cost efficiency of watermelon production in Tanzania

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Abstract:

ABSTRACT This study was designed to assess the cost efficiency of watermelon production in Rufiji and Mkuranga Districts. Specifically the study determined cost efficiency level of watermelon farms, determined variation in cost efficiency between farms of different size and capital and examined sources of cost inefficiency. Two stage random sampling was used in selecting 200 farmers from the two Districts who were used to collect information required in achieving the major objectives of the study. Cost efficiency (CE) for farms in Mkuranga ranges from 0.10 to 0.99 with the mean CE of 0.73. Results for Rufiji show that the CE for the farms ranges from 0.89 to 0.99 with the mean CE of 0.90. Findings also revealed that farms with small farm size and capital size had higher mean CE than farms with large size and capital size in the study area. As for the sources of cost inefficiency, education level, farm size, capital size and logistic services were found to have significant influence on cost inefficiency. Apparently, these results suggest that watermelon production is generally cost efficient and the efficiency is influenced by capital size and farm size in the selected areas of study. Recommended in this paper is the encouragement of farmers to consider size of capital and farms when producing watermelon to ensure maximized efficiency. Keywords: Watermelon, Smallholder Farmers, cost efficiency, Tanzania.

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1.0 Introduction

Watermelon is used as a cash crop in various parts of Tanzania where it is produced such as Mkuranga and Rufiji districts. Besides being produced with high input costs, watermelon is considered to be one of the most important cash crops grown along the coastal part of Tanzania (Mkuranga reports, 2014). It is a fruit with nutritional and health benefits contributing to about 30-50 per cent of total calories needed by a person per day (Busari *et al*., 2012). Thus, the increasing awareness of health benefits increased the importance of watermelon in Tanzania (Nga, 2013). Along with this healthy awareness, there is a possibility of finding employment throughout the year for smallholder farmers and agricultural labourers through watermelon production as the crop is not seasonal (Lwangia, R., personal communication, 2015). Furthermore, watermelon is generally a labour intensive crop and thus offers a considerable promise for generating increased rural employment opportunities. For example, over the past decade, watermelon subsector provided employment to about 536 000 farmers and traders (Rufiji and Mkuranga reports, 2014).

Watermelon production in Tanzania

Watermelon production in the study area has led an ardous road for years and inspite of its importance to smallholder farmers' livelihood, yet recently there have been downfall situation. For example Table 1 shows an increasing trend of watermelon production in Mkuranga and Rufiji districts from 2010/11 to 2013/14. However, in 2014/15 and 2015/16 the production volume decreased. Mburu *et al*. (2014) and Rufiji and Mkuranga reports (2016) ascertained that the problems of difficult access to production inputs due to high cost of production inputs are the cause and detrimental to the effort of increasing production. For example Tanzania fertilizers are tax free but there are about six indirect taxes and charges that contribute to high price of fertilizer before reaching the farmer. This is high compared to Uganda which has four taxes and Kenya which has five charges (Mkindi, 2016). This is probably why Todd *et al.,* (2012), reported that Tanzania's agricultural input intensity is very low compared to other countries in Sub-Saharan Africa. For example fertilizer application rate is 19.3 kilogram per hector (kg/ha) in Tanzania which is lower than 100 kg/ha of Kenya. According to Mkuranga district report (2014), the production of watermelon is very demanding, in terms of production inputs needed. Farmers have mainly relied on improved input technologies to increase watermelon production. Being produced under smallholder farming, watermelon needs improved seeds, irrigation and other productivity enhancing technologies such as fertilizers, insecticides, fungicides, herbicides and for proper handling from the farm to the consumer (MAFSC, 2013). However, very few farmers can manage to use those new innovations due to high watermelon input costs (ESRF, 2010; Ngaiza, 2012; Kayandabila, 2013). That is, about 70% of Tanzania farmers are not using pesticides, insecticides, herbicides, improved seeds and other improved agricultural inputs due to high cost (Aloyce *et al.,* 2015). This negligible improved inputs use partly explains lagging agricultural production level growth in the country (Morris *et al.,* 2007). Encouraging increase use of improved inputs may not solve the problem of low production unless efficiency is determined, that is to see if the resources are optimally used. This is so especially when it is reported that, in view of the production level situation, it seems efficiency has been declining (Mkuranga and Rufiji report, 2016). Therefore, there is a need to better substantiate or refute this statement by providing scientific evidence.

Table 1: Watermelon production in Mkuranga and Rufiji Districts; 2010/11 – 2014/15

District	Production (Tons)					
	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Mkuranga	1,157	1,762	3,565	10,166	1,870	1700
Rufiji	1,350	1,200	7,240	9,280	4,053	3870

Source: Rufiji and Mkuranga Districts annual reports (2016)

Rapid growth in demand from expanding populations in Tanzania, in which estimates suggest that there might be 150million Tanzanians by 2050 with Gross domestic product growing nearly at 7% per annum the increased national prosperity and population will stimulate demand for watermelon, thus farmers have become important in ensuring watermelon is available (Lewis and Trevor, 2015). However, their importance in this subsector will be valued if they benefit out of this business (Nga, 2013). Following commercialization of agriculture, watermelon cost efficiency might be convenient for farmers to maximize their benefits and handle other costs resulting from production of other food crops. This is well explained by the economic efficiency theory which asserts that production of a unit of a produce such as watermelon is considered to be economically efficient when that unit of the product is produced at the lowest possible cost (Mbanaso and Kalu, 2008). There's a hidden assumption here, "all else being equal". A point to note is that, a change that lowers the quality of the good while at the same time lowers the cost of production does not increase economic efficiency. Moreover, the economic efficiency theory provides a basic framework to help understand the various factors that are associated with existing production costs (Mbanaso and Kalu, 2008). Thus, an understanding of the main principles of economic efficiency theory could provide scope for responsible authorities and researchers to find ways of making some elements of watermelon production work more cost efficiently and thus improve production.

