Analysis of Technical Efficiency of Sugar Cane Production in Ethiopia: The Case of Wonji/shoa Sugar Cane Estate Farm.

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Abstract

Ethiopian sugar cane production is unsatisfactory to uphold the country's comparative advantage. Thus, this study was conducted to examine possible reasons for low productive performance of sugar cane production by using cross sectional data gathered from Wonji/Shoa Estate Farm and analyzing its technical efficiency. Accordingly, both error component model and technical inefficiency effects model have been estimated in one step approach after data have been transformed to log. Maximum likelihood estimate of technical efficiency was obtained from half normal model which was supposed to describe the data adequately. Technical inefficiency effects are modeled as a function of area, cane age, cane variety, cane type (ratoon) and soil type.The result revealed that various distributional assumptions of technical inefficiency have approximately similar impact of on technical efficiency estimates. On average, sugar cane production in each plot are 77% efficient, implying that there is ample opportunity for the estate plot to raise output level at present technology.

Keywords: *Technical Efficiency, half normal model and Sugarcane*

1. Introduction

Ethiopia is becoming one of the fastest economically growing countries in the world. In 2012/13 fiscal year; Ethiopia's economy grew by 9.7%, tenth in a row of robust growth. In 2012, Ethiopia was the twelfth fastest growing economy in the world with average annual real GDP growth rate for the last decade was 10.9% (Africa Economic Outlook 2014). Accordingly, agriculture, which accounts for 42.7% of GDP, grew by 7.1%, while industry, accounting for 12.3% of GDP, rose by 18.5% and services, with 45%of GDP, increased by 9.9% in 2012/13 albeit at a slower pace because of constraints on private-sector growth (Africa Economic Outlook 2014)

In order to reach in such situations, the country set out a series of economic reform programs since 1991 which comprises structural adjustment programme with the aim of economic growth and poverty reduction. Following this the country has adopted agricultural development led industrialization (ADLI) Strategy in 1993, Interim Poverty Reduction Strategy Paper (IPRSP) in 2000, Sustainable Development and Poverty Reduction Program (SDPRP) in 2002. These strategies were intended to bring about economic growth through increase in agricultural productivity and were primary focused up on the poverty reduction.(Africa Economic Outlook 2014). In 2005 a plan for Accelerated and Sustained Development to End Poverty (PASDEP) was introduced in the country. This strategy primary aimed in the promotion of small scale market oriented agriculture which goes beyond poverty reduction. The country adopted such strategies to bring about improvement in agricultural sector, which is the back bone of its economy. However, very little has been observed towards productivity improvement over past decades. As a result, to improve economic growth of the country, productivity growth of agriculture is inevitable. Despite substantial attempt on part of government to commence technological improvement in agriculture, the reason why the productivity of the agricultural sector remains very low and became a challenge in the road towards agriculture based economic growth in the country (Alemayehu, 2010).

Taking this in to account the Government of Ethiopia developed a five year (2010/11-2014/15) Strategic Plan named as Growth and Transformation Plan (GTP).The GTP is designed for sustaining a rapid and broad-based growth path in the country. (MOFED 2010)

In order to achieve the GTP plan the government has chosen among others expansion of sugar cane plot and the sugar industry to be one of the tools to meet the pillars of as one means of economic growth, hence expansion and establishing sugar cane plots and construction of seven new sugar factories are under progress.

Currently, production of cane for commercial use is limited in three areas namely Wonji-Shoa, Methara and Fincha. The country has been covering its sugar requirement through local production using the three sugar industries. However, nearly more than 20% of sugar requirement is met through import due to the shortages created in the past few years. The increase in sugar consumption is mainly a result of four demand determining variables. These are population growth, improvement in income, consumption habit and the growth of the industrial & service sector, mainly hotels & restaurants as well as the food and beverage industries (ADSWE2013).

