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Identifying Efficient and Profitable Farm Enterprises in Uasin-Gishu County, in Kenya

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Abstract: In Uasin-Gishu County, many of the farm enterprises are associated with low incomes due to price fluctuation, poor utilization of scarce production resources and increasing land sub-division. To improve the low farm incomes, farmers have gradually diversified their farming activities by adopting other farm enterprises perceived to be high yielding with high market value. The objective of this study was to compare Technical Efficiency (TE) and Gross Margins (GM) of different farm enterprises within Uasin-Gishu County to help farmers make informed decisions on the right combination of farm enterprises that eventually improve farm income. Cross-sectional data from 100 randomly selected farmers were collected and subjected to Gross Margin Analysis and Data Envelopment Analysis (DEA) methods to determine Gross Margins and Technical Efficiency scores respectively. The results showed that, passion fruit and dairy farming had the lowest level of Technical Efficiencies (56.6 and 43.4%, respectively) and higher levels of Gross Margins (Kshs 195,167 and Kshs 27, 653, respectively). Relative to maize and wheat on the other hand, maize and wheat had the highest level of Technical Efficiencies (66.3 and 75.3%, respectively) and at the same time low Gross Margin levels (Kshs 27, 328 and Kshs 27,353, respectively) relative to passion fruit and dairy farming. Passion fruit and dairy farming were the more profitable farm enterprises and have a lot of potential to improve farm incomes than maize and wheat farming but only if proper utilization of the scarce resources is observed.

Key words: Diversification, farm enterprises, gross margin, low farm income, technical efficiencies

INTRODUCTION

Statistics show that Agricultural incomes among majority of Kenyan households account for 60% of the total household income (Kuyiah *et al.*, 2006). According to IFAD (2001), poverty in Africa emanates from low farm incomes and unemployment. In Uasin-Gishu County, this is not different because; about 80% of the farmers are small-scale owning less than 2 ha of land and depend mainly on agriculture as source of livelihood (Jayne *et al*., 2001). For a long time, farmers within the county have been receiving low farm incomes from maize and wheat production. Which are mainly relied on as source of food and income. However, to improve the low farm incomes, the farmers have gradually diversified their farming activities by adopting new farm enterprises perceived to be high yielding with high market value. Currently, the farmers are adopting high value and high yielding horticultural crops that include: passion fruit, chillies, French beans among others. According to Anderson (2003) and Gockowski and Michel (2004), horticultural crops have high market value and yield more and regularly and hence suit the needs of smallholder farmers who face resource constraint and have no marketable surplus. Kuyiah *et al.* (2006) also found that high-value farm enterprises are suitable for smallholder farmers because they give more returns out of the scarce resources. Furthermore, farm enterprises such as horticulture, tea and dairy farming can increase farm incomes even under conditions of risk (Obare *et al*., 2003).

The specialization and commercialization in agricultural production have been for long believed to be part of a broader strategy of improving the farm incomes. The argument behind this is that, farmers are constrained in terms of resources and hence cannot produce all crops at the same time (Jones and Jayne, 2003). On the other hand agricultural diversification and trade-off arises from the notion that benefits from different agricultural enterprises do not fall simultaneously, so that incase income from one enterprise falls, it will be compensated by the rising income of the other enterprise(s). It is therefore, a risk management strategy farmers employ to increase and stabilize farm incomes. In addition, diversification provides an opportunity to exploit potential complementary relationships between enterprises through improved utilization of the scarce resources (Meuwissen, 2001).

The agricultural incomes have also been argued to be improved through use of high yield and adequate input

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use such as; fertilizers, seeds, credit as well as availability of good rural infrastructure and no doubt good results have been achieved (Ishtiaq *et al*., 2005). However, use of yield enhancing inputs has been considered by many studies as insufficient in improving the farmer's income because, exploitation of such opportunities have been exhausted in many rural farming areas in the world and Uasin-Gishu County is not an exception. Farm diversification at optimal levels therefore remains as one of the best alternative strategies to alleviate poverty through increase and stable farm income under conditions of resource constrain and price instability.

