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Analysis of Sugarcane Farming in the Sugar Mill District Semboro Jember, Indonesia: A Data Envelopment Analysis Application

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Abstract

Sugarcane farming play a pivotal role in Indonesia as the major source of raw material for sugar industry in the country. With increasing population and econonomic activities, Indonesia continues facing excess demand for sugar to meet domestic consumption. Efforts to increase sugar production is hampered by lack of land availability and the declining in sugarcane productivity due to ratooning system practiced by sugarcane farmers. The efficiency, therefore, is one of main problems that need to be addressed in sugarcane industries. This paper attempts to assess such an efficiency aspect of sugarcane cultivation at farmers level. Data envelopment analysis (DEA) was used to assess the efficiency of sugarcane plantation in major sugar mill area in Jember, East Java province Indonesia. Results show that existing sugarcane farming is inefficient and call for serious policy intervention in order to support the livelihood of rural community and sugar industries nationally. Lesson learned for policy makers on managing sugarcane farming were then drawn from this study.

Keywords : Sugarcane plantation; Data Envelopment Analysis; Efficiency; Ratooning system.

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1. Introduction

Sugar is one of the most strategic commodities and play a greater role in Indonesia economy. Sugar industries employ more than 140 million people nation wide and contribute significantly to households farmer of sugarcane plantation. Sugar also is one the five staple foods which has become highest priority in Indonesian agriculture agenda. This is due to the fact that the relative instability in sugar market will affect economic of the nation. Sugar is not only consumed directly by people as food additives, but also is used in food, and beverages industries. Hence, disruption in the production side of sugar industries will inevitably affect the economic of those industries.

In Indonesia, sugar industry has been experiencing a dramatic shift in the global market. In nineteen century Indonesia was the second sugar exporter country in the world beaten only by Cuba. Nowadays, the country has been a net importer of sugar since the 1960s and now ranks as one of the world's biggest importers in the global sugar market. One of the reasons for this shift is the availability of harvested area. Sugar harvested area during 2009-2013 is relatively stagnant at average of 440 thousand hectare with average productivity of 5.5 metric tonnes per hectare. Indonesia is expected to produce 2.1 million metric ton (MMT) of white sugar in marketing year 2014/2015 [38]. With existing demand of sugar at 5.7 million metric tonnes (MMT), there is a wide gap of supply of sugar production in the country which cannot be met with the existing technology and sugarcane production.

As in any tropical country, sugarcane cultivation is the major source of sugar industries in Indonesia. Most of Indonesia’s sugarcane plantation area almost exclusively located in Java island due to its rich volcanis soil and a vast supply of labor. The availability of Java sugarcane area, however, is declining recently due to land conversion and competition of scarce land resources with other economic activities. In addition, it is difficult to find fertile land outside Java. As a results sugarcane production is estimated to decline from 28.7 MMT in 2013/2014 to 27.1 MMT in 2014/2015.

The development of sugar industries in Indonesia, therefore, faces many challenges, which hinders the government effort to increase sugar production nationally. In addition to limited land availability for sugar plantation, the national program for increasing sugar productivity is also constrained by limited raw materials, and low quality of seeds [23]. Farmers are often forced to practice cultivating sugarcane with ratooning system known locally as “keprasan” with average of ten times even more. The ratooning system is a technique at growing return sugarcane that felled. Anon [4], states that ratooning sugarcane management has been intensively done since the issue of the President Instruction number 9 in the 1975 about people’s sugarcane intensification. Since 1990, the trend of the use of ratooning system of sugarcane has continued to increase, that is around 60% from total square existing sugarcane [27].

As a result of such a common practice, sugar productivity tend to be declining recently. For example, while national sugar productivity tend to be stable around 4.9 ton/ha during period 2000-2011, the productivity of sugar production at center of sugar plantation in Jember, East Java have been declining from 5.001 ton/ha in 2010 to 4.603 ton/ha in 2011 .

The phenomena of using ratooning system or "keprasan is even ubiqutious in area where land is competing with industries and farmers have limited access to financial capital such as those in Jember, East Java where 13.5% of East Java sugarcane production is supplied. The practice of using keprasan for more than ten times has created other problems. In addition to lower production, the tendency to use dry land to plant sugar cane has resulted in inefficiency in sugar plantation at farmer's level.

