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Full Length Research Paper

Determinants of technology adoption in the production of horticultural export produce in Kenya

J. N. Nzomoi^{1*}, J. K. Byaruhanga¹, H. K. Maritim², P. I. Omboto²

¹Masinde Muliro University of Science and Technology, P.O BOX 190, Kakamega, Kenya

²Moi University, P. O. Box 3900, Eldoret, Kenya.

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The horticultural sector is currently the second largest foreign exchange earner in Kenya after tea. It employs more than a half a million people in the formal sector and over two million people in the informal sector. The major export destinations demand some minimum quality levels of the produce entering their market. There have been technological innovations with regard to seed priming, treatment, disease and insect resistance and overall quality improvement. However the increased profitability associated with such technological advancement has not been fully enjoyed in Kenya and other developing countries due to non-adoption, partial adoption or inappropriate adoption of the improved technologies. This necessitates the application of the full range of the available technology in the production process to maximize output and profits. This paper investigates the determinants of technology adoption in the production of horticultural export produce. Multistage and random sampling methods were used to select the study areas and horticultural export producers respectively. One hundred and twelve (112) respondents were interviewed using structured questionnaires. The study covered Nakuru, Kiambu, Laikipia, Thika and Machakos districts. The data was analyzed using the omnibus logistic function employing the SPSS software Version 10. Regression results indicated positive coefficients for levels of education, role of government, funds availability and membership to professional bodies by the firms alongside other variables. Results further revealed that failure to utilize technologies was due to financial constraints, inappropriate technologies, technical knowledge, nature of the businesses, poor infrastructure, access to information as well as the technologies themselves not being available. This paper concludes that education levels, government involvement, access to finance and membership to professional bodies positively influence technology adoption.

Key words: Adoption, technology and horticulture

INTRODUCTION

Kenya's horticultural industry has been rated as the most successful in Africa (Kenyaweb, 2004). This success is attributed to the country's geographical location that gives it both a temperate and tropical climate that allows growing of a wide variety of crops. The horticultural export business in the country is in the hands of about 200 registered active exporters, majority of who are members of industry associations such as the Kenya Flower Council (KFC) and the Fresh Produce Exporters

Association of Kenya (FPEAK). Flowers constitute 60%

of the horticultural exporters and out of 100 registered flower exporters, 80 % of the flowers are exported by 50 companies, which are members of KFC. FPEAK is largely represented by 60 fruit and vegetable exporters who have contracted thousands of farmers across the country to grow specified crops for export. Four large exporters – Kenya Horticultural Exporters, Vegpro, Sunripe and Everest Enterprises, control the biggest percentage of exports. The European Union is the largest buyer of Kenya's horticultural produce led by Britain, Netherlands and Germany in that order. Other buyers include the US, Japan, the Middle East and South Africa.

Modern technology may be divided into four Principal types, (Knight et al., 1972). First we have biological technology which includes new crop varieties as well as other

*Corresponding author. E-mail: nnzomoi@yahoo.co.uk. Mobile: 0722 225015

technologies which incorporate materials of a biological nature. For instance we have technologies generated through biological breakthroughs such as breeding of new High Yielding Varieties (HYVs), disease resistant varieties or even drought resistant varieties. Second there is chemical technology which includes chemical fertilizers, chemical means for pest and weed control such as fungicides, herbicides and insecticides. Thirdly we have mechanical technology including farm machinery and farm equipment used during land preparation in such activities as tilling, pest control, weeding, spraying and transportation among others. Finally there is management technology which includes the knowledge concerned with decision-making and management of farming activities without directly involving the use of new materials.

Although the various technology types are distinct, there is a considerable overlap among them when it comes to their adoption. For instance the application of chemical, biological and mechanical technologies necessarily entails the application of managerial technology. For this reason, this study does not address itself to a specific type of a technology but aggregates together the four technology types simply as "technology". Thus, the study investigates why technology is not utilized and not which technology is not utilized. In this study horticulture is defined to include fruits, flowers and vegetables only.