It is asserted that the use of scarce production resources to play greater cost efficiency is a hot issue for farmers (An *et al.,* 2013). Since Poldrugovac *et al* (2016) ascertained that efficiency is one of the key factors of management control and a prerequisite for making improvements; farmers need to improve watermelon production by utilizing resources efficiently. Efficiency is the ratio of desired output to the required input for any farm (Fan, 2016). Thus efficiency is attained when there is optimal utilization of resources. However, optimal utilization of human and material resources (input) for effective production (output) depends on cost efficiency (Poldrugovac *et al* 2016). Advances in cost efficiency enable the production system to perform better using existing resources and create satisfaction. According to economic efficiency theory cost efficiency is a unit's capability to achieve the maximum productivity and efficiency possible considering the costs and input levels to find the ratio between the least possible cost and the existing cost (Keshtkaran *et al*., 2014).

Cost efficiency is the product of technical and allocative efficiencies (Keshtkaran *et al.* 2014). Therefore, in order to enhance cost efficiency, technical and allocative efficiencies should also be enhanced. Lack of cost efficiency can be sourced from technical and allocative efficiencies and the lack of allocative efficiency is related to different production methods, socioeconomic factors and incorrect use of different technologies. The lack of technical efficiency is related to waste of resources including wrong and inferior farming equipment or farm characteristics or material purchases or excess labour used (Fan, 2016). Therefore, Keshtkaran *et al.* (2014) affirmed that, a production system has cost efficiency when it could present correct and adequate services using least quantities of inputs to achieve a certain level of output and combining the inputs to produce it at least cost (allocative efficiency) in a useful and proportionate manner (technical efficiency). Thus the study on cost efficiency of watermelon production is important in order to obtain the current status of cost efficiency of the subsector to understand if resources are utilized efficiently to obtain the desired output with little cost possible. Moreover, at the farm level, cost efficiency evaluation is crucial in signaling profit potential and identifying areas for improvement (Jiang and Sharp, 2011).

Cost efficiency has been widely studied in scientific literature worldwide; in retail (Assaf *et al.*, 2011), hotel and franchising (Paldrugovac *et al.,* 2016), banking (Dong *et al*., 2014), healthcare (Keshtkaran *et al.*, 2014), internet companies (Cao and Young, 2011) and in agriculture (Tohale and Suer, 2007). These show how important cost efficiency is in various subsectors. Studies which have been done on efficiency in Tanzania include those of Msuya and Ashimogo (2006) and Mwajombe and Mlozi (2015). Although in most studies, efficiency is a matter of concern, the cost efficiency variation couldn't be analyzed in terms of farm size and capital size making use of stochastic frontier analysis (SFA) approach and that assumed efficiency are the same across farms with different farm size and capital size. Furthermore, Gunjan, (2007) recommended future studies on variation in efficiency in terms of capital size. It is on these grounds that the study came with the following objectives; Determine cost efficiency level of watermelon farms, determine variation in efficiency between farms of different size and capital and examine sources of cost inefficiency. Thus the study proposed the following Hypotheses:

Hypothesis 1**:** *There is no cost efficiency in watermelon farms in the study area.*

In order to examine which farm characteristics (sources of cost inefficiency) cause significant variations in efficiency, the following Hypotheses were proposed:

Hypothesis 2: *Marital status of a farmer has no significant influence to cost inefficiency.*

Hypothesis 3: Sex of the farmer has no significant influence to cost inefficiency.

Hypotheisis4: Education level of a farmer has no significant influence to cost inefficiency.

Hypothesis 5: Logistic services have no significant influence to cost inefficiency.

Hypothesis 6: Farming experience has no significant influence to cost inefficiency.

Hypothesis 7: Farm size has no significant influence to cost inefficiency.

Hypothesis 8: Capital size has no significant influence to cost inefficiency.

1.3 Cost efficiency measurement Approaches

There are two approaches commonly used in measuring cost efficiency the choice of which method to use depends on the study as well as theoretical and empirical reasons. Data envelopment analysis (DEA) is one of them. DEA is a non parametric method which was first proposed Charnes, Cooper and Rodes (Farrel, 1957). The method allows from use of multiple inputs and outputs. The input costs and production costs are combined to determine the relative cost efficiency for a firm or parts of a firm also called decision making units (DMUs). Cost efficiency is shown by an index with values from 0 to 1. The firm with cost efficiency value 1 indicates 100% efficient firm and if the value is less than 1 the firm is inefficient. For DEA to be applicable to a sample the DMUs or firms have to be in similar activities and similar environment so that common group of input costs and production costs can be determined. Advantage of this method relies on its statistical strength over other conventional accounting methods, less sensitive to misspecification errors and doesnot suffer heteroscedasticity and multicollinearity (Dzeng and Wu, 2013). Its disadvantage lies to the fact that it is more sensitive to outliers and cannot measure random errors.

The other commonly used method is stochastic frontier analysis (SFA). This is a parametric method introduced by Aigner, Lovell and Schmidt and Meeusen and van den Broeck in 1977 (Kangile, 2015). This method has a disadvantage that it imposes specific assumptions on functional form of the frontier and distribution error term. However it has an advantage that it accounts for noise (random errors) and has the ability to conduct conventional tests of hypotheses which is the basis of this study (Kumbhakar and Lovell, 2003). Furthermore, surveys of the empirical literature suggest stochastic frontier analysis is the most commonly used approach because of the random factors involved in agricultural production (Battese 1992, Coelli 1995, Bravo-Ureta *et al.* 2007). Thus in this paper, SFA was applied to determine economic efficiency of watermelon production.

