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Important Variables Influencing Milk Yields on Smallholder Farms in Western Kenya

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ABSTRACT----- ***This study sought to assess the most important variables influencing milk yields on smallholder farms in Western Kenya, a region with persistent milk insufficiency. Four approaches were assessed on ranking of important variables: Use of farmer focus groups, key informant interviews (pair-wise ranking of variables), beta weights and Product measure (multiple linear regression). The findings showed that all the four methods produced different ranking order. Using a combined weighting system, the most important variables influencing milk yields on smallholder farms were found to be fodder; dairy meal, credit, Artificial insemination, improved research technologies, group membership, policy and economic returns. Collectively, they explained 63.9% of the variance in milk yields in the area (F_8, 291= 65.089, p<0.001).We argue that a combined weighting approach appears to be a sharper ranking method in selecting important variables from many components in a value chain system.***

Keywords---- smallholder farms, milk yields, important variables, pair-wise ranking, beta weights, product measure, multiple linear regression

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1. INTRODUCTION

Kenya and Sudan are the largest milk producers in Sub Saharan Africa accounting for 47% of the total cow milk produced, with Kenya having a market share of 24 percent (Karanja, 2003). The dairy industry in Kenya is the single largest agricultural sub-sector, contributing 14 percent of agricultural GDP and 4 percent of total GDP (Muriuki et al. 2004). Dairy production under the intensive system consists mainly of small-scale subsistence model, multi-objective farmer behaviour, low levels of inputs and outputs, and dominated by informal marketing of liquid milk (Ndambi et al., 2007; Staal et al., 2008). To revitalize and put Africa's agriculture on a commercialization path, New Partnership for African Development (NEPAD, 2002) through Comprehensive African Agriculture Development Programme (CAADP) strategy outlines the need for national agricultural sectors to focus on strategic commodities using the value chain approach (UNECA, 2007). Within this framework, Kenya through Vision 2030, has adopted the value chain approach to commercialize smallholder agriculture, including dairy (Government of Kenya, 2007).

Despite these efforts, there still exist gaps on how to determine out of many components in the value chain system the most important variables necessary for upgrading the dairy value chain with smallholder inclusion. Current methods employed to identify interventions are mainly qualitative (GTZ., 2008; Rich et al., 2009; Trienekens (2011). The objective of the study was to identify and prioritize, using a combination of both qualitative and quantitative methods, the most important variables influencing milk yields on smallholder farms in Western Kenya region. Low production of cows and low milk supply still persist in Western Kenya despite indications of great potential for dairy development in the region (Waithaka et al, 2002; Wanjala et al., 2014). The study would be useful in informing new approaches in selection of key interventions necessary in upgrading the milk value chain in the region.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Butula and Butere sub counties in Busia and Kakamega counties of Western Kenya. Western Kenya lies on the Equator between latitude 0.030N to 10N and 340 E to 35.300E longitude. The region has an estimated 99000 smallholder dairy farmers keeping about 192300 improved dairy cattle (FAO, 2011). Western Kenya produces about 215 Million litres of milk and is a deficit region (Waithaka *et al*., 2002; Wanjala et al., 2014). Both Butula and Butere lie in Agro Climatic Zone (ACZ) Low Midland 1 (Jaetzhold *et al*., 2006) characterised as sugarcane-maize zone, at an altitude of 1200-1500 Meters above sea level. Mean annual rainfall is 1500-2000 mm and is bimodal with long rains occurring in March-May and short rains October-December. Farmers practice mixed livestock-crop farming: Sugarcane is the main cash crop, while maize, cassava, beans, sorghum, millet and sweet potatoes are major food crops. Livestock kept include indigenous chicken, local zebu cattle, sheep and goats. Dairy farming is a key activity in Butula and Butere. Butula has a dairy cattle population of 3400 and about 1700 farmers, while Butere has a dairy cattle population of 2600 and about 1300 farmers. There are six administrative divisions, three in Butula and three in Butere.

2.2 Study Variables, Data collection and Analysis

2.2.1 Step 1: Qualitative approach

Eleven potential predictors from the value chain system were selected from a review of secondary data, six focus group discussions and six key informant interviews with livestock department (Morgan, 2002). These included fodder, dairy meal, extension, research technologies, Artificial Insemination (AI), group membership, credit, vertical linkages with buyers, economic returns, policy and community attitude. Within each sub county, all divisions were stratified and each produced one focus group. Each group comprised twelve participants: six men and six women randomly selected from a list provided by group leaders. The groups identified the variables influencing milk production on smallholder farms followed by prioritization using pair wise ranking method (Mulwa, 2006). Key informants from livestock department separately, also ranked the variables through interviews (Werner, 1993; Saunders et al., 2009)