While the use of sugar and sugar cane is very diverse as well as important for one country's economy; Ethiopia's sugar cane production and productivity is very low for decades, the reason for this is various and numerous. As Wonji/Shoa Estate Farm is one of the producer of sugar cane in Ethiopia, it is also suffering from the low production and Productivity of sugar cane, thus in this paper a different attempts was made to examine the reason for low production and productivity of sugar cane in Wonji/Shoa Estate Farm by using the technical Efficiency.(Wonji/Shoa Sugar Factory Annual Report 2013)

2. Statement of the Problem

The favorable physiographic setting of the Ethiopia created different ecological zones that are complementary to each other. The highlands provide substantial water flow as surface and groundwater, nutrient and soil to lowland plain areas that has warm temperature suitable for cane production. The lowlands that surround the central highlands have easy access to ports and engulf the country in all directions (ADSWE, 2013)

Though there is a wide range of development of sugar cane plantations on the country, to meet the domestic and foreign demand still there is a problem of technical efficiency, because of the difference among sugar cane producing Ethiopian sugar factories such as; Metehara sugar factory harvest 5601 ha, Wonji/shoa harvest 2,777 ha per annum and Fincha's harvest7,372 per annum. There for, the importance of measuring andanalyzing the level of technical efficiency of sugarcane is very important.

Despite the fact that technical efficiency of small holder farmers has been extensively studied in Ethiopia, there are limited studies on technical efficiency of the country's sugar industries. Some of the studies that were conducted regarding technical efficiencies are; Dejene Merga (2013) on sugar cane at Fincha sugar factory, God'swill, etal(2011) wrote a working paper on A Comparative Analysis of International Water Management Institute the Technical Efficiency of Rain-fed and Smallholder Irrigation, Alemayehu(2010) on coffee.

Nevertheless, these previous studies focused on the study of technical efficiency of cereal crops other than Sugar cane. Thus, little attention was given to the analysis of technical efficiency of sugar cane production in Ethiopia except Dejene Merga, who studies technical efficiency at Fincha sugar Factory. In this study an attempt was made to measure the technical Efficiency of sugar cane production at Wonji Sugarcane Estate Farm.

3. Research objectives

3.1 General objective

The General objective of the study is to analyze the technical efficiency of Sugarcane production and to identify factors affecting level of technical efficiency among the Wonji Sugarcane Estate Plot.

3.2 Specific Objectives

- To measure the technical efficiency of Sugarcane production at Wonji Sugar Cane Estate Plot
- To identify factors affecting the variation in the level of technical efficiency and sources of inefficiency among Wonji Sugarcane producing plots
- To identify factors that are significantly cause variations among plot per plots of Wonji sugar cane producers
- To show the decline or incline of the production of sugar, production of sugar cane productivity at Wonji/shoa Sugar Cane Estate farm and to identify the possible reasons.

4. Research Methodology

4.1 Description of the Study Area

Wonji- Shoa Sugar Factory is found in Oromiya Regional State at 108 kilo meter South of Addis Ababa near Adama city in Woniji town which was established by a Dutch holding HVA company, 1954.

At the beginning, the Company was granted a concession of 5,000 ha of land at Wonji Awash River flood plain for the establishment of a Sugar Estate and Sugar Factory. Because of the increasing demand for sugar in Ethiopia the Wonji Sugar Cane Estate Plot expanded itself and included an additional 1,600 ha of land from Shoa 1962, which is within a 7 km distance from Wonji, and known then after as Wonji/Shoa Sugar Factory.

Wonji plain has average elevation of about 1530 m.a.s.l , which is in the range of 1500 – 2300 m.a.s.l. The Plain is surrounded by steep topography where it is bounded by River Awash in the north and east and by border drains in the south and west. It is characterized by very flat land having a small general slope (<5%) predominantly varying from NW to SE (north to south), where the maximum drop in topography is about 6 m within a horizontal distance of 12 km.

The mean annual rainfall of the area is about 704 mm. The mean average minimum and maximum temperatures of the region are 15.2 ^{o}C and 27.6 ^{o}C, respectively with average value of 21.4 °C. The average pan evaporation of the area is 6.8 mm/day. The area is between the transition of the two zones: Semi-arid to dry sub-humid.

4.2 Data Sources and Data Collection Method

In the study Secondary data was obtained from irrigation water supply sector, plantation office, and planning and project office.