In the area of horticultural production there have been technological innovations with regard to irrigation, chemical fertilization, pruning techniques and harvesting among others. The introduction and adoption of tissue culture has also become a standard technique for propagation of fruits, vegetables, ornamental plants and some tree crops (such as oil palm) in both developed and developing nations. According to Hudson (1980), the production of virus-free seedlings is important in producing healthy plants especially such crops as strawberries, potatoes, bananas and orchids. Shoot-tip grafting in such fruit crops as citrus is an improved technique, which has spread to India, China, Chile, Brazil and Egypt. Recent advances in bio-technology including genetic engineering and protoplast fusion will undoubtedly make incorporation of the desirable characters in a breeding program more feasible and faster than present conventional means. However the increased profitability associated with such technological advancement has not been fully enjoyed in Kenya and other developing countries due to non-adoption, partial adoption or inappropriate adoption of the improved technologies. Consequently it is obvious that despite these developments there are constraints that have hindered the full utilization of these production and marketing innovations. This implies that the actual marketed output levels have remained far below the potential levels if such technological innovations were fully made use of. This denies the country the much-needed foreign exchange. Hence the need for an investigation into the determinants of techno-

logy adoption in the production of horticultural produce in Kenya.

RESEARCH DESIGN AND METHODOLOGY

This study utilized primary data. A structured questionnaire containing both closed and open-ended questions was designed to elicit information relevant to the issue under investigation. The Sampling Frame, from where the sample was drawn, was obtained from the Horticultural Crops Development Authority (HCDA). It consisted of all registered producers of flowers, fruits and vegetables for export. This list consisted of both small-scale and large-scale producers.

Multistage, random sampling procedure was employed in selecting the sample from where the data was collected. This method ensures a high degree of representativeness by providing the elements with equal chances of being selected as part of the sample (Babbie, 1994). The survey data was collected from firms located in various parts of the country. The sample data was distributed as follows; Naivasha (29) (especially flower growers-where nearly 75% of total flower producers in Kenya are located), Nairobi (23), Kikuyu (12), Thika (12), Ruiru (10), Limuru (9), Nakuru (8), Athi River (4), Machakos (3) and Ngong Hills (2). A multiple regression equation was estimated by use of the omnibus logistic function under the SPSS software Version 10. Both qualitative and quantitative methods were employed in the data analysis.

CHOICE OF THE ECONOMETRIC MODEL

To adopt or not to adopt technology is a discrete choice. Discrete choice econometric models have been widely used in estimating models that involve discrete economic decision problems (Guerra and Moon, 2004). Similarly, Feder et al. (1985) recommend the use of qualitative response models in these studies, mainly the Tobit and Probit models. It is however difficult to choose between these two models owing to the statistical similarities between them (Amemiya, 1981). Baker (1992) utilized a multivariate logit model in studying computer adoption and awareness in Mexico while Heissey et al. (1993) used the same model to determine adoption of new wheat varieties in Pakistan.

This study utilized the logit model because the dependent variable is dichotomous and the model is computationally simpler. The probit model was not used because of the nature of the variables used in the study since it assumes cumulative normal distribution. Kipsat (2002) also rejects the use of the probit model on the grounds that it leads to inefficient estimators and that the estimated probabilities are not constrained to lie between the (0, 1) range demanded by probability theory.

The logistic regression, like the log-linear model, is part of a category of statistical models called Generalized Linear Models. This broad class of models includes ordinary regression and ANOVA as well as multivariate statistics such as ANCOVA. Logistic regression enables a researcher to predict a discrete outcome such as group membership, from a group of variables that may be continuous, discrete, dichotomous or a mixture of any of these. The predictor variable in logistic regression can take any form. This is because logistic regression makes no assumption about the distribution of the independent variables; -they do not have to be normally distributed, linearly related, or of equal variance within each group.

SPECIFICATION AND ESTIMATION OF THE LOGIT MODEL

This model is based on the cumulative logistic probability function. Its specification takes the following form:

Table 1. Summary of expected signs of the independent variables.

| Variable | Definition | Expected sign of its coefficient |
|----------|-------------------------|----------------------------------|
| X1 | Educational Level | Positive (+) |
| X2 | Local Technology | Positive (+) |
| X3 | Professional Membership | Positive (+) |
| X4 | Financial Constraints | Negative (-) |
| X5 | Government Involvement | Positive (+) |
| X6 | Land Type | Positive/Negative (+/-) |
| X7 | Land/Farm Size | Positive (+) |

Source: Own computation

$$P_i = F(Z_i) = F(\alpha + \beta X_i) = 1 / (1 + e^{-Z_i}) = 1 / (1 + e^{-(\alpha + \beta X_i)}) \dots \dots \dots (1)$$