2.2.2 Step 2: Quantitative approach - Use of Beta Weights

A cross-sectional survey using semi structured questionnaire was carried out from a stratified proportional random sample of 400 farmers keeping dairy cattle in Butula and Butere. 227 farmers were chosen from Butula while 173 were selected from Butere. The questionnaire was administered by trained enumerators selected with the assistance of the livestock office. The questionnaire sought to assess the influence of each of the eleven variables (Independent variables-IVs) on milk production (dependent variable- DV). The responses were measured on a likert scale (1= strongly disagree, 2= disagree, 3= neutral, 4 = agree and 5= strongly agree) and, were re coded into dummy variables for easy interpretation of the results in a multiple regression analysis (Tabachnick and Fidell, 2001; De Maris, 2004). Responses 1, 2 and 3 were coded 0= absence, while responses 4 and 5 were coded 1. Bivariate correlation analysis were carried out on farms producing milk only (Saunders et al., 2009, Hinkle et al., 2003). Variables with significant p values were analysed further using multiple regression and the resultant beta weights (contribution of each independent variable to the regression equation, holding all other independent variables constant) used to rank important variables (Nathans et al., 2012; Nimon et al., 2010; Pedhazur, 1997).

To ensure that the effect produced by each IV was not as result of one or more of the other variables (Pedhazur, 1997), collinearity diagnostics was carried out using three standard measurements of Tolerance (T), Variance Inflation Factor (VIF) and condition index. Evidence of Multi collinearity problems exist when the values of $T<0.1$, Variance Inflation Factor (VIF)>10, Eigen value = 1, Condition index = 30 (De Maris, 2004; Tabachnick and Fidell (2001).

2.2.3 Step 3: Quantitative approach - Use of Product Measure

The product measure (Pratt (1987), was calculated by multiplying the variable's correlation (its relationship to the dependent variable in isolation from other independent variables) by its beta weight (which accounts for contributions of all other predictors to the regression equation). The product measure uniquely reflected in one statistic both direct and total effects (LeBreton et al, 2004) and hence enable ranking of important variables based on the non over-lapping partitioning of the regression effect (Nathans et al., 2012).

3. RESULTS AND DISCUSSION

3.1 Qualitative rankings

The results of ranking of important variables influencing milk production on smallholder farms are shown in Table 1. In depth focus group discussions with farmers ranked fodder, dairy meal, availability of AI services, access to credit and use of improved research technologies as the most important variables. Farmers perceived community attitude, linkage with buyers and returns as least important. The livestock department on the other hand identified fodder, community attitude, extension, dairy meal and AI services as most important while favourable policies, higher returns from milk sales and use of improved research technologies were ranked least. Thus both the top-down approach (livestock department) and the bottom-up approach (farmer groups) yielded different perspectives on priority factors affecting milk production.

The results indicate that though qualitative approaches are rich in providing insights on phenomenon under investigation (Saunders et al., 2009; Mulwa, 2006; Kruger et al., 2000; Werner., 1993), stakeholders in the same sector have different order for ranking important variables. This could have implications on priority interventions and hence the need for consensus before designing and implementation of appropriate policies and development programmes that support participation of smallholders. Rich et al. (2009) observes that qualitative methods alone are indeed incapable of accurately determining where in the value chain stakeholders should
focus and what would be the impact of such interventions.

Table 1: Summary of pair wise ranking of important value chain factors influencing milk production on small holder farms

	Butula			Butere			Total	Overall Rank	
Parameter	Marachi West	Marachi Central	Marachi East	Butere	Lunza	Shiatsala		Farmer groups	Livestock Department
Fodder	1	1	2	1	1	1	7	1	1
Dairy meal	2	2	3	2	2	2	13	2	4
Availability of AI service	3	3	1	3	3	3	16	3	5
Extension advice	6	5	4	5	6	6	32	6	3
Use of improved research technologies	4	6	6	4	7	4	31	5	9
Access to Credit	5	4	5	6	5	5	30	4	6
Group membership	7	8	7	7	4	7	40	7	7
Linkage with buyers	10	10	9	11	10	11	61	10	8
Higher returns from milk sales	9	9	10	9	9	9	55	9	10
Favourable policies	8	7	8	8	8	8	47	8	11
Community attitude	11	11	11	10	11	10	64	11	2

Legend: 1 = highest, 11 = lowest

3.2 Relationships between variables

Assessment of independent variables to determine whether there is a linear relationship with milk yields on smallholder farms are indicated in table 2. Out of the eleven variables entered, three variables (extension, community attitude, linkages with buyers) were not significant and therefore dropped. The findings showed that there was significant and positive correlation between availability of fodder, dairy meal, AI, credit, group membership, policy and research technologies and average milk yield on farms ($p<0.001$). This means that as these variables increase, milk production also increases and as they decrease, milk production also decreases.