2 Methodology

2.1 Study Area, Sampling and Data Collection

The study was conducted in Rufiji and Mkuranga districts of Tanzania purposely. The districts are ideal for studying watermelon due to their high production potential. Moreover, about 50 percent of the total watermelon production in Tanzania is contributed by Rufiji and Mkuranga districts (MAFSC, 2013). Thus, two stage random sampling was done. First, villages were selected based on probability proportion to size. That is, the village which is large had high chance of being included in the sample. Therefore, 25 villages were selected. Second, simple random sampling was used to select respondents. A total of eight respondents were chosen randomly from each village making a sample size of 200. Data were collected using questionnaire from the following fourteen villages from Rufiji district: Mwangia, Kibiti A and Kibiti B, Chumbi A, Chumbi B and Chumbi C, Ikwiriri Kusini, Ikwiriri Kati and Ikwiriri Kaskazini, Utunge, Mgomba kaskazini, Mgomba kusini, Jaribu Mpakani and Ngalengwa and Mkuranga District in the following villages: Funza, Mtakwisha, Mbezi, Kisiju, Mkokozi, Magodani, Lugwadu, Mwandege, Kiparang'anda, Kimanzinchana mashariki and Kimanzinchana magharibi. In each questionnaire; production costs, quantity of watermelon produced, farm size, capital size, logistic services and socioeconomic characteristics of farmers were considered. Key informants interviews were also used to supplement questionnaire data.

2.2 Analytical Framework

2.2.1 Theoretical model

Define your cost –function-derived from constrained cost minimization:

$$C_i \geq C(P_{i1},P_{i2},\ldots,P_{ik},Y_i;\beta) \quad (1)$$

Where:

C_i = observed cost for the i^{th} farmer (i=1,2,….n)

P_{ij}=cost for kth input faced by i^{th} farmer (j=12,…k)

B=vector of parameters that reflect the relationship between input costs, output and minimum cost of production

For C(.) to a cost minimization solution, it needs to satisfy the following properties: should non-negative, non-decreasing in input prices and output, homogeneous of degree one and concave in input prices. These are met if the underling production function is quasi concave.

In practice observed cost of production include random error leading to stochastic cost function as shown in equation 2

$$C_i \geq C(P_{i1},P_{i2},\ldots,P_{ik},Y_i;\beta)\exp(v_i)\ldots\ldots(2)$$

Where vi is an independently and identically distributed error assumed to follow normal distribution with mean zero and constant variance (σ_v^2)

Since actual costs can be higher than the stochastic minimum cost due to inefficiencies, equation 2 is modified by including non-negative producer specific inefficiency error as in equation 3.

$C_i \geq C(P_{i1},P_{i2},\ldots,P_{ik},Y_i;\beta)\exp(v_i+u_i)$ …………………………………………………(3)

From this model, empirical model was derived. The distributional assumption about the inefficiency error term is presented under the empirical model.

2.2.2 Empirical models

Stochastic Cost frontier model

Quantification of cost of production was conducted from the data provided by each farm. The following input costs (variable cost) were included; seeds (amount of seeds x average price of seeds), fertilizer, pesticides, manure, sprayers, land rent and labour which involved land preparation, ploughing, harrowing, planting, weeding, spraying, watering, transporting and harvesting. Family labour cost was calculated by using weighted average wage rate (Reigs and Picazo, 2005). The following formula was used total wage for a hired labour/total paid hours=weighted average wage rate.

Hired labour in watermelon production farms are paid per one person per worked days per hectare. Labour cost was multiplied by number of labourers in the end to get the total labour cost. All these costs were calculated per hectare. Watermelon weight was calculated by using number of pieces per ton. For small watermelons one ton contains about 1000 pieces, medium watermelon about 700-800 pieces, large watermelons 500-600 pieces per tonne. The average price for small piece watermelon is 500 Tsh, for medium ranges Tsh. 1000-2000 and large watermelon ranges from Tsh. 3000-5000. The nature of the farmers in the study area are smallholder farmers, used simple farming tools, depreciation is almost equal to zero (Saravia and Gomez-Paloma, 2014). Since the farmers rent land for cultivating watermelon, land rent was used as a proxy indicator for fixed cost.

In analyzing cost efficiency, Battese and Coelli (1995) model was used to specify a stochastic frontier cost function with the error inefficiency component and to estimate all parameters together in the one step maximum likelihood estimation. This model is implicitly expressed as follows

$\text{Ln } C_i = g(P_i, y_i; \beta) + V_i - U_i$ …………………………………………………(4)

where

Ci represents the total cost of production, *g* is a suitable functional form such as the translog; *Pi* is the vector variable of input prices such as pesticides, fertilizer, seed, land rent and labour. *Yi* is the value of watermelon output produced in tonnes; *β* is the parameter to be estimated. The systematic component *Vi* represents the random errors which is assumed to be identically and normally distributed with mean zero and constant variance as N (0, σ^2v). *Ui* is the non-negative disturbance representing cost inefficiency and is independent of Vi and distributed as truncated normal with truncations at zero of the normal distribution (Battese and Coelli, 1995).

Usually there are two common functional forms to choose: namely Cobb - Douglas (C-D) or Translog . Cobb-Douglas is commonly chosen due to its simplicity and the fact that it is easy to estimate and interpret the parameters which are few (An *et al*., 2013). However Cobb Douglas tends to impose unrealistically restrictive assumptions on the functional relationships for example it assumes all firms have same production elasticities. In this study translog functional model is chosen since it is much more flexible according to actual situation and anticipation of interaction effects between the efficiency variables at the expense of the fact that it requires estimation of many parameters since it incorporates second order parameters and it is difficult to interpret the coefficients.

The following formula for likelihood ratio was used for testing hypotheses for functional form and distribution assumption selection and the effect of sources of inefficiency.

$LR=-2(LLH_0-LLH_l)$

Where LLH0 log likelihood of the restricted model (C-D) and LLH1 is the log likelihood for unrestricted model (Translog)

Table 2: likelihood ratio test

	Hypothesis	**Test-statistics**	**Df**	**Critical values**	**Decision**
Functional form selection	H_0: βij=0	LR=6459	11	19.045a	Translog functional form is used (anticipation of interaction effects between variables)
Distributional assumption selection	H_0 :μ=0	LR=90	1	3.84b	Maximum likelihood results used (truncated distribution assumption)

a= critical values obtained from Kodde and Palm (1986) statistical tables; b=χ^2critical values from field (2009)

Thus the translog stochastic cost frontier was modelled using five inputs (pesticides, fertilizer, seeds,labour and landrent) as follows

$$LnCi = B_0 + \beta_1 \ln Y_i + \sum_{k=1}^{5} B_k \ln(X_{ki}) + 1/2\beta_6[\ln Y_i]^2 + 1/2 \sum_{k=1}^{5}\sum_{k=1}^{5}[\ln X_k]^2 + .$$

$$\sum_{k=1}^{5} B_k ln(X_{ki}) \ln(Y_i) + Vi - U_i \text{.......................................}(5)$$

Where Xs are the input costs and y output. K's are number of input variables.