The development of increasing sugar production, therefore is facing dilemma of either to increase production using extensification (expansion of land cultivative) or surviving existing production with practice of using "keprasan" as the only viable way to maintain production. The choice of using the former is almost imposible due to high cost of land purchasing. Therefore, choosing the later option is the only feasible way given existing constraints. The critical questions, therefore, is how to efficiently maintain existing sugar production with existing practice at farmers level. The issue of efficiency is has also been found in other studies such as [7,5]; and [27]. It is this critical question that this study is aimed to answer.

Even though various studies have been carried out to assess the productivity of sugar plantation [21,24,37,11], most of these studies are at macro level and did not address the constraints forced by farmers who have been forced to use technique ratooning system (keprasan). Given the constraint imposed by farmers to use ratooning system (keprasan), the question of efficiency in using their input of production is very important since these are the factor of production that the farmers can have control over them This study is the first one to address this phenomenon. In addition, little rigourous work has been undertaken to quantitatively study the efficiency of existing sugarcane cultivation. Study on efficiency of sugarcane plantation will enhance to identify the source of efficiency so that improvement can be made. It is also important to identify the relationship between efficency and socio economics factors affecting such an efficiency at farmers levels. This study attempts to fill this gap by examining efficieny of sugarce cultivation driven by ratooning system constraints.

It is expected that result of this study could be used as a lesson learned for policy makers, either, in Indonesia or elsewhere to improve the productivity of sugar production both at micro and macro levels.Using data at farmers level at sugar mill of Semboro are in Jember East Java, this study is aimed to assess the efficiency of sugar cane plantation at farmers level.

2. Method of Analysis

Since the central theme of the study is how existing practice of sugar cane cultivation at farmers level can be efficiently managed, the measurement of efficiently of inputs and output therefore is carried out. A Data Envelopment Analysis or DEA is common method being used to assess such an efficiency measure.

Data envelopment analysis is non-parametric technique developed by [10] which is further the development of measurement efficiency frontier developed previously by [20]. One of the advantages of using DEA is that we do not have to assume the production function of units being analyzed. Instead we can simply use data of inputs and outputs used by decision making unit or DMU.

Mathematically, Charnes [10] provide a formal method of measuring efficiency using DEA :

Max $\sum_{r=1}^{s} = u_r y_{ro}$ (1)

Subject to : $\sum_{r=1}^{s} = u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$

$\sum_{i=1}^{m} v_i x_{i0} = 1$

$u_{r,} v_i \geq 0$

Where y_{rj} and x_{ij} are output and inputs of the j[th] decision-making unit, respectively. Variables u_r and v_i represent weights associated with outputs and inputs that will be calculated by solving the above equation. The term $\sum_{i=1}^{m} v_i x_{io} = 1$ is used when one is willing to switch from ratio form to linier programming form. In DEA term, equation (1) is also known as multiplier model of DEA.

The implementation of DEA is often done using duality using linier programming or using "Envelopment form" of DEA. It is written as

Min $\theta = \theta^*$

Subject to $\sum_{j=1} x_{ij} \lambda_j \leq \theta x_{i0}$

$\sum y_{rj} \lambda_j \geq y_{ro}$

$\lambda_j \geq 0$

The above equation represent the CRS or Constant Return to Scale form of DEA. Analyzing efficiency under the CRS assumption is rather restricted. The CRS assumption holds good only when all units are operating at an optimum level. Several factors (such as imperfect competition and accessibility to funds) might influence the DMU not to operate at an optimum level [14]. Recognizing these deficiencies, [8] provide the DEA formula for the VRS assumption with the following :

$Max \sum_{r=1}^{s} = u_r y_{ro} - u_0$ (2)

Subject to : $\sum_{r=1}^{s} = u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_0 \leq 0$

$\sum_{i=1}^{m} v_i x_{io} = 1$

$u_r \geq 0$

$v_i \geq 0$

To implement DEA method, inputs and outputs of each DMU must be specified. In our case input for sugarcane production at farmer's level consist of land, organic fertilizer, non-organic fertilizer and labor. Although DEA method allow us to use multiple output, in this study, the production of sugar cane measured in quintal (=100 kg) is the only output being used. The DMU consists of fourty farmers of sugarcane plantation. The data on inputs and output used for this study is listed in Table 1. Analysis of DEA was carried out both under CRS assumption and VRS assumption.