Returns from milk sales was significant at 5 % level but with negative relationship with milk yield, meaning that higher returns from milk sales do not have a corresponding increase in yields in the study area. Bivariate correlation among the independent variables showed that all values were less than 0.7. Saunders et al (2009, pg. 459), classify a value greater than 0.7 as a strong positive relationship. Thus the findings indicated that the eight variables had low collinearity problems and hence potential candidates in a multiple linear regression analysis.

Table 2: Pearson's Correlation analysis

	Average milk yield/cow /day in litres	Fodder Dummy	Dairymeal dummy	Research dummy	Credit dummy	AI Dummy	Group dummy	Policy dummy	Returns dummy
Average milk yield/cow/ day in litres	1.000								
Fodder dummy	.599*	1.000							
Dairymeal dummy	.656*	.545	1.000						
Research dummy	.338*	.152	.222	1.000					
Credit dummy	.519*	.365	.490	.163	1.000				
AI dummy	.334*	.240	.205	.011	.093	1.000			
Group dummy	.627*	.450	.692	.127	.510	.285	1.000		
Policy dummy	.449*	.369	.365	.057	.309	.163	.511	1.000	
Returns dummy	-.145**	-.017	-.103	-.134	.007	.128	-.086	-.055	1.000

*p<0.001, **p<0.05

3.3 Predictors of Milk Production

The multiple regression model employed to determine the relationship between eight independent variables (x_1 to x8) and one dependent variable (Y - milk yield) is given below:

$$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + e,$$

Y = Milk Yield (litres)
b_o= Intercept value (constant)
X_1= Fodder dummy
X_2= Dairy meal dummy
X_3= Credit dummu
X_4= Artificial insemination dummy
X_5= research technologies dummy
X_6= group membership dummy
X_7= Policy dummy
X_8= Returns dummy
e = Error term (normally distributed around mean of zero)

b_1 to b_8= Corresponding coefficients of X1 through X8 (amount induced in Y by a unit change in X.

The findings of the multiple linear regression model shown in table 3 reveal that the adjusted R^2 was 0.639. This means that the variables in the model collectively explained 63.9% of the variance observed in milk production in the study area. The remaining 36.1% could be due to other factors beyond the scope of this study. The ANOVA F–statistic showed that P value was less than 0.001 meaning that the model was statistically significant (F_8, 291 = 65.089, p<0.001) and hence a good fit. All the eight variables were highly significant and thus indicating a linear relationship with milk yield on smallholder farms.

The most important predictors with a big effect on milk yields as judged by the strength of beta co efficients (Nimon et al., 2010; Nathans et al., 2012), were: Fodder, dairy meal, research, credit, artificial insemination, group membership and policy. Returns had a significant but negative effect in increasing milk yields. The beta coefficient for each predictor variable is the change in milk production that would result from one unit change in the predictor variable, keeping all other variables constant. For instance, the coefficient of fodder was positive and significant at 1%. According to the results, one unit change in fodder will result in 0.245 unit change in milk yields. Similar findings on significant inputs affecting milk production have been reported in Australian dairy farms by Zamykal et al (2007).

Table 3: Multiple linear regression analysis

Variable	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.765	.457		3.859	.000*
fodder dummy	1.903	.341	.245	5.578	.000*
Dairy meal dummy	1.643	.422	.210	3.888	.000*
AI dummy	1.303	.296	.167	4.406	.000*
Credit dummy	1.416	.353	.172	4.016	.000*
Policy dummy	.901	.339	.111	2.656	.008**
Research dummy	1.472	.289	.187	5.093	.000*
Returns dummy	-1.058	.394	-.098	-2.684	.008**
Group dummy	1.202	.454	.147	2.649	.009**
Adjusted R^2 = 0.639 F_8, 291 = 65.089 P < 0.001 N= 291 Constant=1.765 Std error = 0. 457					

* P<0.001, ** P<0.01
Source: Compiled from field data

3.4 Assessment of Multicollinearity

According to Pedhazur (1997) and Zientek and Thompson (2006), the more predictors there are in the model, the greater the potential for multicollinearity or association between variables. Multicollinearity diagnostics was performed in order to validate the model's ability to produce accurate predictions. In order to combat multicollinearity, several diagnostic tools were used simultaneously to highlight and identify any variables that contribute to the problem. The results on collinearity diagnosis are given in table 4. The Multiple regression model employed eight variables. There was no **e**vidence of serious multi collinearity since the standard indicators of Tolerance, Variance inflation factor, Eigen value and condition index were within the normal range (Tabachnick and Fidell, 2001; DeMaris, 2004).