Since the hypothesis that γ =0 was rejected then MLE give consistent estimates otherwise OLS could have been used. The maximum likelihood estimation of the cost frontier yields estimators for γ, λ and σ, whereby $\gamma = \sigma^2_u / \sigma^2$, $\lambda = \sigma^2_u / \sigma^2_v$ and $\sigma^2 = \sigma^2_v + \sigma^2_u$. The parameter γ represents the total variation of the cost from the frontier that is attributed to cost efficiency and it lies between zero and one. The closer the value of γ to one the greater the deviation of actual production cost from the frontier and hence the cost efficiencies.

Hence, following the adoption of Battese and Coelli (1995) framework for the analysis of the data, the explicit translog stochastic cost frontier functional model which was normalized by deviding each variable except output by seed price (for simplifying interpretation) for the watermelon farms in the study area is therefore specified as:

$$LnCi = B_0 + B_1 lnY_i + B_2 lnP_1 + B_3 lnP_2 + ... + B_8 lnP_7 + 1/2B_9(lnY_i)^2 + 1/2B_{10}(lnP_1)^2$$

$$+ ... + 1/2B_{14}(lnP_5)^2 + B_{15} \ln P_2 \ln P_1 + B6 lnY_i{*}lnP_1 + ...B_{25} lnY_i{*}lnP_7 + +Vi + Ui \text{..............}(6)$$

where Ci represents the normalized production cost in Tanzanian shillings (TShs) per hectare and other variables are described in Table 2. Thus, following Battese and Coelli (1995), the cost inefficiency of an individual watermelon farm is defined in the terms of the ratio of the observed (actual) cost (Cb) to the corresponding minimum cost (Cmin) or potential/ideal cost given the available technology is expressed as:

Cost inefficiency =Cb/Cmin= [g(Pi, yi; β)exp(Vi-Ui)]/[g(Pi, yi; β)exp (Vi)]= exp(-Ui)….(7)

Table 2: Description of variables for the economic efficiency model

Variable		Description	Measurement
Yi	Watermelon output	Amount of watermelon produced per acre	Metric tonnes per hectare (MT/hectare)
P_1	Pestcide cost	cost of pesticides used which include(insecticides, fungicides and pesticides per acre)	Tsh./hectare
P_2	Fertilizer cost	cost of fertilizer used	Tsh./ hectare
P_3	Seed cost	Average seed cost used	Tsh./ hectare
P_4	Land rent cost	Average cost of land used for production	Tsh./ hectare
P_5	Labour cost	Total cost of labour used including family labour and hired labour	Tsh./ hectare

In the analysis of economic efficiency, FRONTIER 4.1 software program was used. The analyses give the Maximum likelihood estimates of the parameters (Coelli, 1995).

The hypothesis that watermelon farms in the study area are not cost efficient was tested using likelihood ratio test statistics.

2.2.2 Variation in efficiency of farms according to farm size and capital size

With regard to the size of farms, it is measured by the number of hectares. According to Eurostat (2010), farm sizes are classified as follows; small farm ranges from 0 to < 10; medium size from 10 to < 50 acres and large farms more than 50 acres. Due to the nature of watermelon farms in the study area, the study categorized farm sizes as follows zero to 2 acres small farms, more than 2 acres, large farms. Two acres farms size was used as a base since that was the mean farm size of all farms in the study area and thus was considered as the medium farm size. Capital size used in farming is based on sorting and descriptive analysis done to obtain mean of capital sizes. The average amount which was used by majority farmers (Tshs. 610 872) was considered as the base for capital size. From zero to average capital size was considered as the small capital size and higher than it was considered as largest capital. Mugera and Langemeier (2011) defined small capital as less than USD 500 000 and large capital as greater than 500 000 USD.

2.2.3 Examining sources of cost inefficiency

Kumbhakar and Lovell (2003) pointed that output can be affected in production process by factors such as natural disasters, random effects, climate, geography, socioeconomic factors and so on. Thus in this case socioeconomic factors such as business experience, sex, marital status, logistic services and educational levels and farm characteristics such as capital size and farm size were used as sources of economic inefficiency (Table 3). The factors in this case source of inefficiency were examined to see their influence on economic inefficiency.
The inefficiency model is defined as:

$$Ui = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \quad \ldots\ldots\ldots\ldots(8)$$

where Ui is the cost inefficiency, $\delta_0 ... \delta_7$ are paramaters to be estimated, Z_1, Z_2, Z_3, Z_4, Z_5, Z_6 and Z_7 represent the farming experience, gender of the farmer, marital status, logistic services and the educational level of the respondent, capital size and farm size respectively. The socio-economic variables and farm characteristics are included in the model to indicate their possible influence on the cost efficiency of the respondent farmer of the watermelon farms.

