Increasing Household Food Security through Resource Balancing among Tobacco Producers

Abstract

Poverty, food insecurity and malnutrition cases have been reported among farmers who prioritize cash crops such as tobacco. This is as a result of inefficient allocation of farm resources to tobacco production, with little or no allocation to staple food crops. To increase food production among such farmers, researchers have recommended optimum allocation of farm resources between tobacco and food crops. This study aimed at determining the resource use efficiency for tobacco – food crop production, the optimal farm plans and the factors affecting resource use efficiency for food crops production. The results from data drawn from 200 tobacco farmers in Western Uganda depicted that farmers were 61% efficient in their resource allocation to tobacco and food crops. Results for the optimal allocation plans suggested that farmers should optimally allocate their resources to tobacco and food crops in order to achieve household food requirement. Household size, pesticides use, farm income and support from the tobacco contract companies had a positive association with resource use efficiency for food crop production while input prices, land size and gender had a negative relationship with resource use efficiency. In conclusion, farmers are inefficient in allocating their farm resources between tobacco and other food crops which has far-reaching implication for availability of household foods. This study therefore recommends that government should increase the training and extension services on the adoption of optimum resources for cash – food crop production as well as supporting the farmers through inputs subsidies so as to increase household food production.

Key words: Resource-use efficiency, Tobacco, Food crops, Data Envelopment Analysis, Tobit regression model

UNDER PEER REVIEW

Introduction

The global demand for food continues to grow steadily due to the growing population. It is projected that the global food production should increase by 60 - 70% by the year 2050 in order to meet an over 9 billion people's food demand (FAO, 2009). From recent reports, it is projected that Sub – Saharan Africa will be highly vulnerable to food insecurity than other regions by 2050 (Dijk et al., 2021). Strikingly, SSA crop yields, especially staple foods are projected to decline by 17% by 2050 (IMF, 2022). In east Africa, agricultural activities must produce more than nine times the current production in order to meet food demand by 2050. This implies that the governments of SSA need to strategize on how to improve agricultural production, especially on the staple foods which are highly essential for increasing household food security.

Sub – Saharan agricultural sector, which is expected to increase food production, is composed and cash and food crop production (Li et al., 2020). The two cropping systems are mainly driven by income generation and household food production respectively. However, there have been reported cases of poverty and catastrophic levels of food insecurity among farmers who prioritize cash crop over food crop production, such as tobacco producers. Evidently, tobacco production competes for the same farm resources with other farming activities including food crops such as maize, cassava, sweet potatoes, beans, rice, vegetable and groundnuts, among others (Alderete et al.,2020; Namome, 2018). The competition between tobacco and staple food crops results into over allocation of farm resources e.g. land, labour and capital to tobacco, as farmers are easily enticed with the income their receive(Rubhara et al., 2020). Strikingly, WHO (2015) argued that the high income earned from tobacco sale does not guarantee availability of sufficient food till the subsequent production season as majority of the farmers do not use their income to purchase food till the subsequent harvesting season. Moreover, relying on food purchase cannot guarantee food security. It has been argued that as much as farmers may be rational in choosing what to produce based on income maximization objectives, such farmers might not efficiently use resources at their disposal for farm planning so as to optimize output for both cash and the food crops (Namome, 2018). As a result, there have been widespread shortages of food among tobacco producing households attributed to resource misallocation between tobacco and food crops (Ampala & Ganda, 2012). For instance, research has shown that up to 72.2% of the tobacco farmers in Kenya tend lack enough food, a situation not any different in Uganda(Ampala & Ganda, 2012). A recent study conducted by Mayer et al.(2019) also

UNDER PEER REVIEW

indicated that tobacco production could be associated with food insecurity under unbalanced resources. In Kenya, Kibwage et al.(2014) recommended crop diversification among tobacco producers as a result of low food production. Moreover, recent reports from World Bank Group(2017) illustrated that more than 72% of tobacco producers in Indonesia were living under poverty. The international food policy research institute[IFPRI] also observed that many tobacco farmers in African countries including Uganda are poor and fall in the "alarming" and 'serious" categories of household food shortages, suggesting that tobacco production could be contributing to food insecurity (Grebmer et al., 2013). Similarly, Mozeleski & Pandey (2020) reported severe shortages of food crops among tobacco producers in Sub – Saharan Africa. Furthermore, Sreerama reddy & Ramakrishna reddy (2017) reported that household food shortages was significantly higher among tobacco producers than non – tobacco producers, suggesting that tobacco could be contributing to food shortages as a result of resource misallocation. These were not in odds with the findings of Gomez (2020), who reported that failure to balance farm resources between tobacco and food crops reduces the size of arable land allocated to food crops, which causes food shortage in SSA countries. As such, scholars like Rubhara et al. (2020) recommended optimum allocation of farm resources among tobacco and food crops.