4.3 Data Analysis Method

The analysis basically was employed both descriptive and econometric methods. Descriptive statistics (mean, percentage, range, etc.) was used to summarize the variables used in the model and describe the study area. Econometric model, stochastic frontier model, was employed to estimate the elasticity of production function, identify the determinants of inefficiency and estimate the level of efficiency. The variables both inputs and outputs in the production function and determinants of inefficiency were transformed to their corresponding log values in estimating the Cobb Douglas Production Function.

4.4 Model Specification

The Stochastic Frontier Model with Technical Efficiency Effect

The stochastic frontier production function has two error terms one to account for random effects (e.g., measurement errors in the output variable, weather conditions, diseases, etc. and the combined effects of unobserved/uncontrollable inputs on production) and another to account for technical inefficiency in production.

The stochastic frontier production function can be written as

$Yi = f(Xi;\beta)\exp(Vi-Ui)$

Where Yi is the production of the ith plot Xi is a vector of inputs used by the ithplot; β is a vector of unknown parameters Vi is a random variable which is assumed to be independently and identically distributed (iid) N $(0,V^2)$ and independent of Ui and Ui is a random variable that is assumed to account for technical inefficiency in production Following Battese and Coelli (1995), Ui is assumed to be independently distributed as truncation (at zero) of the normal distribution with mean, μ variance σU^2 $(|N(\mu i, \sigma U^2)|)$ where $\mu i = Zi\,\delta$

Where, Zi is a 1xc vector of plot-specific variables that may cause inefficiency and δ is a c x 1vector of parameters to be estimated. The plot-specific stochastic production frontier representingthe maximum possible output (Y*) can be expressed as:

From cobb Douglas production function $Y=f(K,L)=k^{\alpha} L^{1-\alpha}$

$Yi^* = f(Xi^*;\beta)\exp(Vi)$ thus

$Yi = Yi^*\exp(-U)$ Thus, technical efficiency of the i^{th} plot, denoted by

$TEi = Yi/Yi^* = \exp(-U)$

This means the difference between Y and Y * is embedded in the Ui. If Ui = 0, then Y is equal to Y* This means production lies on the stochastic frontier and hence technically efficient and the plot obtains its maximum possible output given the level of inputs. (Dey et-al., 2000) .

Since stochastic frontier production models were proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), there has been a vast range of their applications in literature. Battese and Coelli (1995) proposed a stochastic frontier production function, which has firm effects assumed to be distributed as a truncated normal random variable, in which the inefficiency effects are directly influenced by a number of variables. Given our research objectives, the generalized stochastic frontier model can be expressed for the plotas:

$Ln\ Y_i = \beta_0 + \beta_1 lnL_i + \beta_2 lnLb_i + \beta_3 lnHl_i + \beta_4 ln\ R_{io} + \beta_5 lnC_i + \epsilon_I$

Ln = denotes logarithms to base e

Y = the maximum attainable output for a given level of all inputs, measured in quintals.

L = Land area cultivated, measured in hectares.

Lb = labor utilized, measured in cost in birr.

R = Total variable inputs (seeds, fertilizer, pesticides, harvesting bags) used and measured inbirr.

C = the value of total capital equipment (Tractor, hand hoe, bicycle, axe, forked hoe, and sickle) measured in birr.

β i 's = are unknown parameters to be estimated.

According to Aigner, Chu and Lovell (1977), the error term is really a composite of two terms:

where $\epsilon i = Vi - Ui$; i = 1…N

where Vi = represents independently and identically distributed random errors N $(0,\sigma v^2)$ This are factors outside the control of the firm.

Ui = represents non-negative random variables which are independently and identically

distributed as N $(0, \sigma u^2)$ i.e. the distribution of Ui is half normal. |Ui|>0 reflects the technical efficiency relative to the frontier production function. |Ui|=0 for a firm whose production lies on the frontier and |Ui|>0 for a firm whose production lies below the frontier

Knowing that firms are technically inefficient might not be useful unless the sources of the inefficiency are identified. Thus, the second stage of this analysis investigates the sources of the plot-level technical inefficiency. The model specification will be.