In Uasin-Gishu County, farm enterprise diversification happens in two ways: Enterprise dumping (total enterprise substitution) and enterprise trade-off (partial enterprise substitution). However, farmers face problems when choosing optimal combination of enterprises to produce due to resource constrains. According to Ishtiaq *et al*. (2005), farmer's profit maximization objective cannot be achieved if cropping mix chosen is not optimal. Combination of some agricultural enterprises at sub-optimal levels leads to reduction in farm incomes. Therefore, for farmers to make informed decisions regarding farm enterprise combination, it is important to understand Gross Margins and technical efficiencies of the different farm enterprises in question.

The objective of this study was to compare Technical Efficiency (TE) and GM of different farm enterprises to inform farmers on what profitable farm enterprises to produce.

This study came at the time when Kenya is facing massive land subdivision, climate change and escalating input prices. All of these factors among others have negatively impacted agricultural production. Due to the limited production resources, especially land, farmers are currently faced with problems of what to produce, how to produce and how much to produce in order to maximize farm income. This study tries to help farmers answer the questions by evaluating different farm enterprises in terms of level of technical efficiencies and gross margin levels.

MATERIALS AND METHODS

Study area: This study was done in Uasin-Gishu County, Kenya between July and August, 2008. The County covers a total area of 3327.8 km^2 and projected population is about 771,536 people. It has a population density of 232 per km^2 and approximately 2603.2 km^2 of arable land. 218 km^2 of its land is under water, swamps, rocks and hills. Urban areas cover about 196 km^2 and current total land under agricultural production is approximately 134,490 ha (Baraza *et al*., 2008). The total number of farmers is approximately 166,635 and type of farming systems and livelihoods include mixed farming (food crops and livestock) and formal/casual employment (Baraza *et al*., 2008). The County is located in the high potential (>1,800 m) and low potential (<1,800 m) agro-ecological zones. The high potential zone generally receives more rainfall over a longer period of time than the low potential zone. Rainfall ranges from 500 to 1,000 mm in low potential zones and 1,200 to 1,800 mm in high potential zones. The average annual rainfall is between 900 to 1,200 mm per year. Rainfall is unimodal with distinct peaks in April and August.

Data and sampling design: Multi-stage sampling procedure was used. First, Uasin-Gishu County was purposively selected because that was where farm enterprise dumping and substitution was taking place. Within Uasin-Gishu County, two divisions (Moiben and Ainabkoi) were purposively selected because it was also where high farm enterprise dumping and substitution was taking place. In each division, 5 locations were randomly selected to give a total of 10 locations. Each location was then stratified into two groups of farmers: those who adopted passion fruit and non-adopters. From the strata of passion fruit adopters, 5 farmers were randomly selected in each location to give a total sample of 50 respondents. The each of the 50 respondents must have produced passion faut Maize, wheat and dairy farming to be included in the analysis. The list of passion fruit adopters obtained from KHDP, Eldoret office was used as a guide in randomly selecting the sample. Data were collected using a structured questionnaire. Data on for each of the form enterprice output and input quantities as well as prices were captured.

Analysis:

Data envelopment analysis: Data Envelopment Analysis (output oriented) method that is based on variable returns to scale assumption as outlined by Coelli (1998) was used. Output oriented approach refers to how much output levels can be proportionally increased without altering the input levels. On the other hand, input oriented approach refers to how much input levels can be reduced while maintaining the same level of output. However, the choice of orientation in many cases has no influence on the results (Coelli, 1998). Furthermore, DEA that is based on variable returns to scale (VRS) was used in this study instead of Constant Returns to Scale (CRS). This is because, farmers in Uasin-Gishu County face imperfect markets, varied management styles, land constraint, capital constraints among other factors that may have prevented optimality in production. It is also important to note that, the input and output oriented efficiency scores are the same under CRS assumption but differ under VRS assumption on the measures of inefficiency scores.

Therefore, input and output oriented models estimate same frontier and identifies same set of efficient Decision Making Units. DEA is a non-parametric method and is not subject to the problems of assuming an underlying distribution about the error term and hence it is less prone to mis-specification (Whittaker *et al*., 1995). It has ability to compare multiple levels of inputs and outputs for a given DMU against all other DMUs in the data set to determine which DMUs are producing at efficient levels. It also provides information about which efficient DMU an inefficient DMU should benchmark to (Coelli, 1998). It generates optimal input/output mix that yield to maximum profit for each farm and thus helps to identify the most efficient farmers for benchmark purposes. According to Stokes *et al*. (2007), DEA is the best method in determining the best allocation of farm scarce resources and the scale of operation. However, the use of DEA has limitations; it attributes any deviation from "best practice frontier" to inefficiency and neglects the influence of nature and human incompetence. Also it does not allow statistical testing of hypotheses concerning production functions and inefficiency. DEA output oriented model is given as follows:

$$\text{Max}_{\theta}\ \lambda\theta \tag{1}$$

Subject to:

$$-\theta y_i + Y\lambda \geq 0 \tag{2}$$

$$x_i - X\lambda \geq 0 \tag{3}$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