Table 4: Collinearity diagnostics

Variable	Tolerance (T)	Variance Inflation Factor (VIF)	Eiglen value	Condition Index
Fodder Dummy	0.647	1.545	0.567	3.441
Dairy meal Dummy	0.427	2.342	0.427	3.596
Research Dummy	0.927	1.078	0.062	10.448
Artificial insemination Dummy (AI)	0.872	1.147	0.263	5.058
Credit Dummy	0.680	1.470	0.352	4.371
Group membership Dummy	0.403	2.484	0.250	5.181
Policy Dummy	0.711	1.407	0.098	8.273
Returns Dummy	0.941	1.063	0.173	6.223

3.5 Ranking using beta weights and Product measure

Table 5 shows ranking of variables using statistical techniques of beta weights and product measure. Beta weights are heavily relied on to assess variable importance (Nathans et al., 2012; Nimon et al., 2010. The regression weight for each independent variable is interpreted as the expected change in the dependent variable that would result from one unit on that independent variable, with all other independent variables held constant. Using the beta weight measure, Fodder dummy, dairy meal dummy, research dummy and credit dummy were ranked highest. Nathans et al (2012) and LeBreton et al (2004) argue that because the beta weight calculation process accounts for the contributions of all variables in the model to the regression equation, each beta weight is a measure of the total effect of an independent variable. According to Pedhazur (1997), sole reliance on using beta weights is only justified in situations where variables are perfectly uncorrelated (i.e. have a 0 value for each pair on correlation matrix). Pedhazur (1997) further observes that a given beta weight may receive the credit for explained variance that it shares with one or more independent variables and hence the other weights are not given credit for this shared variance and, their contribution to the regression effect is therefore not fully captured in the beta weight value.

As a result of this limitation, Pratt (1987) proposed the product measure, which is calculated by multiplying the variable‘s correlation (its relationship to the dependent variable alone) by its beta weight (its contribution when together with other predictors to the regression equation). This measure thus enables rank orderings of variable importance based on the partitioning of the regression effect and uniquely reflects in one statistic both direct and total effects. As shown in table 5, the product measure approach ranked most important variables to be fodder, dairy meal, group membership and credit. Thus both the beta weight and Product measure approaches give a slightly different rank order.

Table 5: Ranking important variables using beta weights and product measure

Predictor	Correlation (r)	Beta weights (b)	Product measure (rb)
Fodder dummy	0.599	0.245	0.147
Dairy meal dummy	0.656	0.21	0.138
Research dummy	0.338	0.187	0.063
Artificial insemination dummy	0.334	0.167	0.056
Credit dummy	0.519	0.172	0.089
Economic returns dummy	-0.145	-0.098	0.014
Group membership dummy	0.627	0.147	0.092
Policy dummy	0.44	0.111	0.048

3.6 Prioritization of Interventions using combined measures

Table 6 summarizes rank order of important variables using different approaches. The eight variables shown were selected through quantitative analysis described in tables 3 and 5. There was agreement between the four approaches on the top two important variables: fodder and dairy meal, and the last two variables: economic returns and policy. However, a slightly different rank order was obtained for the remaining variables. Indeed, quantitative methods are useful in establishing statistical significance and hence support validity, but statistical significance without theoretical or practical significance does not support validity. Because of the richness in data and insights obtained when using both quantitative and qualitative methods (Saunders et al., 2009), we argue that a combined weighting appears to be a better approach in selecting important variables since it capitalizes on the strengths of each to reflect the theoretical basis of the research issue. Using this ranking method, the most important variables influencing milk production on smallholder farms were found to be: fodder; dairy meal, credit, Artificial insemination, improved research technologies, group membership, policy and economic returns.

Based on these findings, a combined weighting system has added advantage as it may provide a sharper targeting in selecting out of many components within the value chain system: the most important variables influencing milk yields on smallholder farms; identification of key stakeholders and where resources are limited for carrying out all key interventions identified, assist in prioritization.

Table 6: Prioritization of important variables using different measures

Variable	Ranking				average	Overall
	Farmers	Livestock department	Beta weights (b)	Product measure		
Fodder	1	1	1	1	1	1
Dairy meal	2	4	2	2	2.5	2
Research	5	9	3	5	5.5	5
Artificial insemination	3	5	5	6	4.75	4
Credit	4	6	4	4	4.5	3
Economic returns	9	10	8	8	8.75	8
Group membership	7	7	6	3	5.75	6
Policy	8	11	7	7	8.25	7

4. CONCLUSION AND RECOMMENDATIONS

This study sought to assess the most important variable influencing milk yields on smallholder farms. Four approaches investigated: Use of farmer focus groups, key informant interviews, beta weights and Product measure produced slightly different ranking order. Using a combined weighting system, the most important variables influencing milk yields on smallholder farms were found to be fodder; dairy meal, credit, Artificial insemination, improved research technologies, group membership, policy and economic returns. We argue that a combined weighting appears to be a sharper ranking method in selecting important variables from many components in a value chain system.

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6. POTENTIAL CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

7. 7. REFERENCES

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