Table 3: Description of variables for the inefficiency model

Variable	Variable	Description	Expected sign
Z1	Farming experience	Time spent in watermelon production in years	-
Z2	Sex (dummy)	Male	-
		Female	+
Z3	Marital status (dummy)	Married	-
		Not married	+
Z4	Education level	Different levels of education from not gone to	-

		school to college	
Z5	Logistic services	These are transportation, purchase and storage. They were measured by asking farmers to give opinion on the standard of logistic services	-
Z6	Capital size	These are capital money in Tsh used in producing a hectare of watermelon	-
Z7	Farm size	This is an watermelon cultivated area	-

When a factor or source of cost inefficiency decrease inefficiency it means that it increases efficiency and vice versa is true. In this case farming experience was expected to decrease cost inefficiency. Farming experience was measured as farmer's years of participating in watermelon farming. The more years used in practicing watermelon farming give the farmer an ability to understand well production challenges therefore be able to cope and thus more likely to produce efficiently. Fakayode *et al.*, 2012 ascertained that experience is important source of efficiency in fruit farming. Education level was another source of inefficiency used in the study which was expected to decrease cost inefficiency of watermelon production. The more educated a farmer is the more likely to learn, understand fast and correctly thus produce efficiently. Logistic services were expected to decrease cost inefficiency of watermelon production. Logistic services are services that enhance production efficiency (Bosona and Grebresenbet, 2012). Logistic services help to reduce wastage of inputs and watermelon produce. The standard or efficiency of logistic services is likely to influence production efficiency. Marital status was used as dummy variable where married farmer decreases inefficiency. That is the farmer who is in marriage is more likely to increase effort of increasing efficiency in farming than the one who isn't due to family responsibilities. Sex was the last dummy variable used where it was expected that a male farmer decreases cost inefficiency than the female farmer. Due to the nature of watermelon production activities which require much time and energy (masculine) and women whose nature of house and reproductive responsibilities find it difficult to devote a lot of time taking care of watermelon Busari *et al.*, (2012). Farm size and capital sizes were expected to decrease cost inefficiency. The larger the farm size the more cost efficient it would become due to economies of scale (Kangile, 2015).

Hypotheses that sources of cost inefficiency have no significant influence on cost inefficiency were tested using maximum likelihood estimates t-ratio values which were compared with theoretical t-values from statistical tables.

3.0 Results and Discussion

3.1 Economic efficiency level

Maximum likelihood estimates for the Translog stochastic cost frontier model indicated that the following inputs variables pesticides, seeds, labour and land rent were significant at 1%, for the first three inputs and 5% for landrent (Table 4). These results are similar to Jiang and Sharp (2010) who found labour cost influences milk production cost efficiency significantly. The positive sign of the coefficients implied that the increase in the variable uses in watermelon production will increase total cost of production and the negative sign implied that the increase in the variable uses will cause a decrease in total cost of production which is good.

Table 4: Maximum Likelihood estimates for the watermelon farms in the study area

Variable	MkurangaCoefficients	t-ratio	Rufiji	t-ratio

		SE		Coefficients	SE	
(Constant)	2.459	1.916	1.2834	3.422	3.40	1.0065
LnOutput	1.300***	0.292	4.452	0.002	0.859	0.0023
Lnpesticides	-0.321***	0.079	-4.0633	-0.127	0.427	-0.2974
Lnfertilizer	-0.042	0.044	0.9545	0.7395	0.6638	1.1140
Lnseed	1.1581***	0.3263	3.5486	0.2196***	0.04165	5.2731
Lnlandrent	-0.82**	0.3732	-2.198	1.158***	0.3073	3.7683
Lnlabour	3.2616***	0.708	4.6066	-0.01427	0.0811	-0.1759
Lnoutputsquare	-0.1029	0.1046	-0.9837	0.1199	0.1487	0.8067
LnoutputLnpestcides	0.02594	0.2743	0.09456	0.1060	0.8346	0.1270
LnoutputLnfertilizer	0.9798**	0.5796	1.691	0.7448	0.2464	0.3023
LnoutputLnseed	0.01971	0.08874	0.221	0.41655	0.9039	0.46083
LnoutputLnlandrent	-0.0092	0.036	0.255	1.006	1.001	1.0049
LnoutputLnlabour	-0.041**	0.020	2.050	2.004	1.920	1.0437
LnpestcidesLnfertilizer	-3.333	8.8741	-0.3756	0.9487	0.8567	1.10738
Lnlaboursquare	1.5275	3.4636	0.441	0.2605	0.6558	0.3972
Lnlandrentsquare	-0.003	0.019	-0.158	-0.8523	0.59059	-1.4431
Lnseedsquare	0.013	0.009	1.444	-0.1028	0.1046	-0.9828
Lnfertlizersquare	0.009	0.034	0.265	-0.024	0.021	1.1428
Lnpestcidessquare	0.033***	0.006	5.500	-0.018	0.013	1.3846
Sigma-squared (σ^2)	0.7200	0.520	1.385	0.910	0.820	1.1097
Gamma (γ)***	0.950	0.130	7.300	0.900	0.220	4.09
mu	-0.410	0.530	-0.77	0.180	0.210	0.857

Dependent variable: Lncost, b.: *** Significant at 1 percent level: ** Significant at 5 percent level: * Significant at 10 percent

The coefficients for pesticides and landrent are negative and significant at 1% and 5% level respectively indicating that pesticides and landrent significantly decreases the frontier watermelon production cost. This implies that 1% increase in pesticide and land usage would decrease the watermelon production cost by about 32.1% and 82% respectively keeping other factors constant. The positive coefficients for seeds and labour imply that as more seeds and labour are employed, watermelon production cost is increased. A significant positive coefficient of labour has also been reported by Kangile (2015) when studying influence of labour on irrigated rice production cost. Therefore, seeds cost and labour cost are significant factors associated with changes in watermelon production cost and impacted positively on watermelon cost of production in Rufiji and Mkuranga districts when holding other factors constant. As for the interacted variables, watermelon output and labour were found to have negative coefficient which imply they are substitute to each other. That is, if a farmer uses high labour cost, the farmer has to give up on watermelon output (the output will be replaced by labour used). Watermelon output and fertilizer had positive significant coefficient meaning that the variables are complement to each other. This implies that fertilizer usage contributes to enhance/improve watermelon output however it increases the cost of production.