However, to increase food crops production among farmers who prioritize cash crops like tobacco, it is necessary to develop optimal resource allocation plans which would guarantee sufficient food crops for the farmers besides tobacco production. Such optimal plans would ensure that farmers have adequate major staple foods like maize, cassava, sweet potatoes as well as receiving some income from tobacco production. Moreover, the optimal plans would also ensure that farmers allocate their farm resources to both tobacco and staple food crops in such a way that they receive income from tobacco as well as producing sufficient foods for their households. This however requires understanding the farmers' level of farmers' efficiency relative to household food requirement (resource use efficiency), the optimal farm plans and factors affecting resource use efficiency. Existing studies such as have explained different types of efficiencies such as profit, technical, allocative and economic efficiencies but little work has been done on resource use efficiency, especially in relation to optimum resource allocation for household food production.To bridge the above gap in literature, the study focused on determining the resource use efficiency, its determinants and the optimal farm plans among tobacco - food crops so as to improve food production among tobacco

UNDER PEER REVIEW

producers in Uganda. The study considered the top three significant food crops in Uganda. These included maize, cassava and sweet potatoes (MAAIF, 2020) versus tobacco.

Materials and Methods

Research area

The study was conducted in western Uganda (Figure 1) in Kiryandongo district. The district has a population of 132,822 (UBOS, 2018). It is located in the Western part of Uganda with its headquarters located 220 Km away from Kampala, the capital city of Uganda (UBOS, 2018). It borders Nwoya, Oyam, Nakasongola, Masindi and Buliisa districts. Kiryandongo district has an average altitude of 1290 meters above sea level. This district covers an area of 3,621 square kilometres which is mostly arable land, 50% is set for agriculture while the rest is allocated to settlements. It has a total of 4 counties, 17 parishes and 252 households. In terms of population, the district has approximately 132,822 persons, which majorly composed of females (UBOS, 2018).This district was purposively selected due to the fact that it has high numbers of tobacco farmers. Furthermore, 30% of the population live below the poverty line, which calls for allocation of farm resources to increase food production (UBOS, 2018). In addition, the district suffers land constrains due to the resettlement of refugees from South Sudan and Kenya (UBOS, 2018). The favorable climatic conditions and high rainfall especially in August makes farming a major economic activity in this district (UBOS, 2018). Besides tobacco, other major cash crops grown includecotton and sun flower. On the other hand, the food crops grown include maize, cassava, sweet potatoes, beans and vegetables.

