimated. ε_i is the composed error term and f is Cobb- Douglas function form. v_i is independently and identically distributed random errors, having N $(0, \sigma v^2)$ distribution while u_i is non-negative random variables, called technical inefficiency effect, associated with the technical inefficiency of production of farmers involved.

According to Battese and Coelli (1995), technical inefficiency effects are defined by:

$u_i = z_i \delta + w_i$
$i = 1,\ldots\ldots, N$

where

z_i is a vector of explanatory variables associated with technical inefficiency effects,

δ is a vector of unknown parameters to be estimated, w_i is unobservable random variables, which are assumed to be identically distributed, obtained by truncation of the normal distribution with mean zero and unknown variance σ^2, such that u_i is non-negative.

Stochastic frontier production functions can be estimated using either the maximum likelihood method or using a variant of the COLS (Corrected Ordinary Least Squares) method suggested by Richmond (1974). The maximum likelihood method was applied, using the FRONTIER computer programme developed by Coelli (1994). The following model specifications were used in the analysis:

$$\ln Yi = \beta + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + v_i - u_i$$

where ln denotes logarithms to base e
Y_i = quantity of vegetable garden products produced by the i- th farmer;
X_1= cost of hired labour
X_2 = cost of organic fertilizer in R
X_3 = cost of inorganic fertilizer in R
X_4 = total land area in hectare
X_5 = soil fertility maintenance cost in R

Vegetable production has different outputs. The stochastic frontier technique can be used only for a single output. Therefore, the different outputs were aggregated to a single output index using the formula:

$$Y_j = \frac{\sum_{r=1}^{s} p_{rj} q_{rj}}{\sum_{j=1}^{n} p/N}$$

where Y_j is the normalized output for the j'th firm, s denotes the number of differentiated products, p_{rj} denotes the price of the r'th product for the j'th firm, and qrj denotes the amount of r'th product for the j'th firm. The average price in the denominator is defined as:

$$\bar{P}j = \sum_{r=1}^{s} p_{rj}q_{rj}/q_r , \qquad q_j = \sum_{r=1}^{s} q_{rj}$$

The inefficiency model based on Battese and Coelli (1995) specification was

$$Ui = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + W_i$$

Where,
Z_1 = Number of farm visits by extension officer per year
Z_2 = Number of farmer training classes attended by farmer
Z_3 = Other income sources of farmers
Z_4 = Slope of the land
Z_5 = Experience of the farmer
Z_6 = Age of the farmer
Z_7 = Diversity of vegetable gardens
Z_8 = Educational level of farmer

4. RESULTS AND DISCUSSION

4.1 Technical efficiency of the vegetable based cropping system

The estimated coefficient for the five inputs: labour, organic fertilizer, inorganic fertilizer, and land, soil fertility maintenance costs are shown in Table 1. Labour, organic fertilizer, inorganic fertilizer, land and soil fertility maintenance cost are significant at p=0.05 level. The estimated Maximum Likelihood (ML) coefficient of land showed positive value of 0.452, and was significant. Therefore increments of land area by one percent will increase output by 0.452%. Similarly, the estimated ML coefficient for soil fertility maintenance cost showed positive and significant value. Therefore increment of soil fertility expenditure by one percent will increase the output by 0.651%. The estimated coefficients for hired labour, inorganic fertilizer, and organic fertilizer showed positive values of 0.204, 0.024, and 0.287 respectively.

The estimated mean technical efficiency for the vegetable based system production is 84.32%. Technical efficiency level ranged from 30.53 to 97.35%, indicating a vast difference between technical efficiency levels of farmers even if they used same level of inputs. Figure 1 shows distribution of technical efficiencies. The farmer's efficiency scores are tightly clustered at the top end with few outliers which may be due to missing variables such as proximity to water. Technical efficiencies of farmers in Msinga district are expected to be high because Department of Agriculture has launched several programmes such as vegetable starter packs and extension programmes to promote vegetable production in this area. Also, several non-governmental organizations (NGOs) have supported vegetable-based systems in Msinga area.