Where in this notation *e* represents the base of natural logarithms which is approximated at 2.718. *P_i* is the probability that an individual will make a certain choice, in this study whether to adopt a certain technology or not. In estimating equation (1) stated above, we multiply both sides by (1 + *e^{-Z}*) *P_i* = 1 so that dividing by *P_i* and then subtracting 1 yield:

$$e^{-Z_i} = 1 / P_i - 1 = (1 - P_i) / P_i \dots \dots \dots (2)$$

However since *e^{-Z}* = 1 / *e^Z*, then *e^Z* = *P_i* / (1 - *P_i*) so that by taking the natural logarithm on both sides of the equation we obtain:

$$Z_i = \text{Log } P_i / (1 - P_i) \text{ or from equation (1) presented above, we have: } \text{Log } P_i / (1 - P_i) = Z_i = \alpha + \beta X_i \dots \dots \dots (3)$$

Where:

Log *P_i* / (1 - *P_i*) = the log of the odds that a certain decision will be made.

α = The constant of the equation

β = The coefficient of the predictor variables (Pindyck and Rubinfeld, 1991).

Unlike the probit model, one special feature of the logit model is that it transforms the problem of predicting probabilities within a 0.1 range of the real line. The slope of the cumulative logistic distribution is greatest at *P* = ½ implying that changes in independent variables will have their greatest effect on the probability of choosing a given option at the midpoint of the distribution. Because of the advantages it has over the probit model, the logit model was used in this adoption study.

Based on theoretical and empirical evidence, the determinants of adoption decisions in this study were hypothesized, *a priori*, to include the following: education level, local technology (technology developed with the participation of the intended beneficiaries), membership to professional organizations, financial constraints, government facilitation, land tenure system and land size.

Thus, the reduced-form technology adoption model was specified as:

Where: *Z_i* = *f* (Ed, TecL, ProfM, Fc, Gov, LanT, LanS,).

Z_i = Probability of technology adoption (1 if adopted, otherwise 0)

Ed = Education level of adopter/farmer

TecL = Local technology

ProfM = Professional Membership

Fc = Financial Constraints

Gov = Government Involvement

LanT = Land Type/Tenure

LanS = Land/Farm Size

Following Gujarat (1995), the specific model estimated was further assumed to take the log-linear form, which tends to give the best results. It is also very convenient for elasticity calculations. Since the study utilized cross-sectional data we specified the equation without time lags as here below shown:

$$Z_i = B_0 + B_1 \ln X_1 + B_2 \ln X_2 + B_3 \ln X_3 + B_4 \ln X_4 + B_5 \ln X_5 + B_6 \ln X_6 + B_7 \ln X_7 + e \dots \dots \dots (4)$$

Where the independent variables are:

X₁ = Education level of the adopter/ farmer

X₂ = Local technology

X₃ = Professional Membership

X₄ = Financial constraints

X₅ = Government Involvement

X₆ = Land Type

X₇ = Land/Farm Size

e = Error term

Table 1

RESULTS AND DISCUSSION

Taking technology adoption, *Z_i*, to be Ln*P* (*x*)/(1 - (*P* (*x*))) as the dependent variable in the logit model, the resulting multiple regression equation becomes;

$$Z_i = 13.743 + 1.537X_1 + 0.463X_2 + 1.646X_3 - 3.591X_4 + 1.559X_5 - 1.269X_6 - 13.674X_7$$

Based on the definitions of the variables as indicated earlier, the equation is presented as:

$$\text{Technology Adoption } (Z_i) = 13.743 + 1.537[\text{Education}] + 0.463[\text{Local Technology}] + 1.646[\text{Professional Membership}] - 3.591[\text{Financial Constraints}] + 1.559[\text{Government Involvement}] - 1.269[\text{Land type/Tenure}] - 13.674[\text{Farm/Land Size}].$$

The interpretation and discussion of each independent variable, as it relates to the dependent variable is explained here below:

Education: This variable took a positive sign (+1.537) implying that highly educated farmers and marketers are better adopters of improved technologies than less educated ones. This is consistent with our theoretical expectations and conforms to the findings of other earlier researchers (Williams, 1958; Salasya et al., 1996) as observed when reviewing literature. This positive correlation shows the influence education has on technology adoption. Educated producers and marketers have exposure to new technologies and innovations, are more receptive to new ideas and are more willing to adopt, hence the positive correlation between education and technology adoption. The education levels of the respondents ranged from secondary to university graduates. However even for the educated ones, some technologies are product-specific or site-specific and the adopters may need to be provided with information on their usage.