Analyzing DEA at both under CRS and VRS assumptions allow to measure "scale efficiency" or SE, which is simple the raton of CRS/VRS. SE will indicate whether DMU operating at increasing or decreasing return to scale. An increasing return to scale DMU indicates that if for example we double the level of input, the output level could increase more than double.

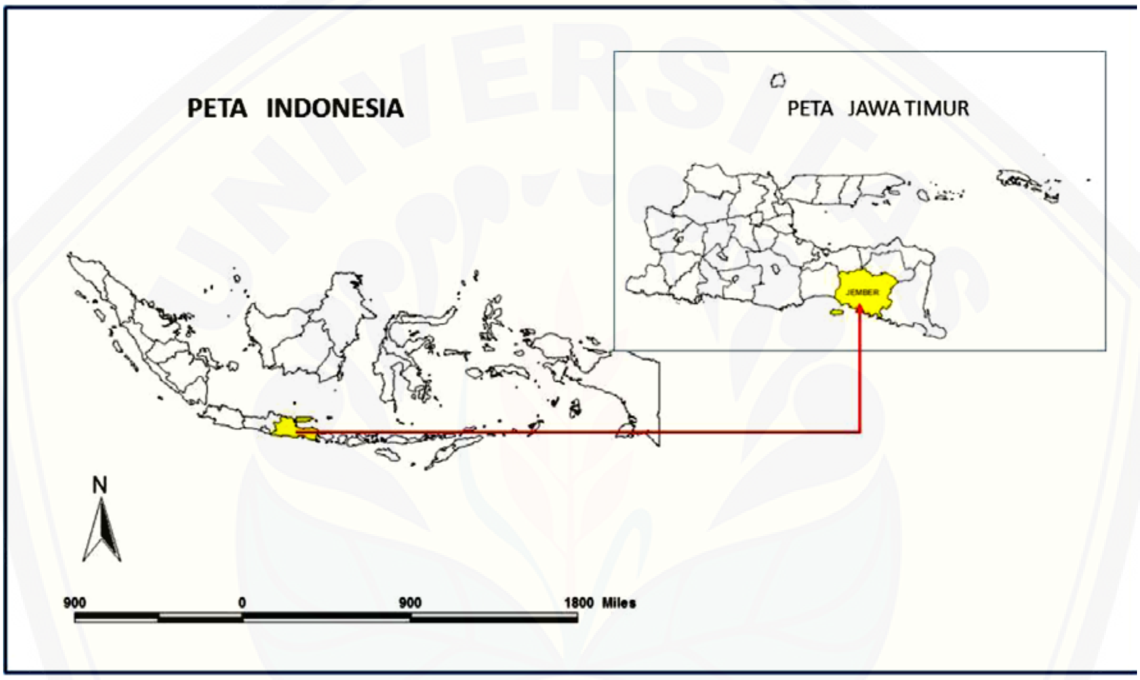

Figure 1: Map of Jember, East Java

Since the focus of the study is to address how efficiency could be achieved at farmers level, the DMU of analysis is farmer who are practicing ratooning system (keprasan) i.e traditional farmers in Jember (Figure 1) sugarcane plantation. Sample was taken purposively. As many as 40 farmer's were taken as sample for DMUs during 2012/2013 planting season. Those farmers are farmers who supply sugar cane to sugar mill industries in Semboro, Jember East Java. The interview was carried out in September to December 2014 using structured questionare. A description of inputs and output for each DMUs is listed in Table 1.

Input orientation of DEA was carried to assess the efficiency. The reason for choosing input orientation, instead of output orientation is based on previous finding such as [34], [13] who state that inputs are important variables and play a greater role in the sugar cane cultivations. It is also these variables that farmers can have control over them.