The results also revealed that cost efficiency (CE) for farms in Mkuranga district ranges from 0.10 to 0.99 with the mean CE of 0.73. Results for Rufiji district show that the CE for the farms ranges from 0.89 to 0.99 with the mean CE of 0.90 (Table 5). This is to say that Rufiji cost efficiency is higher than that of Mkuranga which implies that Rufiji watermelon farms has the best on average CE in the study area. This means that practically, the mean efficiency is useful as it indicated how smallholder farmers in Rufiji used more precise combination of inputs to ensure minimization of cost of watermelon production. This could be explained by the input costs used in analysis for Rufiji which are lower than that of Mkuranga. It was explained during key informant interviews by a famous farmer that Rufiji land is very fertile for crop production one doesnot need a lot of fertilizers or other inputs to cultivate watermelon. These results are in agreement with Thiam *et al*., (2001) ascertained that cost efficiency in developing countries ranges from 17% to 100%.The mean CE level of 90% for Rufiji and 73% for Mkuranga suggests that there is 10% and 27% scope for increasing cost efficiency by reducing the costs of seeds and labour which were significantly and positively affecting watermelon production cost in Rufiji and mkuranga respectively. Seed costs for example are expected to be exorbitant since seeds used are imported from other countries.

The value of gamma was found to be 0.95 for Mkuranga and for Rufiji (0.90) implying that 95% and 90% of the variability in the total cost of production which is not accounted by the stochastic cost frontier was being influenced by cost inefficiency factors in watermelon production. Only 5% and 10% were due to random factors that are beyond farmers' control in Mkuranga and Rufiji respectively. Furthermore, the results implication is that there is 5% and 10% decrease in input variable on average, if all the farms in Mkuranga and Rufiji respectively become fully efficient. As for the hypothesis that *there was no cost efficiency in the study area*, the null hypothesis was not rejected at 5% level of significance since test statistic LR (Likelihood ratio)chi-square calculated was found to be 43.73 which is less than critical Chi-square (113.15) implying that watermelon farms in the study area were not cost efficient. However the hypothesis does not tell us the magnitude of the inefficiency so our conclusion later will rely on cost efficiency level discussed above.

3.2 Cost efficiency according to farm size and capital size

Results in Table 5 generally show existence of difference in cost efficiency of farms with different sizes in capital and farm. It was revealed that 68.2% of farms in the study area are small farms (with two hectares or less) and 31.8% of the farms are large farms (with greater than 2 hectares). Furthermore it was revealed that small farm size had highest mean cost efficiency

(CE) (0.92) than large farms (0.82) and smallest minimum CE (0.10) than large farms (0.79). This implied that most small farms had highest CE to give such a high mean CE. Also farms with small capital had higher mean CE (0.94) than farms with large capital size (0.80). An interesting thing is that minimum (0.10) and maximum (0.99) CE for small farm size and farms with small capital size are the same; the same applied to large farm size and capital size. This could only mean that capital size and farm size influence cost efficiency of the study area. These results contradict those obtained by Jiang and Sharp (2010) that in the study of cost efficiency of dairy farming in New Zealand that larger farms tend to have a better cost efficiency score relative to those that are smaller and Mburu *et al*., (2014) that large farms have higher efficiency than small farms in Kenya. This could be due to subsector and geographical differences involved in the study. These results implied that farm size and capital size influence cost efficiency level of watermelon production. The results implied further that, it is possible for small farms and farms with small capital to produce watermelon cost efficiently.

Table 5: Cost Efficiency according to farm size and capital size

	Count	Percent	Mean CE	Minimum CE	Maximum CE
Farm size					
Small farm size	137	68.2	0.92	0.10	0.99
Large farm size	64	31.8	0.82	0.79	0.99
Capital size					
Small capital	139	69.2	0.94	0.10	0.99
Large capital	62	30.8	0.80	0.79	0.99
Rufiji	112	56.00	0.90	0.89	0.99
Mkuranga	88	44.00	0.73	0.10	0.99

3.3 Sources of Watermelon production cost inefficiency

Table 7: Factors influencing cost inefficiency

Variable	Rufiji Coefficients	Standard error	t-ratio	Mkuranga Coefficients	Standard error	t-ratio
(Constant)	11.526***	0.108	106.722	7.345	1.706	4.305
farmingexp	-168.291	102.847	-1.636	-0.150	0.107	-1.402
gender	0.021	0.101	0.208	-0.699	0.884	-0.791
Marital status	-0.034	0.052	0.654	0.173	0.452	0.383

Education level	-0.504***	0.012	.42.000	-0.110	0.102	-0.099
Logistic services	-3.873***	0.944	4.103	0.034	0.157	0.216
Capital size	0.0306***	0.00876	3.493	0.0287***	0.00856	3.271
Farm size	0.046**	0.024	1.917	0.002**	0.001	2.000

Note: a. Dependent Variable: Economic inefficiency b.: *** Significant at 1 percent level: ** Significant at 5 percent level:

Table 7 presents results for sources of watermelon production cost inefficiency. For Rufiji district, it was revealed that education level ($p<0.01$), capital size ($p<0.01$), farm size ($p<0.05$) and logistic services ($p<0.01$) are significant sources of cost inefficiency in watermelon production. However, sex, farming experience and marital status had no significant influence on cost inefficiency of watermelon production ($p>0.10$). Contrary to Rufiji, in Mkuranga district results show that only capital size ($p<0.01$) and farm size (0.05%) had significant influence on cost inefficiency of watermelon production. This also implied that there is significant variation in CE between farms of different capital size and farm size.

As for the coefficients of the variables used as sources of cost inefficiency; education level, farm size, capital size and logistic services had their expected sign which is negative. This implied that the improvements of these factors reduce cost inefficiency. This means these factors increase cost efficiency. For example an educated farmer is more able to understand fast and produce according good farming practices which will facilitate cost efficiency in watermelon production than the one who is not educated or with less level of education. The positive relationship between the education level of household head and cost efficiency can be supported by similar results reported in study which have focused on the association between formal education and economic efficiency (Mburu *et al*., 2014). Same applies to logistic services; a farmer who is using an improved or efficient logistic service is in a position of producing cost efficiently than the one who isn't. Improved logistic services like transportation allow the farmer to access market easily and minimize wastage of inputs which lead to reduction in average cost per unit of output which stimulates expansion of output level. However capital size and farm size coefficients were positive implying that the increase in size of capital and farm used in watermelon production would increase cost inefficiency. The unexpected positive sign could be attributed by the nature of watermelon farms in the study area. These results defy the notion that efficiency is only associated with large farms and capital (Gunjan, 2007).