θ Is the efficiency score for each DMU, x_i is the inputs vector, y_i is the output vector, λ is the N*1 vector of constants, $\lambda \geq 0$ is the non-negativity condition, X is the input matrix (K*N) where: K- Inputs and N-number of farmers and Y is the output matrix (M*N) where: M - Outputs.

Gross margin analysis: Comparative farm enterprise profitability can be determined by use of several techniques. Partial measures such as: GM, budgeting analysis and returns per unit of an input can be used. However, these partial measures do not obey the law of diminishing returns to scale (Whittaker *et al*., 1995) but can be preferred because of their simplicity and flexibility. GM, returns to labor and capital for each farm enterprise were used in this study to benchmark performance of different farm enterprises. GM of a given farm enterprise is the difference between total revenues and total variable costs. The use of GM analysis depends on assumptions. For example in this case land was not treated as an input because it is a fixed input shared by several farm enterprises. Both hired and family labor was considered and assumed to have equal productivity. In addition, all farmers were assumed to have used same production technology and prices used were those prevailing during production season for each of the farm enterprises for each of the farmers.

$$GM_{if} = \left(P_j Y_j - \sum_{i=1}^{n} P_i X_i \right) \tag{4}$$

where, GM_{jf} is the gross margin of enterprise *j* for farmer *f*, P_j is the output price of enterprise *j* Y_j is the output of enterprise *j*, P_i is price of input *I* and X_i is the amount of input *i* used.

RESULTS AND DISCUSSION

Gross margin analysis: Gross margin for each enterprise was determined. But, before comparing the farm enterprises, it was important that statistical test was done to determine if differences between the farm enterprises in terms of GM really existed. Tukey HSD test at 5% level of significance was performed and the results are shown in Table 1. Tukey HSD test was preferred because of its ability to compare multiple groups. The results show that, there was significant difference between the farm enterprises in terms of GM levels as indicated by $p<0.05$ for each of the farm enterprises. Cabbage and tomatoes production had $p>0.05$ indicating no significant difference between their GM levels and those of the other enterprises.

To begin the comparisons, performance of different farm enterprises in terms of GM across the selected

Table 1: Tukey HSD test for significant difference in GM for different farm enterprises

Crop (i)	Farm enterprise (j)	Mean difference (i-j)	S.E.	p-value
Passion fruit	Maize	167839*	14153	0.000
	Wheat	167813*	14153	0.000
	Beans	169138*	17334	0.000
	Millet	140309*	36770	0.005
	Potatoes	166107*	36770	0.000
	Cabbage	96007	36770	0.188
	Tomatoes	26750	28557	0.991
	Dairy	167514*	14153	0.000

*: Indicates existence of significant difference between farm enterprises in terms of GM