Local Technology: This variable took a positive sign (+0.463) as expected. This showed that technology adop-

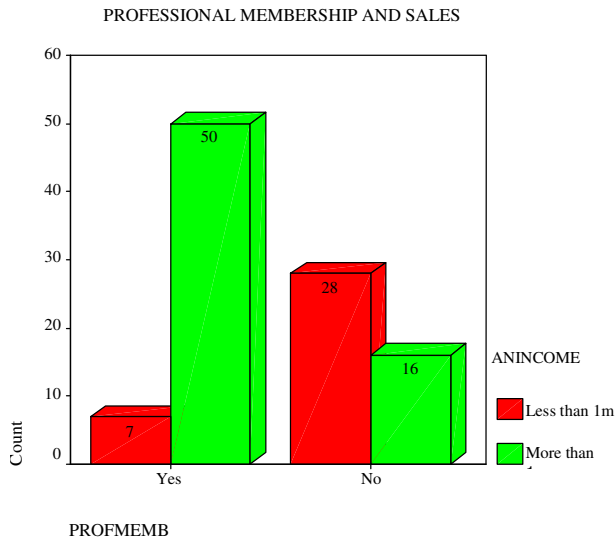


Chart 1.

tion was dependent on whether the technology was locally developed or imported. We had hypothesized that farmers do not easily adopt foreign technologies due to their complexities. The hypothesized sign for the local technology was positive due to the expectation that technologies that are developed with the participation of the intended beneficiaries do not pose difficulties when being adopted. This finding confirms the need for participatory technology development between the innovators and the farmers as recommended by Reijntjees et al. (1992) and Laurens (1997). In this regard technology itself need not necessarily be developed in the adopting country as long as the two parties can work together to ensure suitability, relevance and appropriateness of the technology. This is emphasized by the fact that individual respondents identified numerous problems associated with technologies that are not locally developed such as inappropriateness, lack of qualified personnel to implement them, and high costs associated with acquisition and utilization of such technologies.

Professional membership: This variable had a positive coefficient of 1.646 as hypothesized. The positive coefficient implied a positive correlation between technology adoption and membership to professional organizations. Producers who were members of professional organizations such as the Kenya Flower Council and the Fresh Produce Exporters Association of Kenya among others were better placed to adopt new technologies than those who did not belong to any organization. This is confirmed by the graphical output (Chart 1). Membership to such organizations enabled farmers to acquire information on any new product in the market as well as attend seminars and workshops at which stakeholders would meet and exchange ideas. This should be encouraged for both small-scale and large-scale producers.

Financial constraints: This variable took a negative sign (-3.591). This is in conformity with our expectations presented while generating the model. This hypothesis was based on the understanding that some innovations may be too costly for the adopter to access and make use of them. For this reason the variable of financial constraints was expected to negatively influence technology adoption. This meant that firms facing financial constraints are less likely to adopt new technologies than firms with sufficient funding. Based on our data set for this study, the negative sign of the variable confirms our expectations. These findings are supported by similar findings by earlier researchers (Heady, 1952; Salam, 1985; Salasya et al., 1998; Nandwa et al., 1997) who also identified costs as key determinants of adoption of improved technologies or improved varieties of seeds, fertilizers, soil conservation methods and irrigation methods among others.

Government role: Role of government took a positive sign (+1.559) as expected. The justification was that successful adoption of some technologies might require government facilitation. This showed that government plays a significant role that enables firms to enhance their production and marketing strategies. For technologies to be utilized there is need for government involvement in making it possible for the users to conveniently benefit from the availability of the new technology. It may also be said that failure to utilize technologies by the various intended beneficiaries can be blamed on the government's inability or reluctance to facilitate the same. The positive correlation means that the higher the level of government involvement the better it is for the farmers to adopt new technologies. Intervention measures to enhance technology adoption should therefore be designed to include appropriate government role. This government role should be the very bare minimum since excessive government meddling can actually curtail productivity.