$Ui = \delta 0 + \delta 1\ Z1 + \delta 2\ Z2 + \delta 3\ Z3 + \delta 4\ Z4 + \delta 5\ Z5 + Wi$

Z1 =land size in hectares

Z2= cane age in month

Z3= cane variety

Z4=Soil type

Z5= cane type

Wi =an error term that follows a half normal distribution

δ I's= inefficiency parameters to be estimated

5. Results and Discussion

5.1 Descriptive results

5.1.1Production of Sugar Cane

The total production of sugarcane production varies from one plot to other plot. The variation which emanates from the plot the mean average output was 14,937 quintals but the minimum production 855quintals and the maximum production under plot was 48,061 quintals.

Land
Is the major determinant of the sugar cane yield, the mean hectare of land from the total plot is 12 and the maximum area under the observed plot is 25 hectare , the minimum area is 1 hectare which is expected to constitute a low yield of sugar cane.
Equipment
The Equipment constitute the total cost of tractors and other for land preparation like uprooting, plowing, harrowing, sub soiling, and planning, the estate uses renting and purchasing of this tractors. The maximum cost that incurred during the study year was 218,630 birr with a mean of 31,489 birr.
Labour
Labour cost is a cost that is paid for the labor that is engaged in cane planting, cane husbandry, cane cutting and other activities there are 1230 laborers in the Wonji/Shoa Estate Farm and among this 607 are semi-permanent and 623 are seasonal.
Material
The Material includes both the cost of fertilizer and pesticides the mean material cost 33495 and the maximum material cost is 247,645 birr.
Cane variety
The total area of each plot at wonji Sugar cane estate plot during the study year planted on 4,792hectares of land incorporate of 5 types of seed cane variety which is 5percent of N-14 type of seed cane, 32 percent of NCO334 type of cane variety, 35 percent of B52298 type of seed cane variety, 13 percent of Mex 54 seed cane type of seed cane variety and 13 percent of Co-680types of seed cane were captured by 4, 792 hectares of land during the study year.
Cane Age
The maximum cane age from the 153 observation of plot of sugar cane is 30 months and the minimum age is 12 months with mean 23 months as the study Wonji estate (2001) confirms that the optimum age to get the best yield from sugar cane is at the age 23 of month
Soil Type
From the e classification of soil the pre dominant soil type in the estate plot is C1 type which is followed by A2 type of soil which consists of 23 present of the total harvested area the final soil type BA2 type of soil which holds 8 present of the area
Cane Type (Ratooning)
The main benefit of ratooning is that the crop matures earlier in the season. Thus at WWSE from the observed 153 data 29 % of the cane type or ratoon is 7^{th} and the 28 % is 1^{st} ratoon. The descriptive results of the variables are presented in the table below.

Table 1: Results for the variable description

Variable	Unit Of Measurement	Minimum	Mean	Maximum
Production of Sugar Cane	Qt	855	14,937	48,061
Land	Ha	1	12	25
Equipment	Br	12586	31,489	218,630
Labor cost	Br	291	24059	181329
Material	Br	9500	33495	247,645
Cane Age	in month	12	23	30
Cane Type (Ratooning)	no.	1st	5th	7th

5.1.2 Sugar Cane and Sugar Production

The production of sugar cane and sugar production for 14 consecutive years of Wonji/ Shoa Sugar Factory is showed in Table2. From the table I it can be seen that the maximum production of sugar cane was during the year2011/12 which is 5282 hectare of land the high production of sugar cane is because of the Estate plot has manage to expand to plant sugar cane, and the minimum production was at the year 2012/13 which was 2777 ha the reduction of sugar cane is as a result of the factory's in expansion process.

Table 2. Wonji/Shoa Sugar Factory Sugar Cane and Sugar Production

S.no	Milling Season	Total area harvested (hectare)	Average age (month)	Total Cane production in Qts	Productivity Cane/ hectare /Month	Production of sugar in ton
1	2000/'01	4,106	17.6	6,166,420.0	87	71,244.5
2	2001/'02	3,905	18.6	5,935,665.0	82	73,163.3
3	2002'03	4,379	18	6,294,312.0	80	74,045.1
4	2003/'04	4,110	17.3	6,282,340.0	88	72,515.8
5	2004/'05	4,173	17.9	6,370,668.0	85	74,191.6
6	2005/'06	4,094	18.3	6,153,118.0	82	73,721.7
7	2006/'07	4477	17.3	6,045,737.0	78	70,414.0
8	2007/08	4181	15.8	4,880,358.0	74	57,375.0
9	2008/09	4783	16.4	5,951,260.0	76	70,409.0
10	2009/10	4579	16.4	5,341,443.0	71	60,394.0
11	2010/11	4904	16.9	640,791.0	77	75,220.0
12	2011/12	5,281.58	16.3	6,285,820.0	71	70,113.0
13	2012/13	2,777.00	19	362,951.3	69	42,091.0