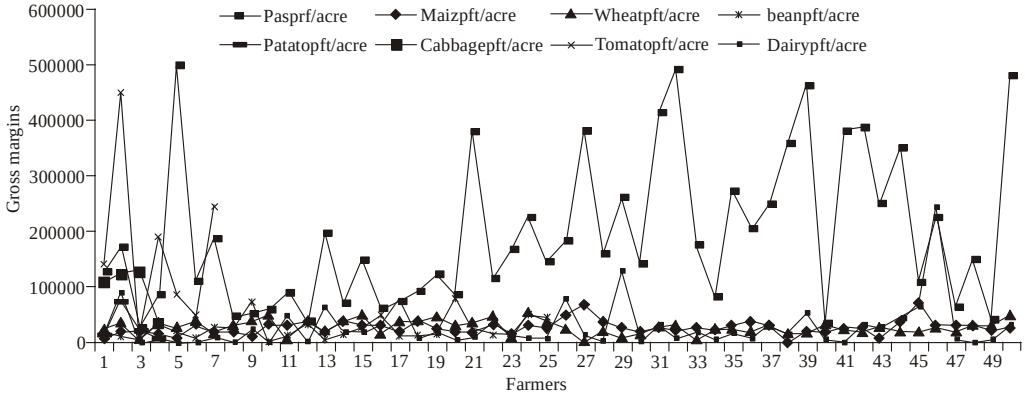

Fig. 1: Performance trend of different farm enterprises across sampled farmers

Table 2: Returns to land, labor and capital

Farm enterprises	Average Gross margin (Ksh/acre)	Labor costs (Ksh./acre)	Total variable Costs (TVC) (Ksh/acre)	Returns to labour (GM/labor costs)	Returns to cash capital (GM/TVC)
Passion fruit	195,167	35,225	87,032	5.54	2.24
Tomatoes	168,417	11,267	29,526	14.95	5.70
Cabbage	99,160	9,788	18,173	10.13	5.46
Potatoes	29,060	8,963	21,428	3.24	1.36
Wheat	27,353	9,088	19,029	3.01	1.44
Beans	26,029	6,835	9,739	3.81	2.67
Dairy	27,653	9,556	17,710	2.89	1.56
Maize	27,328	8,258	16,806	3.31	1.63

Survey data 2009

farmers were plotted as shown in Fig. 1. The results in Fig. 1 shows that, the GM curve for passion fruit lies above the curves of the other farm enterprises. This indicates that passion fruit enterprise was more profitable farm enterprise among majority of farmers. Majority of farmers got GM/acre of passion fruit ranging from Ksh. 100,000 to Kshs 500,000. The next enterprise in the rank was tomatoes with GM per acre ranging from Ksh. 100,000 to Kshs 450,000. Dairy production was third in the ranking with highest GM per acre of about Ksh. 250,000. The traditional crops (maize and wheat) earned the farmers less than Ksh. 100,000 per acre. Therefore, from this comparison, passion fruit and dairy farming were more profitable farm enterprises.

Returns to land, labor and capital: To determine returns to land, all GMs per acre for each farmer per farm enterprise were summed and averaged as shown in Table 2. Passion fruit (Ksh. 195,167) still remained the more profitable farm enterprise followed by tomatoes (168,417) while cabbage (Ksh. 99,160) was third in the ranking. Maize (Ksh. 27,328 per acre) and wheat (Ksh. 27,353 per acre) were ranked the last. Returns to labour was determined by dividing the GM per acre for each enterprise by the labour costs per acre for each of the farm enterprise. The labour costs included both family and hired labour and was assumed to have equal productivity. The results show that, tomato production was leading at Ksh. 14.95 per shilling of labour cost used, while passion fruit contributed Ksh. 5.54 per shilling of labour cost used The higher value of returns to labour in tomatoes was attributed to the fact that tomatoes production had low labour costs of Ksh. 11,267 per acre when compared to passion fruit enterprise with Ksh. 35,225 per acre. The differences in the labour costs of passion fruit and tomato production may have been due to the differences in the length of their production seasons. That is, tomatoes have shorter production season than passion fruit production and hence the shorter the production season, the lower the labour costs and vice versa. Maize and wheat were ranked the last in terms of returns to labour despite their low labour costs. The reason behind this was that, maize and wheat had low value of GM resulting from low yields and low market value of their output.

Capital for each farm enterprise was determined as equivalent to total variable costs (labour and input costs) involved in production of each farm enterprise. GM per acre for each of the farm enterprise was then divided by the total capital used per acre of each of the farm enterprises. In the return to farmers' capital, tomato production was leading at Ksh. 5.70 per shilling of capital spent in production. It was followed by cabbage at Ksh.5.46 per shilling of capital spent, beans at Ksh. 2.67 per shilling of capital spent and passion fruit at Ksh. 2.24