Small-scale farmers (those who have below 1 ha vegetable farms) were found more efficient than large farmers (those who have above 1 ha vegetable farms). Mean technical efficiency of small farms was 89.93% and it ranged from 65.75 to 96.89%. However, mean technical efficiency of large farms was 79.43% and it ranged from 30.53% to 97.35%. Because most small-scale farmers are involved full time in farming, they try harder to get maximum output from their land. Both small-and large-scale farmers use some hired labour, especially during peak periods, i.e. planting, constructing and maintaining irrigation furrows and during harvesting. The higher efficient of small-scale farmers compared to their larger counterparts may be accounted for by the presence of the farmer on a full-time basis with his/her managerial acumen. Family labour was treated as hired labour in the sense that its opportunity cost was taken into consideration in order to avoid an unfair bias toward small-scale farmers in the estimation of their relative efficiencies.

4.2 Factors causing technical inefficiency of vegetable based cropping system

The estimated coefficients in the inefficiency model are of particular interest to this study. The estimated efficiency scores were used to find the factors affecting the efficiency. The factors considered in estimation of technical efficiency of farmers and their estimated coefficients are shown in Table 2. While the estimates for all other factors in Table 2 were based on questionnaire data, diversity in terms of number of species was based on inventories in farmers' fields. The inventories showed that the species number per vegetable garden ranged from 2 to 6 with mean of 4. There was no relationship between the farm size and crop diversity. From the eight coefficients estimated in Table 2, only age is not significantly related to efficiency at 5% confidence level. All the other factors affect technical efficiency level of farmers in the study area.

Table 1: OLS estimates and Maximum Likelihood Estimates for parameters of the stochastic frontier for farmers involved in vegetable based cropping in Msinga district

Variable		Coefficient			Standard error		T-ratio
		OLS	MLE	OLS	MLE	OLS	MLE
Constant	β_0	2.326	1.582	0.648	0.568	3.49*	2.78*
Hired labour	β_1	0.155	0.204	0.062	0.058	2.35*	3.47*
Organic fertilizer	β_2	0.263	0.287	0.065	0.059	4.03*	4.85*
Inorganic fertilizer	β_3	0.046	0.024	0.008	0.007	5.41*	3.27*
Land	β_4	0.399	0.452	0.073	0.064	5.44*	6.97*
Soil fertility maintenance cost	β_5	0.440	0.651	0.132	0.133	3.33*	4.86*
δ^2			0.127				
γ			0.53				
Log likelihood		-37.48	-18.36				
LR test			38.22				

* Significant at 5% probability level.

Number of farm visits by extension officer coefficient was negative and significant, which indicates that increase of the farm visits of extension officers, decreases the inefficiency level of farmers in the study area. Participation of farmers for farmer training class coefficient was also negative and significant. Because of training class their skills increase as well as their adoption of new technology for cultivation. These results indicate that government can effectively support farmers by allocating funds to human resource development.

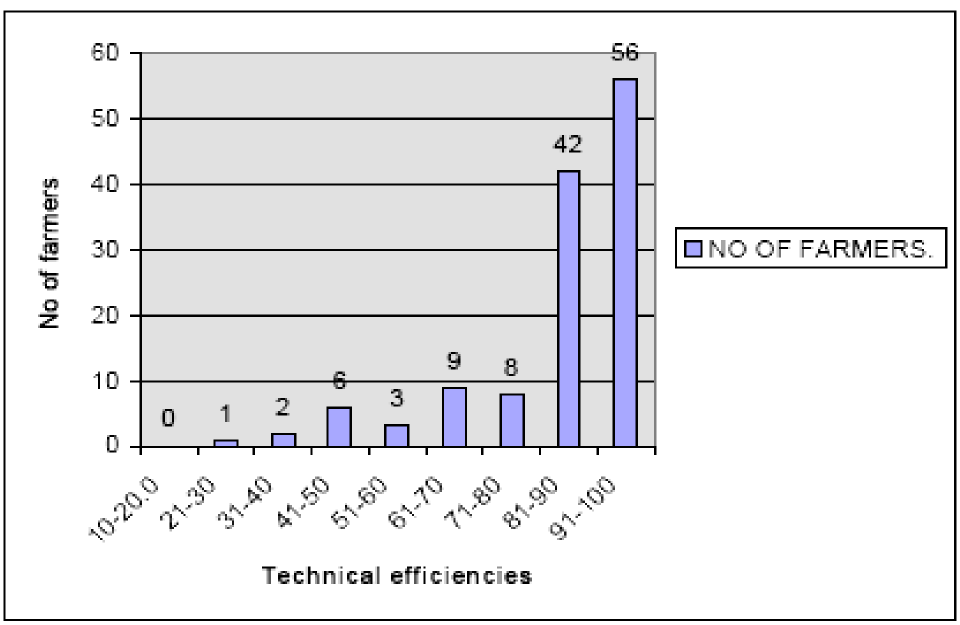

Figure 1: Distribution of technical efficiency level for farmers involved in vegetable based cropping in Msinga district