As for hypotheses tests which were about sources of cost inefficiency. The null hypotheses for marital status, sex and farming experience were not rejected at 5% level of significance implying that the sources of inefficiency have no significant influence to cost inefficiency of watermelon farms in the study area. However; education level, logistic services, capital size and farm size were found to have significant influence on cost inefficiency. This implies that cost efficiency vary with education level, logistic service, capital size and farm size in Rufiji district. In Mkuranga district only capital size and farm size had significant influence on cost inefficiency.

4.0 Conclusion and recommendations

It can be concluded from the findings that watermelon production in Rufiji and Mkuranga districts is generally cost efficient. Capital size and farm size influence cost efficiency level significantly since it was found that small farm size and farm with small capital had higher mean cost efficiency than large farm and farm with large capital size. That is the cost efficiency varies according to farm size and capital. Efficiency however, can be realized by farmers if government intervenes in the area of logistic services and improving education level of farmers since it was found that these were significant sources of cost inefficiency. This would increase their output level and also contribute significantly to effectiveness and sustainability of watermelon value chain and food security in the nation as a whole and the selected villages in Rufiji and Mkuranga areas in particular. Furthermore, economic efficiency theory recognize that; cost efficiency refers to an economic state in which every resource is optimally allocated to serve each farmer in the best way while minimizing waste and inefficiency. These findings support economic efficiency theory and have important theoretical implications. Study findings on efficiency level indicated watermelon production is generally efficient and thus the statement that production has declined due to inefficiency is refuted by this scientific evidence. However, there is a 27% room for efficiency improvement through better use of production resources to minimize waste by reducing cost and inefficiency. To the researchers' knowledge, this is the first efficiency research done on the sample of watermelon farmers specifically in the study area in Tanzania. It is especially valuable, while in contrast to other research, it is an empirical study which determined variation in efficiency in terms of capital size by using SFA. This study also contributes to the ongoing debate concerning the variation in efficiency among agricultural farms of different size and capital used (Masterson, 2007; Phillip, 2009; Mburu *et al*., 2014). The findings have policy implications, particularly in terms of the current debate on large or small farm agricultural development strategy. Any reform to watermelon subsector should proceed with caution.

Based on the findings of the study, the following recommendations are made for improving efficiency and sustainable watermelon production by farmers:

(i) Since the study area was not fully cost efficient, Government should formulate policies that will ensure expansion of production by improving cost efficiency and thus supply of watermelon to markets. These policies need to favour watermelon and other horticultural crops production farmers to tackle production challenges especially input cost. The policies should encourage farmers to use agricultural inputs efficiently using minimum cost possible in watermelon production. This will help in making farmers enjoy economies of scale through lowering input price per unit and spread fixed cost over a large output.

(iii) Since education was found to be significant in reducing cost inefficiency, it should be improved. Improvement in education can be achieved through provision of extension services to update the farmers in recent advanced trend in watermelon production. This can be done by providing technical and field training supports to farmers by appropriate authorities in terms of free manuals or pictures of advanced agricultural practices or of sponsored working tours to successful watermelon farmers in the country or even outside the country in order to encourage farmers, even for those with low education level, producing watermelon fruits with minimum cost. These should be regularly undertaken so that less or uneducated farmers could acquire knowledge from the professional and experienced farmers.

(iii). Since logistic services significantly influence cost inefficiency, these services in the districts should be improved. This can be done by responsible authorities to give priority to road improvement especially feeder roads to ensure farmers access market easily with less cost. This will reduce cost of other logistic services like purchase of inputs and also reduce the importance of storage or selling on farm.
(iv) Since it was found that capital size and farm size influence cost efficiency, farmers in the study area should consider them when producing watermelon.

(vi) Future studies on cost efficiency of Rufiji and Mkuranga infrastructure investment is important as it was realized in the findings that logistic services have significant influence to cost inefficiency of watermelon production. Also, since this data only provides a snapshot of the current state, future studies should be focused on longitudinal data in order to see the variation of cost efficiency in years.

5.0 References

An, Z., Bao, Y. ,Xia, W. and Shuping, W. (2013). Efficiency Evaluation of China's Medical Service . *Scientific research iBusiness*, Vol 5, 1-5.

Assaf, A., Barros, C. and Seller, R. (2011). Efficiency determinants in retail stores. A Bayesian framework, omega. *The international journal of management science*. Vol 39 No. 2: pp283-292.

Battese, G. and Coelli, T. (1995). A model for technical efficiency effects in a stochastic frontier production function for panel data. *Empirical economics* 20; 325-332.

Bosona, T. and Grebresenbet, G. (2012). Logistics and supply chains in agriculture and food: Pathway to supply chain excellence. Swedish University of agricultural sciences, Uppsala. Sweden.

Busari A., Idris-Adeniyi, K. and Oyekale, J. (2012). Economic Analysis of Vegetable Production by Rural Women in Iwo Zone of Osun State, Nigeria. *Greener Journal of Agricultural Sciences*. 3(1):006-011.

Cao, X. and Yang, F. (2011). Measuring the performance of internet companies using a two stage data envelopment analysis model. *Enterprise information systems*, Vol. 5: 207-217.

Cochran, G. W. (1977). Sampling Cocran, W. G. (1977). Sampling techniques. John Wiley and Sons publishing company. New York. USA.

Coelli, T. J. (1995). Recent developments in frontier modeling and efficiency measurement. *Australian Journal of Agricultural economics* 39(3): 219-245.

Dong, Y., Hamilton,R. and Tippett, M. (2014). Cost efficiency of the Chinese banking sector. A comparison of stochastic frontier analysis and data envelopment analysis. *Economic modeling*. Vol 36: 298-308.