Table 3: DEA results

DMU no.	Passion (θ)	Passion Π/acre	Maize (θ)	Maize Π/acre	Wheat (θ)	Wheat Π/acre	Dairy (θ)	Dairy Π/acre
1	1.000	130000	0.347	10355.00	0.896	25933.3	0.221	7376
2	0.492	173986.7	1.000	19595.00	0.772	33810	1.000	90988.8
3	0.188	29550	0.472	21450.00	0.438	9750	0.204	821.1
4	1.000	88466.6	0.287	16271.43	0.819	33700	0.141	3759.7
5	1.000	500000	0.475	6610.00	0.660	27000	0.051	549.6
6	0.390	111220	0.760	32153.33	1.000	37600	1.000	1374.1
7	1.000	186800	0.643	18200.00	0.738	19450	0.151	8950
8	0.247	48700	0.623	19120.00	0.848	29800	0.089	1591.1
9	0.251	52500	0.331	11040.00	0.830	37810	0.540	22720
10	0.245	60760	0.766	35043.33	0.975	48025	0.116	543.4
11	0.284	90000	1.000	32630.00	0.921	8361.8	0.368	51846.6
12	0.259	39550	0.980	36100.00	0.868	38950	0.400	1724.9
13	0.519	197800	0.456	20265.00	0.602	21450	0.136	65510
14	0.260	72000	0.616	35783.33	0.835	39900	0.248	20232
15	0.334	150800	0.623	31560.00	1.000	49466.6	1.000	17788.8
16	0.448	63000	0.587	32300.00	0.469	15550	0.238	32780
17	0.323	76200	1.000	20741.25	0.901	36250	0.540	79600
18	0.301	92300	0.703	36550.00	1.000	36900	0.159	7128.5
19	0.444	123700	0.527	26416.67	0.941	45580	0.226	18487.5
20	0.292	87800	0.452	18071.88	0.707	31100	0.114	3910
21	0.863	383200	0.535	19056.22	0.912	35175	0.135	9350
22	0.362	118666.7	0.603	31335.00	0.875	45700	0.386	39143.3
23	0.453	168200	0.571	16176.67	0.705	10630	0.196	12100
24	0.546	225865	1.000	32100.00	0.911	51980	1.000	8416
25	0.427	147400	0.749	26878.33	1.000	38900	0.136	6466.6
26	0.511	185300	1.000	47550.00	0.701	26100	0.535	78330
27	1.000	381933.3	1.000	66290.00	1.000	2616.6	0.238	13860
28	0.436	161900	0.851	40069.20	0.562	19520	0.105	3100.6
29	0.767	262650	0.628	26600.00	0.921	8361.8	0.810	127330
30	0.407	143200	0.456	20020.00	0.460	14200	0.113	3161.5
31	0.915	414500	0.701	28150.00	0.692	26900	0.278	31445
32	1.000	493600	1.000	22357.14	0.763	29470	0.165	9147.8
33	0.444	175400	0.556	26738.00	0.359	5735	0.472	19100
34	0.262	83950	0.534	23750.00	0.679	24214.2	0.107	3683.6
35	0.704	274150	0.746	33000.00	0.649	22900	0.272	16903
36	0.503	204720	0.814	39506.00	0.552	18300	0.137	6330.9
37	0.918	250500	0.943	30700.00	0.777	30775	0.231	29710
38	1.000	361020	0.404	1586.50	0.527	15150	0.186	15413.3
39	1.000	464975	0.536	21795.00	0.549	16650	0.450	52900
40	0.282	35320	0.497	20280.00	0.980	32240	1.000	5078.1
41	0.863	383200	0.511	25102.00	0.672	23666.6	1.000	2207.4
42	0.836	387200	0.616	28590.00	0.599	18700	1.000	32068
43	0.626	250750	0.489	8293.667	0.736	28825	0.602	26921.3
44	0.818	350400	0.762	35996.67	0.517	18945	0.700	43380
45	0.639	109166.7	1.000	70580.00	0.601	19100	1.000	64116
46	0.387	225875	0.610	29355.00	0.682	26675	1.000	242000
47	0.416	65000	0.599	32140.00	0.506	19504.6	0.110	4538
48	0.401	149600	0.587	32300.00	0.811	32700	0.113	2487.5
49	0.243	42480	0.549	22553.00	0.739	28933.3	0.117	4450
50	0.566	483075	0.663	27300.00	0.753	48715	0.404	31829.4

θ: TE scores; Π: GM levels

per shilling of capital spent in production. The differences in the returns per shilling of capital spent may be attributed to the fact that tomatoes are normally produced within short season when compared with passion fruit. As a result, total variable costs within the seasons also vary. Tomatoes had the lowest total variable costs at Ksh 29,526 per acre when compared with passion fruit Ksh. 87,032 per acre. The difference may also have been due to inefficiency in the use of resources (either underutilized or over utilized) in production of passion fruit.