Table 2: Determinants of inefficiency in a Cobb-Douglas model for farmers involved in vegetable production in Msinga district

Variable	Parameters	Coefficient	Standard error	t-ratio
Farm visit	δ_1	-0.087	0.029	-2.911*
Farmer training	δ_2	-0.106	0.0238	-4.446*
Other income source	δ_3	0.000005	0.000002	2.488*
Slope of the land	δ_4	-0.563	0.180	-3.123*
Experience	δ_5	-0.033	0.013	-2.467*
Age	δ_6	-0.001	0.004	-0.271
Diversity	δ_7	-0.012	0.008	-1.45*
Education	δ_8	0.174	0.028	6.17*

* Significant at 5% probability level.

The experience coefficient was also negative and significant, indicating that more experienced farmers tend to be more efficient. This may be due to good managerial skills, which they have learnt over time. Extension service should be aware of the experienced farmers as a resource with potential to train the less experienced ones.

Coefficient of slope of the land also gives significant results with efficiency. Negative coefficient for slope of the land indicates that farmers who have flat land are more efficient than farmers who have sloping land. The reason is probably that if they have sloping land they will need to allocate more money for improving soil conservation of land, and cost of production will be high because irrigation is difficult and less effective on steep land. Moreover because of soil erosion in the sloping land overall productivity of the vegetable production system is reduced. Soil conservation programmes seems therefore to be an appropriate measure to improve efficiency of farmers who cultivate steep land.

The coefficient of species diversity is significant and negative. That means increase of the species diversity of the vegetable system increases the efficiency level. Some farmers grow 3-4 cash crops in the same system (e.g. tomatoes, pepper, butternuts, groundnuts, cabbages, spinach, sweet potatoes etc). But some of them cultivate one or two cash crops in the system. Species diversity is important in terms of positive effect on soil condition and erosion control. The relatively low amount of soil loss of vegetable based cropping systems can be attributed to high species diversity. Diversity of vegetables grown depends partly on farmers' preferences and partly on the geographic location (proximity to irrigation water). It would apparently be beneficial for the farmers if crop diversification programmes were implemented in the area. For this purpose, different institutions such as KwaZulu-Natal Department of

Agriculture and Environmental Affairs, AFRICARE, CAP, and other Non-Governmental Organisations should work collaboratively.

Coefficients of education and other income sources showed positive and significant relationship with inefficiency, which indicates that with increased education and off-farm income, their efficiency level decreases. A plausible explanation is that more educated farmers are involved in part time farming. Because of education they have permanent jobs and other income sources. This result suggests that those farmers who are involved in only vegetable cultivation as full time farmers are more efficient than others, because they devote more time to vegetable cultivation.

4.3 Causes of low productivity and unsustainability of the vegetable based cropping system

The majority of farms in the study area are small-scale home gardens below 1 ha. The majority of cultivations of vegetables, such as tomatoes, in the area belong to the smallholder category. Majority of owners are subsistence level farmers who are not willing to invest in productivity improvement programmes unless there is a state support or some other guarantee in the case of crop failure. Many others are part time farmers with other sources of income and not very much interested in vegetable cultivation. Only a small group of farmers have commercial orientation and are willing to improve productivity. However, because of increasing population pressure farmers do not have more land even though they want to expand the system. On the other hand the younger generation is not willing to work as farmers. They are migrating to urban areas to seek employment. Among the sample farmers, only 1.5% was below 30 years.

Input use in many vegetable based cropping systems is minimal. Only 44% of the farmers in the study use inorganic fertilizer for cultivation, but even they do not use sufficient amounts. Those who use organic fertilizer also apply inadequate amounts for cultivation. Reason for not using inorganic fertilizer is high cost. All the farmers in the study area reported that if the government would provide fertilizer at a subsidized price for farmers, they would use it. Lack of constant replenishment of soil nutrients through manure application and leaching of soil nutrients due to heavy rains are among the factors contributing to low soil fertility. Moreover, in the majority of cultivations plant density is below the recommended level and gap filling has not been done properly, so the yield per hectare is low.