S.no	Milling Season	Total area harvested (hectare)	Average age (month)	Total Cane production in Qts	Productivity Cane/ hectare /Month	Production of sugar in ton
14	2013/14	4,718.4		6,417,040		77,051

Source: Ethiopian Sugar corporation's data

As it can be observed from the table the productivity of sugar cane is declining as the time passes and the total area that is harvested is declining so productivity is the major factor for the production of sugar cane.

5.2 Econometric Results

This section discusses the results of the estimation of the Stochastic Frontier Approach (SFA). Both the error component model and technical inefficiency effects model were developed using the one step approach. The estimate of technical efficiency and the value of technical inefficiency component were also predicted, without violating different distributional assumptions attached to ui, using the maximum Likelihood method in Stata13.0. In this chapter Cob-Douglas production function was used. The distributional assumptions are half-normal distribution of error term, ui. The effect of these distributional assumptions on technical efficiency levels of each plot was investigated. Nonetheless, analysis was made using this half normal distribution of stochastic frontier model.

The stochastic and inefficiency models estimated before the data are transformed show that most variables in error component model and technical inefficiency effects model are statistically insignificant. However, lamda ƛ (the variance parameter showing the ratio between the normal error term and half normal positive error term) is statistically significant. This verifies the fact that there are measurable inefficiencies in cane production probably caused by differences in age and type of cane as well as the soil type of the area. The value of gamma, furthermore, signifies us that around 80% of variation in the model are caused by technical inefficiency. The result from this model also illuminate that the mean technical efficiency of sugar cane for each plot at Wonji/Shoa Estate Farm is around 77%.

5.2.1 Hypothesis Testing of Efficiency and In Efficiency

After the important test have been made it was followed that the γ value of 0.80 was found and interpreted as, 80% of the variation in output among plots is explained by technical inefficiency. The second test, following the existence of inefficiency, is to check if there exist one or more variables that could explain the variation in technical inefficiency. Since the calculated LL ratio value (38.39) is greater than the critical value of LL ratio (20.69) the null hypotheses that determinant variables in the inefficiency effect model are simultaneously equal to zero is rejected.

5.2.2 Production Frontier and the Technical Efficiency Estimates

The results of maximum likelihood (MLE) and ordinary least square (OLS) of the cob- Douglas SFPF the input coefficients in the two models are positive as expected and significant at 1 percent level except for the coefficient of material cost which is not significant. The sum of the coefficients is 1.04 indicating increasing return to scale. The largest contributor to sugar cane production in wonji sugar factory is area which has an elasticity of 0.88 this means a 1 percent increase in land will increase the sugar cane production by 0.88 percent. The results are shown in table below.

Table 3: MLE of the Stochastic Frontier and OLS Production Function for Sugar Cane Estate Farm

Variable	MLE		OLS	
	Coef.	P>|z|	Coef.	P>|t|
Ln(area)	0.882***	0.000	0.873***	0.000
Ln(Equipment)Cost	0.15***	0.000	0.06***	0.000
Ln(LabourCost)	0.062***	0.001	0.097***	0.000
Ln (MaterialCost)	0.0090	0.679	0.0255	0.172
Constant	6.11***	0.000	5.591***	0.000
Variance sigma^2	0.1460	0.120		
Gamma	0.80***	0.037		
Lambda	1.98***	0.0082		
Log likelihood	-12.687			
chibar^2(01)	6.51			
Wald chi^2(4)	1185.53			
Adj R-squared			0.871	
F-statistics			257.62	

*** is significant at 1 %

Source own survey

5.2.3 Variance Parameters

Maximum likelihood estimates was used to estimate the gamma value with the estimation of mean technical efficiency and the value of parameter estimates for the inefficiency effects model.