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Table 1: Inputs and output of decision making units

DMU	Land (ha)	Organic Fertilizer (qu/ha)	Non Organic Fertilizer (qu/ha)	Labor (man days/ha)	Output (qu/ha)
1	43	6	10	177	900
2	5	20	7	166,5	800
3	60	4	10	178,5	1000
4	3	10	7	169,5	900
5	4	3	10	166,5	750
6	5	20	7	161	1000
7	2	10	7	148	500
8	2	6	10	147,5	800
9	3	3	10	176,5	875
10	4,25	10	7	166,5	700
11	4	3	10	162,5	750
12	0,7	3	10	119	325
13	44	12	10	164	1100
14	2	3	27	158	400
15	4,855	10	7	156,5	900
16	7,484	20	7	144,5	1800
17	2,547	6	10	163	825
18	4,2	3	10	166	900
19	1,135	3	6	165	400
20	0,593	3	10	113,5	300
21	1,036	10	7	158	500
22	31,168	10	10	176,5	1000
23	9,483	10	3	179,5	1000
24	1,982	6	10	162	750
25	5,856	20	7	169	800
26	1,216	10	7	163,5	1000
27	0,175	3	6	57,5	120
28	1,434	6	10	164	700
29	1,25	4	10	167	750
30	2,3	20	7	172	900
31	4,2	3	10	169	900
32	27	10	8	170,5	1000
33	0,175	3	5	65	160
34	0,593	3	10	107	300
35	1,982	4	12	161	750

36	3	3	12	168	1100
37	1,25	4	10	168	750
38	2	2	11	167	700
39	4	10	10	162	800
40	5	20	8	167	800

In addition to assessment of efficiency at farmer's levels, the study is also aimed to determine factors affecting the efficiency of sugarcane production. This is a follow up analysis of DEA. A regression analysis was used to carry out such an analysis with the efficiency scores as variable dependen and several socio economic factors as explanatory variables.

The descriptive statistics of variables from the sample is presented in Table 2.

Table 2: The Descriptive Statistic Inputs and Output

Variabel	Mean	Std Dev.	Min	Max
Production	767.625	303.270	120	1800
Land	7.696	13.558	0.175	60
Organic Fertilizer	7.975	5.916	2	20
Non Organic Fertilizer	9.125	3.509	3	27
Labor	156.075	27.138	57.5	179.5

3. Results and Discussion

A result of DEA for each DMU with respect to its efficiency scores and optimal target of inputs are presented in Table 3. In table 3, land variable is not presented due to the fact that land is fixed and in reality can not be annexed or reduce. Hence, Table 3 present only input variables. As can be seen from Table 3 all inefficient DMU unit call for reduction of the level of input from existing usage. Reduction vary for each DMU and inputs variable. The biggest reduction for organic fertilizer should be done by farmer number 30 (DMU=30) with reduction of 8 quintal/ha or 41 % of existing usage. For non-organic fertilizer a big reduction should be done by DMU 14 with an equivalent of 16.45 quintal/ha or 61%. Reduction for labor variable in terms of man per day will be the highest for DMU number 22 with equivalent of 18 man per day or 10% of existing usage. On averge, to reach optimal level of efficient inputs should be reduced between 3.3% for labor to 9 % for non-organic fertilizer.

Table 3: Actual versus Optimal Level of Input of DMU under VRS DEA

DMU (farmer)	Organic Fertilizer (qu/ha)		Non Org. Fertilizer (qu/ha)		Labor (man per days/ha)		Score DEA
	Actual	Target	actual	target	Actual	target	
1	6	6	10	10	177	167.26	0.77
2	20	16.03	7	7	166.5	152.02	0.53
3	4	4	10	10	178.5	168.92	0.98
4	10	10	7	7	169.5	164.70	0.84
5	3	3	10	10	166.5	166.11	0.83
6	20	16.03	7	7	161	152.02	0.67
7	10	10	7	7	148	148	0.50
8	6	6	10	9.05	147.5	147.50	0.87
9	3	3	10	10	176.5	166.65	0.99
10	10	10	7	7	166.5	165.55	0.62
11	3	3	10	10	162.5	162.50	0.84
12	3	3	10	7	119	102.15	0.88
13	12	12	10	9.35	164	155.55	0.74
14	3	3	27	10.55	158	158	0.49
15	10	10	7	7	156.5	156.50	0.79
16	20	20	7	7	144.5	144.50	1
17	6	6	10	10	163	163	0.76
18	3	3	10	10	166	166	1
19	3	3	6	6	165	165	1
20	3	3	10	6.58	113.5	94.44	0.92
21	10	8.80	7	6.65	158	146.61	0.58
22	10	10	10	9.94	176.5	158.32	0.72
23	10	10	3	3	179.5	179.50	1
24	6	6	10	9.45	162	162	0,76
25	20	17.41	7	7	169	149.41	0.50
26	10	10	7	7	163.5	163.50	1
27	3	3	6	6	57.5	57.50	1
28	6	6	10	9.07	164	164	0.80
29	4	4	10	10	167	167	1
30	20	11.72	7	7	172	160.22	0.79
31	3	3	10	10	169	166	1
32	10	10	8	8	170.5	164.24	0.78