Land type/ land tenure system: The variable on land ownership policy was expected to take either positive or negative sign. It was thus indeterminate depending on whether land was privately owned, leased or rented. For example farmers who are squatters may avoid adopting technologies that are expensive and are of long-term nature while those who own land may have the motivation to adopt new technologies even when such technologies are expensive. Regression results showed a negative sign (-1.269) implying that land ownership system negatively influenced technology adoption. However, it can be seen from the graphical output (Chart 2) that farmers who privately own land get the highest incomes from sales of their produce than those who have leased or rented land. Thus the positive correlation between financial strength and technology adoption would lead us to expect a positive sign if a majority of the farmers own the land on which they operate. Indeed our

data analysis show that 50.9% of the respondents operated on privately owned land while the rest either leased or rented the land. The negative sign obtained from our results was however not entirely unexpected since it was expected to take either sign.

Land size/farm size: This variable was expected to positively influence technology adoption. The basis of this expectation was that for a firm to grow and acquire a large tract of land on which to operate it might also be in a position to utilize new technology compared to smaller firms, perhaps on account of large-scale production. This variable however took a negative sign (-13.674) implying that technology adoption is negatively influenced by the size of the firm. It was expected that the advantages of large-scale production would positively influence technology adoption and vice versa so that smaller firms would find it difficult to adopt technology than large ones. Empirical evidence allows us to reject the hypothesis. Notwithstanding this rejection however, it is clear that a large firm in terms of establishment and output levels, is definitely better placed to acquire and adopt new technologies than a smaller firm. Perhaps this unexpected outcome can be attributed to the definition of farm size in this study which emphasized physical acreage rather than the volume of output which would have implied financial strength arising from the sales of the output. The second aspect to this finding is that technology adoption is not in any way dependent on farm size but is indeed a function of factors exogenous to the farm.

SUMMARY OF REGRESSION RESULTS AND MULTIPLE RESPONSE ANALYSIS

Post-harvest handling: The quality of horticultural produce is dependent on how the produce is handled and transported to the final consumers. Our data analysis revealed that 87.3% of the respondents experienced post-harvest losses before marketing their produce. Given their perishability, there is need to carefully handle the produce so as to reduce post-harvest losses and ensure it is in good condition by the time it reaches both local and foreign consumers. In the case of vegetables for example some produce such as onions and potatoes can stand transportation and are grown in areas of concentration where climate and soils suit them best. Producing vegetables and fruits in areas far away from the market necessitated careful transportation. In this case shelf life is a critical factor and in the case of tomatoes the varieties grown need to have thicker skins to prevent excessive losses during transportation.

The shape and colour of ripe produce is also an issue and farmers should avoid harvesting too late since this makes the fruits to go bad by the time they reach consumers. With a tendency to buy daily rather than buy in bulk and stock, the consumer expects to see ripe pro-

duce in the market but this has high cost implication for the producer. There is therefore need to look at the harvest cycle and determine the appropriate time to select produce to minimize spoilage. In the case of flowers however they are carefully packed and transported in containers with cooling effect so that they are fresh by the time they reach their overseas destinations.

Financial constraints: A perennial problem faced by farmers is access to working capital. In the production chain the various processes require the usage of funds so that a financially stable producer will realize higher output than a less financially endowed one. A majority of the respondents (55.5%) relied on private savings as their main source of funds for their activities. This was perhaps the case for the established firms who ploughed back profits to expand their businesses and rarely relied on bank loans. Indeed we see that only 17.3% of the respondents relied mainly on bank loans. In this study most farmers identified financial incapacitation as a major constraint in their operations. Indeed with regard to technology adoption 96.3% of the respondents were unanimous that it required funds to implement.

Poor commodity prices: Respondents identified poor and often fluctuating commodity prices as a major problem especially for the fruits and vegetable producers. This is a serious constraint given that farmers tend to produce more the higher the price. A persistently low price would be a disincentive to the farmers who may opt to produce other commodities attracting higher prices. A substantial number of flower producers however were contented with the prevailing prices offered for their produce. This was partly because of the foreign market outlet for the flowers where better prices are offered. A number of solutions were suggested to this problem including improved bargaining power in world markets. To this end 61.9% of the respondents wanted the government to assist in improving their bargaining power in the world markets. Another way of improving commodity prices was to improve its quality relative to that of your competitors.