The value of gamma (γ) is 0.80 and significant at 1% level indicating 80 % variation in sugar cane yield due to inefficiency factors. However, 20 percent of the variation in output was due to random noise beyond the control of Estate plot. Examples of such random shocks include weather floods, bushfires and diseases. These values are in the ranges of the findings of many of the research works reviewed (Hasan and Islam 2010, Teshome, 2005, Khairo and Battese, 2004, Oji *et al.*, 2007).

5.2.4 Estimation of Plot Level Technical Efficiency

From table below frequency distribution of mean technical efficiency of sugarcane producing of plot units of Wonji/Shoa Estate Farm there is a big gap between plot units ranging from mean technical efficiency 96 % to 10 %. Accordingly this variation as caused by seed variety, age of sugarcane on time of harvest, cane type, soil type and area are the predominant variable that affect the technical efficiency of plot units of Wonji Estate Farm. As it is observed from the value of gamma which is 80 % implying the total variation in technical efficiency is caused by inefficiency variables

Generally among the total plot units of Wonji/Shoa Estate Farm as maximum mean technical efficiency range exist, also minimum mean technical efficiency range also persist incorporating 2 plot units and 0.7 percentages of the total plot units of the study area respectively. The other mean technical efficiency range is represented by the table for further understanding refers to table below.

Table 4: Frequency Distributions of Technical Efficiency of Wonji/Shoa Sugar cane Estate Farm

Efficiency range	Frequency	%age
10-20	2	1%
21-30	1	1%
31-40	0	0%
41-50	1	1%
51-60	13	8%
61-70	18	12%
71-80	36	24%
81-90	70	46%
90-100	12	8%
Average Technical Efficiency		77

Source own survey

5.2.5 The factors of Technical Inefficiency

In the analysis of technical inefficiency effects model, the sign of coefficients of the model is taken in to account based on the analysis of (Coelli, 1996). If the coefficient of the parameter in the model is positive, it means that the variable is increasing the level of technical inefficiency of the ploter and whereas, if the sign of the coefficient of the parameter is negative, it shows that the variable under consideration is decreasing the level of technical inefficiency or increasing the level of technical efficiency of the production of sugar cane.

The inefficiency factors were estimated by using the estimated (σ) coefficients of the inefficiency effects. The inefficiency effects were specified as those related to **cane age**, **Cane variety**, **Area** and **Soil type** under sugar cane.

Area (Land): - The result in Table shows the coefficient of area is negative, which shows a negative relationship with technical inefficiency.

Cane age: - The maximum age for sugar cane is at 23 month.
Cane variety: The inefficiency effect of the sugar cane varieties is positive and it indicates that**Nco-334 variety** is the best seed variety for production of sugar cane and the next best variety is N-14 but at Dejene (2013) study it was found that N-14 Variety was first, the lowest contributor to the technical efficiency is B52-298 variety.
Soil type: - The measure of soil type is constructed by forming soil management group based on previously studied results made by Wonji sugar factory by physiographic character of the soil. The soil in the cane plantation of the estate are divided in to five categories these are:- Alluvial back swamp, Alluvial basin, Alluvial levee , piedmont collvial and Alluvial levee . Even though the type of soil insignificantly influences technical inefficiency of the production of the sugar cane it has positive effect. Operating on Alluvial levee soil type seems to be more technically inefficient than operating on Alluvial back swamp.
Cane type (ratoon): The coefficient of cane type is negative (-0.002) as well as insignificant showing that the relationship between cane type and technical inefficiency is negative. The Inefficency results are shown on table below.