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33	3	3	5	5	65	65	1
34	3	3	10	6.58	107	94.44	0.92
35	4	4	12	10.35	161	161	0.83
36	3	3	12	12	168	168	1
37	4	4	10	10	168	167	1
38	2	2	11	11	167	167	1
39	10	10	10	9.25	162	159.53	0.61
40	20	16.03	8	7	167	152.02	0.53
Average	7.98	7.38	9.13	8.30	156.08	150.97	0.824

Table 4 presents the frequency of efficiency score both under CRS and VRS assumptions, and the corespondent ”scale efficiency”.

Table 4: Frequency of Efficiency Scores

Efficiency Score			Frequency CRS	Frequency VRS
1,00	-	0,95	9	14
0,94	-	0,89	3	3
0,88	-	0,83	2	5
0,82	-	0,77	6	6
0,76	-	0,71	10	3
0,70	-	0,65	2	1
0,64	-	0,59	2	2
0,58	-	0,53	2	3
0,52	-	0,47	4	3
Mean			0,783	0,894

As can be seen from Table 4 under CRS assumption higher frequency scores are in the range between 0.71-0.76 and 0.95-1, while under VRS assumption higher frequency scores is in the range 0.95-1. This implies that under VRS, more farmers tend to have higher efficiency than that of CRS. The average score of efficiency is 0.783 under CRS assumption and 0.894 under VRS assuption resulting the SE score at 0.876 which indicates decreasing return to scale (DRS). Results from Table 3 indicate that the average efficiency score of 0.783 under CRS implies that on average, sugarcane cultivation at farmer level indicators inefficiency at current level of production. Farmer’s could reduce or use inputs more efficiency by reducing around 12 % of their inputs. Under VRS assuption reduction of input level by approximately 11 % coud produce the same optimal level of output.

The efficiency scores obtained from DEA assessment will have impact on the number of inputs under different scenarios as depicted in Table 5. Table 5 also indicates that the number of farmers who are operating at efficient frontier increased 71 % from 7 DMUs to 12 DMUs.

Table 5: Average inputs used under different scenarios

	Production (qu/ha)	Land (ha)	Organic Fertilizer (qu/ha)	Non Organic Fertilizer (qu/ha)	Labor (man days/ha)
CRS (11)	914,54	3,82	12,18	7,45	156,73
DRS (7)	871,43	22,17	11,14	9	167,86
IRS (22)	661,14	5,03	4,86	10	152

As can be seen from Table 4, most farmers operating their economic scale under increasing return to scale. That is, the economics of scale for the most productive farming is at maximizing average product. This result are similar those obtained by [17] and [1] where most farmers are operating at VRS. This result also indicates inefficiency is atributed to sugarcane production. The inefficiency is atributed to the use certain type of inputs which may prohibit farmer to operate at optimum level. For example, inefficiency of using land as factor production could reduce output up to 30%. Inefficiency at using land may reduce its possibility, hence, will reduce production. Results from this study indicates that in order for farmers to achieve the optimal level of production, the number of land could be reduced by 4%, organic fertilizer by 7%, non-organic fertilizer by 9 % and 3% of labor.

3.1. Factors Affecting Efficiency in Sugar Cane Farming

As stated earlier, one of the objectives of this study is to assess factors affecting the efficiency of sugar cane farming. This is a follow up DEA analyse, hence, DEA score obtained from previous analysis were used as dependent variable. The explanatory variables are the age of farmer, level of education, number of family member, how many times ratooning system (keprasan), state of farming (dummy), and access to credit (financial markets), land ownership and extension services. Results of regression analysis are presented in Table 6.