Storage facilities: Due to lack of suitable and appropriate storage facilities on the farms and the perishability nature of horticultural produce, farmers are often forced to market produce at peak production periods to avoid incurring losses when the produce goes bad. This was the case especially with fruits and vegetables. It is however possible for the farmers to extend the season by controlled environment production such as the use of irrigation or early and late varietal selection. This is another strategy that farmers can adopt to maximize returns from their produce. In addition storage facilities need to be available at the destinations to ensure the produce is of good quality when it is sold. This ensures the right price is paid for the produce and enhances the financial position of the farmer. In this study 75.9% of the

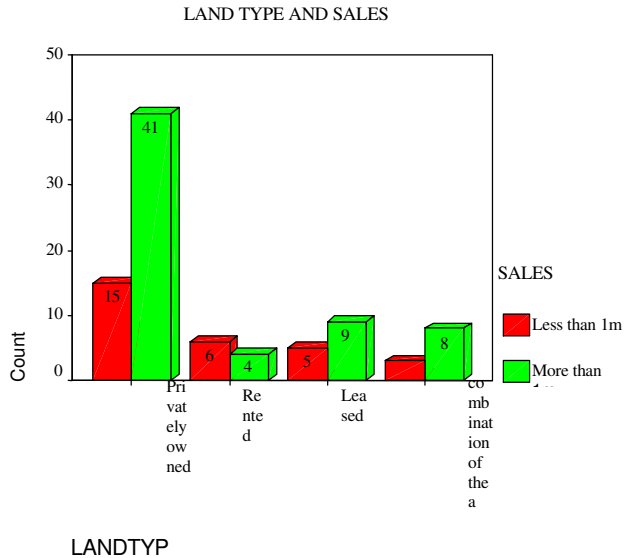


Chart 2.

firms interviewed relied mainly on foreign market outlets for their produce implying that there is need to ensure sufficient storage facilities in the importing country. This ensures that the produce is of high quality by the time it changes hands.

Market infrastructure: Accessibility is crucial to any form of business enterprise whether agricultural or industrial. In this study our findings indicate that only 10.7% of the respondents were accessible while the rest either had poor access roads or were simply inaccessible. This was especially the case for small-scale producers who lack the financial capacity to improve access roads leading to their enterprises.

The hub of any horticultural marketing network is the wholesale market. Wholesale markets are located in most urban centers but suffer from a number of serious constraints. For instance the physical size of the market may be too small to cope with the volume of trade. In other markets the problem is the availability of storage space to handle cargo as it arrives and leaves the market. The most needed facility for vegetable and fruit wholesalers is access to cold storage facilities. This greatly reduces spoilage of produce and allows traders to effectively market their produce in a measured way, rather than having to sell all deliveries on the day of arrival.

Respondents also mentioned poor road network as a constraint regarding where they can source their produce and where they can sell it. Poor road network also damages the fresh consignments and greatly reduces the life span of the vehicles carrying the produce due to tear and wear. For export purposes the air transport ensures timely delivery of produce to various international destinations. Even then, such produce would need to be deliver-

ed to the airport from the various production points in good condition so as to fetch more in international markets when exported.

Market information: Access to accurate market information is crucial to horticultural farmers. Respondents identified market information as one of the benefits they obtain from being members of professional organizations. However for the small-scale producers who do not belong to such organizations, this is a serious constraint. For such farmers the HCDA as a regulator in this field should assist in acquisition of accurate, timely and relevant information to help them plan production and marketing levels. There is need for the farmers to understand why prices change both in the short run and the long run as well as how to interpret prices and respond appropriately in terms of what and when to produce.

Conclusion and Policy Implications

From the above discussion it can be seen that the variables that influence technology adoption positively include level of education, local technology, professional membership and government involvement. On the other hand variables that influence the dependent variable negatively are financial constraints, land tenure system and land size or farm size. Thus, it is clear that before adopting any new technology farmers considered financial implications, relevance, profitability and efficiency. In this regard technology adoption can be said to be dependent on farmer characteristics and other factors exogenous to the firm.

The analysis also reveals that most production is done on small scale basis and that flower producers get more income than fruit or vegetable growers.

Based on study findings, several implications may be drawn. There is need to improve the education levels of the producers and to enhance and rationalize government role in the production process. There is also need to assist farmers and exporters to access credit as well as support professional organizations in the horticulture sub-sector. In addition, there is also need to strengthen the existing extension system and to promote the use of post-harvest technologies and facilities. Finally the provision of accurate market information as well as the provision of sound infrastructure will enhance production of horticultural export produce.

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