Table 5: Inefficiency Stochastic frontier normal/half-normal model

Variable	Coef.	Std. Err.	z	P>|z|
Lnareainha	-0.01	0.018	0.580	0.565
LnCaneage	-0.020	0.068	0.290	0.774
Cane variety	0.004	0.006	0.550	0.583
Soiltype	0.001	0.005	0.270	0.789
Canetype	-0.002	0.005	0.390	0.696
cons	0.303	0.222	1.360	0.172

6. Conclusion

The empirical results predict that technical inefficiency effects were significant in explaining the yield for Wonji Sugar Cane Estate plot units. The mean technical efficiency was estimated at 77%. The inefficiency model indicated that all plot units were less efficient in their production and lost to the tune of 23% of their potential output. These losses differ from one plot units to another. Some Plot units had a slightly higher technical efficiency than other plot units.
The mean technical efficiency for the plot units was 0.77 compared with the minimum of 10% and 96% of the maximum technical efficiency for the plot units of wonji sugar can estate ploting units. This revealing that almost plot units have mean technical efficiency of 77%. The predominant variables that induce variation in level of technical efficiency in the study were Seed variety, cane age, area, cane type and soil type.

Regarding the level of ground water and its effect as the information from different researches and interviewed staff ofWonji/Shoa Estate Farm shows that, the plot is facing a serious problem in land (seed bed) preparation and late harvesting operations. The first problem (late commercial cane planting), since sugarcane has optimum planting period, affects the normal growth of sugarcane (germination, stock population, tillering, stock height), which are indicators for final sugar yield (quality and quantity). Delayed time for harvesting operation (beyond the normal growing period) has economic implications because of its effects on the yield as well as land preparation (in case uprooted), the later effect will result in the problem of delayed seed plantation. Delayed harvesting will reduce crop yield per hectare per month as well as the deterioration of sugar quality. Sugarcane requires adequate moisture supply throughout the growing period (i.e. establishment, early vegetative, stem elongation and early yield formation) in order to obtain the maximum potential yield. Sugar content seems to decrease with increased cane tonnage yield. Therefore, cane harvesting should be done at the most suitable moment when an economic optimum of recoverable sugar per area is reached. However, water surplus during the late growing periods (stem elongation and maturity) has an adverse effect on the yield than the water surplus during the first periods (establishment and early vegetative (tillering). Excess (frequent) during the yield formation period has an accelerating effect on flowering, which is not desirable as far as sugar production is concerned since its significant reduction of sugar yield (both quality and quantity) .Therefore, efforts on the management of water resources, especially ground water in such areas is extremely important for the sustainability of agriculture.

Canal performances were highly affected by deformed canal shapes and trees grown along an embankment which is manifested by very slow water velocity. Leakages because of damaged canals, canal breaches and broken structures were also causing large quantities of water to be wasted. Such conditions lead not only to inadequacy, but also to inequity, in water supply. Hence, water losses should be minimized.

The need for rehabilitating the irrigation system demonstrate that the system has previously not been properly maintained and control structures are frequently reported as being either in a very poor condition or very inoperable. Moreover, addressing of the entire canal network is necessary due to the fact that seepage and leakage are not limited to specific canal category and to some parts of canal network. Most of the canals and canal structures have problems with comparable magnitude.

7. Recommendations

The mean technical efficiency of Wonji sugarcane Estate Plot found in this study is77% where as the maximum and minimum technical efficiency is 96 % and 10 % respectively. Thus, there is a need to increase the technical efficiency by 23% by adopting the following points

- The pump irrigation type of sugarcane watering system is highly prone to suffer from hydroelectric power fluctuation and as well it is time taking to access all over plot units if once interrupted because of hydroelectric power break which have a significant impact on reducing the technical efficiency of sugar cane yield. There for enough generators should be available in such situations, in regard to the water loss from the canals
- Rehabilitating of the canal system is necessary before lining with lining materials. After that lining of selected canals with any lining material is preferable. The work must be started from upper reach of the scheme and should go down

to smaller canals following topography and discharge capacities. Besides, repairing of water controlling structures at each junction along the way should be carried out simultaneously.

- The other recommendation is for each plot unit plots it is better to use the maximum age at 22 month, more of 22 month or less will cause the yield of sugar cane to decrease.

It is better to expand N-co -334 type of seed cane variety which directly related to technical efficiency of plot units. This is to mean, a plot unit with appropriate seed cane variety N-co -334 is less technically inefficient than a plot unit with other types of seed selection (B52298, OV, CO421 and N-14). This result shows that N-co -334 seed cane Variety is the best and most producing and maximum output among all the seed cane variety.

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