As can be seen for table 6, as predicted, the number of “keprasan” is significantly affecting the efficiency score. That is as the number of “keprasan” increases (farmer use more ratooning system) the less likely the farmers will operate efficiency. This is also in line with findings from previous study by [33] which indicate that higher frequency of ratooning system or “keprasan” will lead to lower productivity. Stoler [33] found that ratooning for more than 20 years, for example, caused low productivity in sugarcane farming in Fiji. Variable of state of sugar cane farming i.e either as main business or part time business will determine the efficiency level. Farmers who work at sugar cane farming as full time job tend to score less efficient. This may be atribute to the fact that full time job farmers tend to practice “keprasan” which may lead to inefficiency. This argument might be counter intuitive as farmers who work full time at sugar cane farming may have full control over their productions and inputs.

Table 6: Regression Results

Variabel Input	Coefficient	SE	t-ratio
Constant	1.041847	.1708375	6.10
Age	-.0031269	.0044536	-.0.70
Education	-.0053614	.0077256	-0.69
Number of family member	.0003707	.0187535	0.02
Number of “keprasan”	-.0274923*	.0112844	-2.44
State of farming	-.0907901**	.0529181	-1.72
Access to credit	.0365963	.0603697	0.61
Land ownership	.0080686	.069564	0.12
Extension services	.147737*	.0528894	2.79

Other variable that have significant determination to the efficiency score is the extension variable. This is also a dummy variable with 1 being farmers who participate in extension service and 0 otherwise. Farmer who participate or received extension service from agricultural agency tend to have higher score of efficieny, vice versa. This is understandable given the fact that these who participate in extension service will have more knowledge in their production activities, therefore, will have control to achieve efficient level of production. It is commonly known the success of sugarcane farming depends very much on good crop managment practices.

It is also supported by previous study such as [12] who found the significant of extension services on sugarcane cultivation success. Farmers who don’t participate in extension service tend to have higher cost, they need adequate extension service to be efficiency in their production activitis.

Findings form this study has various policy implications. First, every year the government, through ministry of Agriculture (MOA) set the target of harvested area, sugarcane production and white sugar production. In 2014, for example, the goverment set the target of harvested area of 456.3 thousand ha and 3.10 MMT white sugar. Yet in reality harvested area was only 450 thousand ha, total sugar cane production in 2014 reached only at

233.7 thousand ton with 2.3 MMT white sugar. USFDA [38] even forcasted that white sugar production to decline to 2.1 MMT in 2011/2015. Based in this fact, it can be inferred that setting the increased of production both on up stream and downstream industries is unrealistic given chronic inefficiency of sugarcane cultivation and sugar mills industris. Efforts by goverment to revitalize several state owned mills will not be fruitfull without revitalizing or improving efficiency at sugarcane plantations. It is well known that the Indonesia's sugarcane farms are poorly managed resulting the averge yield (sucrosa content) at only 6-7 %. This is much lower than that of Thailand which has average yield of 12 %, or India which have sucrosa content of 8-10%. Therefore, it is important that improving efficiency at sugarcane through lowering cost of production, for example, would help to improve efficiency.

Second, the goverment, through MOA, allocatie assisstance budget, known as, development budget to local goverment to improve Indonesian plantation sector in general. This allocated budget is aimed to improve extension services, pest and desease control as well as monitoring and evaluation. Nevertheless, the disbursement of this budget is through local goverment and based on fiscal year. This is often incompatible with planting seasons faced by farmers. Hence, an improved of disbursement of budget for sugarcane plantation is needed. Third, improving efficiency of sugar cane cultivation could be delivered through incentive mechanisme that is attractive to farmers. It is important to note that there is too much distortion in the pricing policy for agricultural sector in general, and sugar industry in particular. Import of raw sugar materials, for food and beverge industris has, to some extent, distorted sugar price in the market. This creates disincentive for sugarcane farmers leading to more inefficiency and low productivity. Therefore, prudent price policy for sugar industris is sorely needed.

4. Concluding Remarks

Sugar cane production plays a pivotal role in regional economy in Indonesia, especially in supporting rural economy through provision of jobs and income for rural households. Despite its position as one of strategic commodities in Indonesia, effort to increase sugar production to meet national demand has always been faced by obstacles by limited land availablity and chronic inefficiencies in sugar mill and sugarcane plantation are among the main obstacles to raise sugar production.