Dzeng, R. and Wu, J. (2013). Efficiency measurement of construction industry in Taiwan: A stochastic frontier cost function approach. *Journal of Management and economics* 31(4): 335-344pp.

Economic Social Research Foundation (ESRF) (20l0). Strengthening Micro-enterprises in Tanzania: The case of small scale vegetable farmers. Dar es Salaam. Tanzania.

Eurostat (2010). Distribution of utilized agriculutural area by size class retrieved in 10 september, 2016 from http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Distribution_of_holdings_and_utilised_agricultural_area_by_size_class_(utilised_agricultural_area)

Fakayode, S. B., Rahji, A.Y. and Adeniyi, S.T. (2012). Economic analysis of risks in fruit and vegetabls farming in Osun state, Nigeria. University of Ilorin. Nigeria.

Fan, X. (2016). Efficiency research on Chinese commercial banks based on super-efficiency DEA method. *American journal of industrial and business management.* 6: 526-534.

Farrell, M. (1957). The measurement of productive efficiency. J*ournal of Royal statistical society* 120:253-281.

Field, A. (2009). Discovering statistics using SPSS. Third edition. SAGE publication Ltd. p338-803.

Gunjan, M.S. (2007) Measuring efficiency of the hotela and restaurant sector. The case of India. *International journal of contemporary hospitality management.* 19(5): 378-387.

Jiang, N. and Sharp, B. (2010). Cost efficiency of dairy farming in New Zealand; a stochastic frontier analysis. *JEL classification*: D24 · L79 · Q12: 26pp

Kangile, J.R. (2015). Efficiency in production by smallholder rice farmers under cooperative irrigation schemes in Pwani and Morogoro regions, Tanzania: Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 34-59pp.

Kayandabila, Y. (2013). Beyond Agriculture – Building Linkages for the Poor. Ministry of Agriculture Food Security and Cooperatives 25th November 2013

Keshtkataran, A., Barouni, M., Racangard, R. and Yandrani, M. (2014). Economic efficiency of radiology wards using data envelopment analysis. Case study of Iran. *Health*. Vol 6 No. 5:311-316.

Kumbhakar, C. and Lovell, K. (2003). Stochastic Frontier analysis. Cambrige University Press, Cambrige. 333pp.

Lewis, J. and Trevor, W. (2015) a report from the southern highlands food systems programme: The United Nations Food and agriculture organization (FAO), p6, 53

MAFSC (2013). Horticultural crops production and main challenges facing farmers Handout. Ministry of Agriculture, Food Security and Cooperatives. Dar es Salaam. Tanzania.

Masterson, T. (2007). Productivity, Technical Efficiency,and Farm Size in Paraguayan Agriculture. The Levy Economics Institute of Bard College.Paraguay: Working paper No. 490: p28

Mbanasor J. A. and Kalu, K.C. (2008) Economic Efficiency of Commercial Vegetable Production System in Akwalborn State, Nigeria; ATranslog Stochastic Frontier Cost Function Approach: Tropical And Subtropical Agroecosystem vol. 8.No. 313-318. Mexico.

Mburu, S., Ackello-Ogutu,C. and Mulwa, R. (2014). Analysis of Economic Efficiency and Farm Size: A Case Study of Wheat Farmers in Nakuru District, Kenya Economics Research International: Volume 2014, Article ID 802706, 10 pp

Mkindi, J.(2016). Registration of fertilizer faces various barriers in Tanzania: the citizen, April, 21st, 2016. Dar es salaam.

Mkuranga District Report, 2014/2015. Coastal region. Tanzania.

Morris, M., Kelley, V.A., Kopicki, R.J. and Byerlee, D. (2007). Fertilizer Use in African Agriculture: Lessons Learned and Good Practices. Washington D.C.: World Bank.

Msuya, E. and Ashimogo, G. F. (2006). An estimation of technical efficiency in Tanzanian sugarcane production. A case study of mtibwa sugar company outgrowers' scheme. *Journal of Economic development*. Vol. 1. Mzumbe university Tanzania. Pp67-97.

Mwajombe, K. and Mlozi, M.R. (2015). Measuring farm-level technical efficiency of urban agriculture in Tanzanian towns. The policy implications. *Journal of social sciences*. Vol. 2 No. 2: 62-72.

Nga, B.T., Cuong, T.H. and Lebailly, P. (2013). An analysis of the value chain of fresh milk in the north of Vietnam- The case study of Sonla province, Vietnam. Vietnam social economic development. Proceedings of scientific research. A quarterly review. No. 68 pp 272-286.

Ngaiza, R. S. (2012). An integrated policy approach to commercializing small holder maize production for Tanzania at FAO-University of Nairobi workshop held at 6-7/6/2012. Nairobi. Kenya. Prepared by policy and planning department, Ministry of agriculture, food security and cooperatives.Tanzania.

Phillip, D. (2009). Does size matter? Evidence fro sugarcane outgrowers in Morogoro, Tanzania. Eastern and Southern Africa Journal of agricultural economics and development. Vol. 6: p18, 144.

Poldrugovac, K., Tekavcic, M. and Jankovic, S. (2016). Efficiency in hotel Industry. An empirical examination of the most influential factors. *Economic research*. Vol. 29(1): 583-593.

Reig-Martínez E., Picazo-Tadeo A.J. (2005). Calculating shadow wages for family labour in agriculture: An analysis of Spanish citrus fruit farms in Spain, Agricultural Systems , 82, pp. 17-30.

Rufiji District Report, 2014/2015. Coastal region. Tanzania. 50pp.

Sadoulet E. (2001). Mercati imperfetti e modelli di comportamento delle famiglie contadine, La Questione Agraria , 3, pp. 39-73.

Tchale, H. and Sauer, J. (2007). The efficiency of maize farming in Malawi. A bootstrapped translog frontier. *Cashiers D'economic et sociologie rurales*, No. 83-83.

Thiam, A., Boris, E, Bravo-Ureta,B., Teodoro, E. and Rivas (2001). Technical efficiency in developing countries agriculture: A meta analysis. Agricultural economics 25: 235-243.