Generally, it was expected that farm enterprises with higher production costs will have low returns to labour and capital. However it was not the case for tomatoes and passion fruit which had the highest production costs and at the same time higher returns to labour and capital when compared with maize and wheat which had low production costs as well as low returns to labour and capital. The reason was that, unlike maize and wheat, horticultural crops (like tomatoes and passion fruit) are high yielding and high value crops (Obare *et al*., 2003; Kuyiah *et al*., 2006) which eventually translates to higher gross margin levels even under circumstances of higher production costs. The higher total variables costs associated with passion fruit and tomatoes were attributed

to the fact that passion fruit and tomatoes (horticultural crops) are high consumers of pesticides and labour intensive.

Results of the data envelopment analysis: Data Envelopment Analysis was used to identify technically efficient farmers in each of the farm enterprises. The gross margins of technically efficient DMUs or farmers in each of the farm enterprises were used for comparative analysis. The rule of the thumb was that, technically efficient DMU must have an efficiency score of one while inefficient DMU must have an efficiency score less than one. Passion fruit, maize, wheat and dairy farming were used in the analysis because they were common enterprises among the respondents. Beans, cabbage, potatoes and tomato production had varied number of observations (farmers) and at the same time less than fifty and thus they were dropped in the analysis. For better results, only Passion fruit, maize, wheat and dairy enterprises were used in the analysis because of their homogeneity in terms of number of observations. The DEA results are presented in Table 3.

The results show that, the mean technical efficiency in passion fruit was 0.566, maize, 0.663, wheat 0.753 and dairy farming 0.404. The technical efficiencies means, only 56.6, 66.3, 75.3 and 40.4% of the total possible output per acre were obtained respectively. The remaining percentages of output per acre were lost due to improper utilization of the resources and other extraneous factors. Although passion fruit and dairy farming were more profitable, their activities remained largely manual hence contributing to poor resource utilization in production than in the case of maize and wheat as indicated by their low technical efficiencies. Nonetheless, this indicates that passion fruit and dairy enterprises still have a lot of potential to increase further the current farm income if the limitations are minimized. That is, if full efficiency in production is achieved in all the farm enterprises, passion fruit and dairy farm enterprises will increase the current farm income by a bigger margin than the increase by maize and wheat. The differences in the efficiency scores might have been due to the use of mechanization and scale of production. Mechanization is widely used in wheat farming operations than in maize production. Mechanization improves production efficiency and that is why the efficiency score in wheat production is higher. In conclusion, passion fruit and dairy production is suitable for smallholder farmers who face scarcity of resources. This is because, passion fruit and dairy farming has high potential for increasing further farm incomes than traditional crops such as maize and wheat. Passion fruit is a horticultural crop (and cash crop) associated with high market value hence its ability to increases farm incomes by greater margin.

CONCLUSION

Passion fruit and dairy farming were the more profitable farm enterprises when compared to the traditional farm enterprises (maize and wheat). This shows that, comparative advantage of producing passion fruit and dairy farming in Uasin-Gishu County exists. Passion fruit and dairy farming had the lowest level of Technical Efficiencies (56.6 and 43.4%, respectively) and higher levels of gross margins (Kshs 195,167 and Kshs 27,653, respectively). On the other hand, maize and wheat had the highest level of Technical Efficiencies (66.3 and 75.3%, respectively) but low gross margin levels (Kshs 27,328 and Kshs 27,353, respectively) relative to passion fruit and dairy farming. Even though passion fruit and dairy production had the highest profit margins, they still have a great potential to increase further the farm incomes as indicated by their low Technical Efficiency scores. However this will only be possible if proper utilization of the scarce resources is observed.

RECOMMENDATION

- Farmers are advised to adopt passion fruit and dairy farm enterprises. This is because they are more profitable and have a higher potential to increase further farm incomes even under conditions of resource constrain as indicated by their higher gross margin levels and low Technical Efficiency scores.
- Given the low technical efficiency levels of all the farm enterprise, farmers are advised to properly utilize the scarce production resources. This will help reduce cost of production as well as increase yields and consequently farm incomes.
- This study determined Technical Efficiency scores for different farm enterprises but did not determine the causes of inefficiency in production of the farm enterprises. Further research to determine causes of the production inefficiency is recommended. Understanding the causes of production inefficiencies in different farm enterprises will be important in formulation of effective and efficient policies necessary for improving efficiency in production.

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