Small-scale sugarcane cultivations are major contributor to sugar production in the country, yet lack of coherence policy directives has forced farmers to practice ratooning system material or knonws as "keprasan" to maintain production of sugar. The practice use "keprasan" has led to inefficiency in sugar cane production. Given the constraints faced by farmers, they can utilize their inputs without sacrificing the target of production. This study implies goverment should pay more attention to provide access to marginalized farmers in providing other input so that ratooning system practice could be reduced. The goverment can also play a crucial role in providing extension service so efficiency of production could be achieved. Other scheme by goverment such as providing law interest rate, comprehensive pricing policy could induce farmers to engage in planting new seed for sugar production. In addition, improving sugarcane infrastructures and rural infrastructure in general, will help to lower cost transportation, so that it will have impact on lowering cost and improve efficiency.

References

[1] Abatania LN, Hailu A, Mugera AW. Analysis of Farm Household Technical Efficiency in Northern Ghana using Bootstrap DEA. Paper presented at the 56th Annual Conference of the Australian Agricultural and Resource Economics Society. 2012.

[2] Ahmad, Usman. Efficiency Analysis of Micro-Finance Institutions in Pakistan. MPRA Paper No. 34215, posted 1. 2011.

[3] Alemdar, Tuna & Oren, M Necat. Measuring Technical Efficiency of Wheat Production In Southeastern Anatolia with Parametric and Nonparametric Methods. Pakistan Journal of Biological Sciences, vol. 9(6), pp. 1088-1094, 2006.

[4] Anon. Management of Ratooning Sugarcane. Sugarcane Development Project, Plantation Office, East Java. www.ratoonjatim.co.cc/tebu_keprasan/pengelolaan_tebu_keprasan.htm. 2005 [Jun.15, 2015]

[5] Asmara, Rosihan & Sugianto SK. Analisis Efisiensi Teknis Pada Usahatani Tebu. Jurnal Habitat. vol. XX(1), pp. 62-72, 2009.

[6] Badan Pusat Statistik. Pendataan Usahatani 2009. (PUT09). BPS 13. 2011.

[7] Baksh, R and Yustika, A E. Sugarcane Farmers in East Java: Institutional Arrangement Perspective. Journal od Indonesian Applied Economics, vol. 2(1), pp. 43-56, 2008.

[8] Banker RD, Charnes A and Cooper WW. Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. Management Science vol.30(9), pp. 1078-1092, 1984.

[9] Bardhan P. Size, Productivity and Returns to Scale: An Analysis of Farm-Level Data in Indian Agriculture. Journal of Political Economy, vol.81(6), pp. 1370–86, 1973.

[10] Charnes A, Cooper WW and Rhodes E. 1978. Measuring the Efficiency of Decision Making Units. European Journal of Operational Research, vol 2, pp.429-444, 1978.

[11] Chetchostsak, Danaipong & Sethanan, Kanchana. Efficiency and Effectiveness Evaluation for Thailand's Sugar Factories: A DEA Approach. Proceedings of the Asia Pacific Industrial Engineering & Management System Conference. 2012.

[12] Chidoko, Clainos and Chimwai, Ledwin. Econoomic Challenges of Sugar Cane Production in the lowveld of Zimbabwe. Int. J. Eco. Res, vol. 2(5), pp. 1-13, 2011.

[13] Clowes. Good Management Practices For The Canes Sugar Industry : Sugarcane and its Environment. The International Finance Corporate. 2011.

[14] Coelli, T.J. A Multi-Stage Methodology for the Solution of Oriented DEA Models. Operation Research Letters, vol. 23, 1998, pp. 143-149.

[15] Coelli TJ, Rao DSP, O'Donnell CJ, Battese GE. An Introduction to Efficiency and Productivity Analysis Second Edition. New York (US): Springer Science+Business Media, Inc. 2005.

[16] Dagistan, Erdal. Determination of Technical Efficiency in Wheat (Triticum Aestivum L) Production of Turkey: A Case Study of Cukurova Region. Journal of Food Agriculture and Environment, vol. 8(2), pp. 354-358, 2010.

[17] Dao, G &Lewis P. Technical Efficiency of annual Crop Farms in Northen Vietnam. Faculty of Business, Government and Law, University of Canberra. 2008.

[18] Dlamini, S, Rugambisa, JI, Masuku, MB & Belete, A. Technical efficiency of the small-scale sugarcane farmers in Swaziland. A case of Vuvulane and Bigbend farmers African. Journal of Agricultural Research, vol. 5(9), pp. 935-940, 2010.