Labour scarcity and high labour costs are major reasons for limited attention to productivity improvement programmes. In other words, labour productivity matters more than yields. Therefore the farmers are reluctant to adopt productivity improvement practices such as land and soil conservation practices, shade management and agronomic practices. Some farmers respond to high labour cost by selling the standing crop to the traders during harvesting time. All the farmers in the study area reported that they are getting low prices for their production. The major crops in the vegetable based cropping system in the study area are tomatoes (*Lycopersicon esculentum* L.) and green *mealies* (vegetable maize *Zea mays* L.). Price instability also causes lack of farmers' interests for productivity improvements. According to the farmers in the study area clove prices remained very low for the last five or six years and suddenly increased to record levels. But farmers had already abandoned their cultivations.

Another important constraint is the poor market link between farmers and the market, both regionally and nationally. Middlemen (mobile traders) take advantage of this situation. They buy farmers' products at a low price and sell it to final consumers in urban areas at high price. Farmers do not have proper facilities to store the product when the market price goes down, so they are unable to take advantage of hoarding. Even though the Department of Agriculture and Environmental Affairs in the province promotes the vegetable based cropping system, it has no responsibility for marketing the products. Government could assist farmers by making low-cost market information accessible on a daily basis, linked to both national and global information systems utilizing modern communication technology. Farmers could tap into the supermarkets market as this becoming the dominating form of market outlet for agricultural produce in South Africa and elsewhere (Jayne *et al*, 1997; Manojkumar, 2002). The supermarkets option provides for large volumes to be handled the supermarkets, which allows them to spread their fixed costs and hence reduce the risk of sunk-cost investments.

Vegetable based cropping system is clearly different from the large-scale commercial plantation sector such as sugarcane, citrus, viticulture, forestry etc, which is continuously searching for new technology. Small-scale vegetable cultivation sector research is largely supply driven. Thus, research outcomes on productivity improvement are according to interests of researchers and highly suitable for commercial plantations (fertilizer recommendation, weeding, soil conservation, etc.). But interest of small-scale farmers for such new technology is not encouraging.

A related important issue with production is the quality. A large proportion of vegetables leave the farm gate with quality that is far below the desired level. Many producers do not have proper processing facilities and are also not aware of the quality parameters used to grade vegetables. Small-scale producers sell small quantities of vegetables to finance daily domestic requirements. It is not economically viable to process these small quantities to expected qualities. Even if farmers produce a better quality product, there are no attractive and differentiated farm gate prices for a better quality product. Processing technologies appropriate for small scale producers are lacking. Only 13 farmers in the sample (11%) had post harvest equipment for processing and the only vegetable pack-house in the area was shutdown during the study period.

Various constraints are responsible for low income of vegetable-based cropping system. Farmers responded to these constraints in a variety of ways, the main ones being out migration of youth in farm families, the farmers work as wage labourers, neglect of vegetable gardens, and dependency on annual cash crops such as maize. All these factors will lead to unsustainability of vegetable based cropping systems.

5. CONCLUSIONS

The objectives of this study were to find the technical efficiency of vegetable-based cropping holdings in Msinga district, identify the factors causing inefficiency, and causes of unsustainability of the system. According to the result obtained from stochastic frontier estimation, the average technical efficiency of the vegetable based cropping sector given by the Cobb-Douglas model is 84.32%. Technical efficiency level of farmers ranged from 30.53 to 97.35%. Thus it is clear that there is a vast difference between technical efficiency levels of farmers even if they used the same level of inputs.

From the factors that were assumed to affect technical efficiency, higher number of farm visits by extension officer, more farmer training, less sloping land, more experience, and higher species diversity of cropping system increased the efficiency level of farmers in the study area. Higher education level and more off-farm income sources decreased the efficiency level. All these observations were significant at 5% confidence level.

Over the years the vegetable based crop farming has succumbed to a variety of constraints such as productivity, market, technology, and institution related constraints. These constraints have led to the decline of farmers' income from vegetable-based cropping system. All these factors lead to unsustainability of the vegetable based cropping system. The potential for expanded vegetable production is however high if government and other related institutions pay more attention to this sector.

ACKNOWLEDGEMENTS

The author would like to thank the anonymous referees for their invaluable comments and suggestions. Remaining errors are entirely the responsibility of the author.

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