[19] Dwivedi, AK, Ghosh, P. Efficiency Measurement of Indian Sugar Manufacturing Firms: A DEA Approach. Working Paper Series.2014.

[20] Farrell, M.J. The Measurement of Productive Efficiency. Journal of The Royal Statictical Society Series A, vol. 120, pp. 251-381, 1957.

[21] Frenandez M Dina Padilla, Nuthall PL. Technical Efficiency in The Production of Sugar Cane in Central Negros Area, Phipippines: An Application of Data Envelopment Analysis. Journal ISSAAS, vol. 15(1), pp.77-90, 2009.

[22] Heidari MD, Omid M, Akram A. Using Nonparametric Analysis (DEA) for Measuring Technical Efficiency in Poultry Farms. Brazilian Journal of Poultry Science, vol. 13(4), pp. 271-277, 2011.

[23] Iskandar, Dudi. The Assesment of the Application of Standard Cultivation Technique of Sugarcane PS 851 and PS 951 Seedlings at Nursery Level. Jurnal Agronomi, vol. 9(1), pp. 17-2, .2005.

[24] Islam, Nazmul. Production Efficiency of Sugar Factory of Bangladesh: An Application of Data Envelopment Analysis. Global Journal of Management and Business Research, vol. 15(1), 2015.

[25] Kirner L, Ortner KM, and Hambrusch J. Using Technical Efficiency to Classify Austrian Dairy Farms. Bodenkultur-Wien and Munchen-. vol. 1(4), pp. 15-24, 2007.

[26] Kumar, Sunil & Arora Nitin. 2012. Evaluation of Technical Efficiency in Indian Sugar Industry: An Application of Full Cumulative Data Envelopment Analysis. Eurasian Journal of Bussiness and Economics, vol. 5(9), pp. 57-58, 2012.

[27] Latief, A Sutowo et al. Productivity of Sugarcane Plants of Ratooning with Fertilizing Treatment. Nusantara Bioscience, vol. 2(1), pp. 43-47, 2010.

[28] Marpaung, Yanto TF dkk. Perkembangan Industri Gula Indonesia dan Urgensi Swasembada Gula Nasional. Indonesian Journal of Agricultural Economics (IJAE) vol. 2 (1), pp. 1-14, 2011.

[29] Mihai, Dorel & Ion Dona. Data Development Analysis Approach On The efficient Use of Rural Human

Resources in Agriculture, Industry and Constructions During 2006-2013. Scientific Paper Series Management, Eonomic Engineering in Agriculture And Rural Development, vol 14, Issue 4, 2014.

[30] Ogunniyi, LT. Fertilizer Use Efficiency of Maize Producers in Ogun State of Nigeria. The Pacific Journal of Science and Technology, vol. 13(2), pp. 370-376, 2012.

[31] Prodesta, Rosana. Pengaruh Penggunaan Benih Bersertifikat Terhadap Efisiensi dan Pendapatan Usaha

Tani Pandan Wangi. Thesis. Institut Pertanian Bogor: IPB, Bogor 2009.

[32] Pusat Data dan Sistem Informasi Pertanian. Statistik Pertanian. Kementrian Pertanian. 182, 2011.

[33] Stoler, Andrew L. Managing The Challenges of WTO Participation (Fiji:Preparing for the End Preference). 2015.

[34] Sundara, B. Sugarcane Cultivation. Sangam Book Ltd, 1998.

[35] Sundara, B, Narajan, B and Hari, K. Influence of Phosphorus Solubilizing Bacteria on the Changes in Soil Available Phosphorus and Sugarcane and Sugar Yield. Elsevier Science, Field Crop Reserach 77, 2002, pp. 43-49.

[36] Susilowati, Sri Heri & Tinaprilla, Netti. Analisis efisiensi usahatani tebu di Jawa Timur. Jurnal Littri, vol. 18(4), pp. 162-172, 2012.

[37] Thabethe L, Mungatana E, Labuschagne M. Estimation of Technical, Economic and Allocative Efficiencies in Sugarcane Production in South Africa: A Case of Mpumalanga Growers. Journal of Economics and Sustainable Development, vol. 5(16), pp. 86-95, 2014.

[38] USDA. Indonesia Sugar Annual Report 2014 US Department of Agricultural Foreign Agricultural Service. 2014.