UNDER PEER REVIEW

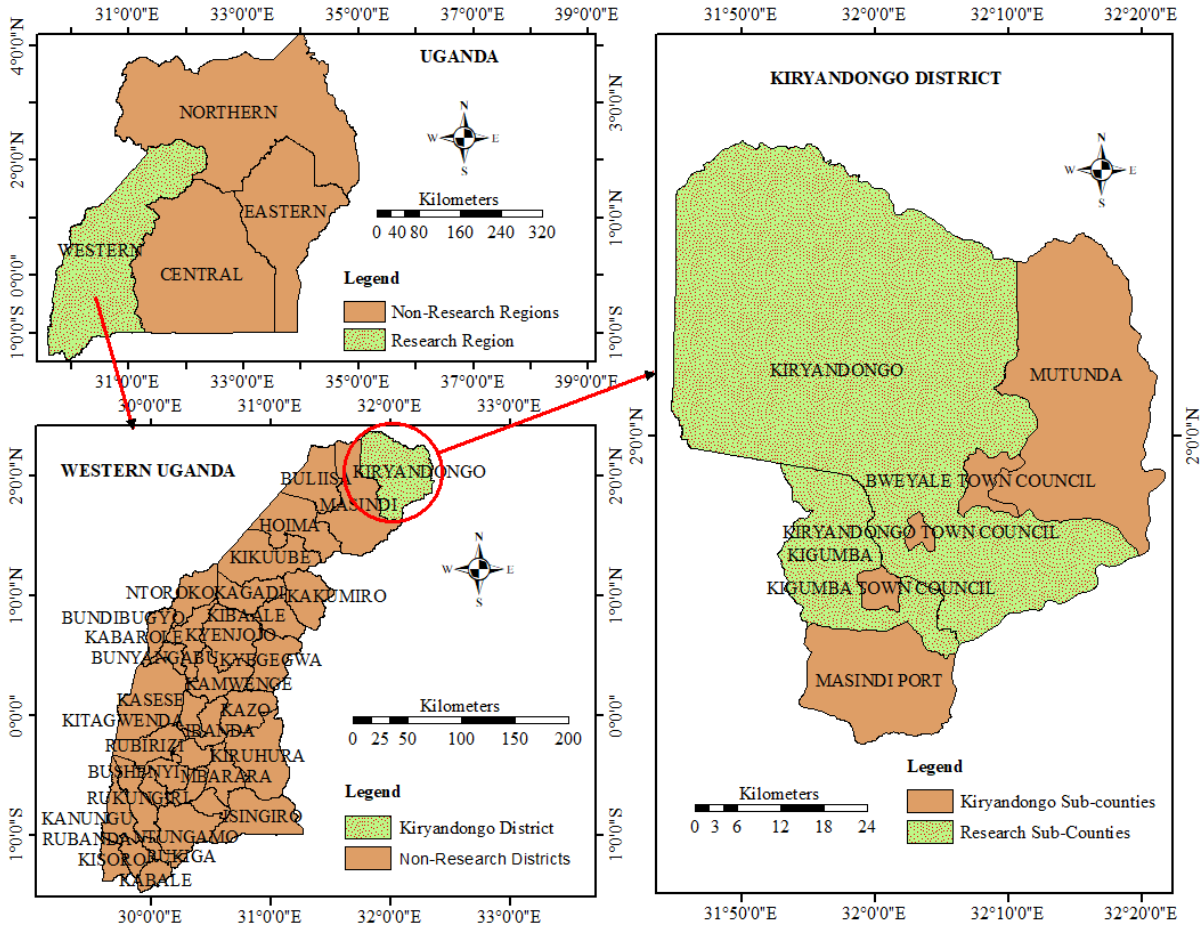

Figure 1: Research area

Sampling and Sample size

The study used multistage sampling techniques. First, Kiryandongo and Kigumba sub-counties were purposively sampled based on the fact that these two sub-counties have the high numbers of tobacco farmers (UBOS, 2018). Secondly, In Kiryandongo sub-county; Kichwabugingo and Kyankende Parishes were purposively selected while in Kigumba sub-county; Kigumba I and Kiigya sub-counties were also purposively selected due to the high volumes of tobacco production in these two Parishes. Finally, eight villages were considered for data collection from these Parishes. The district agricultural officer helped us trace the farmers by availing the list of all tobacco farmers. A total of 200 farmers were considered for the study following a formula by Cochran (1963), which is illustrated below.

$$n = \frac{Z^2 P(1 - P)}{e^2}$$

Where; n =Number of sampled farmers, Z= Z statistic at 95% confidence level , E= Error at 0.05 level and P = proportion which is 0.85 (UBOS, 2018).

Preparation for data collection

In order to collect data smoothly from the farmers, we had to put all the ethical requirements in place. First, the study was presented to Gulu University Research Ethics Committee (GUREC) for approval. After a though analysis, some modifications were recommended by GUREC before its approval. We then thoroughly adjusted the work and got the approval from GUREC. We also obtained approval from Kiryandongo district Chief Administrative Office (CAO) to collect data from the farmers. Secondly, we hired and trained the enumerators on data collection so that they would understand the study's objectives, practice how to ask questions and e familiar with all the study questions. This was followed by pretesting the tool for clarity, relevance and reliable.

Actual data collection

Primary data were collected from the 200 sampled farmers using the semi – structured questionnaire. Face to face interviews were used during data collection between the research assistants and the farmers. They asked the study questions in the local language understood by the farmers and recorded their responses. The tool was developed in such a way that it captured all the variables needed for the study objectives. Specifically, the tool was structured into three sections, with the first section majoring on the socio – demographic characteristics of the farmers. The second section had variables on resource use efficiency and farm allocation plans. The last section of the questionnaire captured variables in household food requirements and household food consumption. Prior to data collection, we seeked for informed consent from the farmers (verbally). The informed consent was verbal. They voluntarily consented to participating in the study. This was as a result of elaborating to them how they would benefit from the study. Similarly, all ethical considerations were adequately followed during data collection. We began data collection on 1st December and completed on 15th December 2022, making a total of 15 days. We concluded the data collection exercise by entering the collected data into SPSS, cleaning and ensuring that it was ready for the analysis.

UNDER PEER REVIEW

Data analysis

Data Envelopment Analysis

Data Envelopment Analysis (DEA), developed by Cooper et al. (2011), has been widely used in agricultural studies to measure efficiency of farmers(Abdulai et al., 2018; Ahmad et al., 2017; Madau, 2012; Wang et al., 2017; Yannick et al., 2016; Yilmaz & Yurdusev, 2011). From literature, the method can also be used to measure resource use efficiency and the optimal farm plans, under given output requirement (Toma et al., 2015). This can be seen in the study by Heidari et al. (2011) who employed DEA to determine the resource use efficiency level as well as the optimal farm plans among poultry farmers; Kouriati et al.(2023) recently applied DEA to determine the optimal levels of factors of production in Greece. As such the study modelled DEA in such a way that it considered farm inputs and relative output, which is the minimum household food requirement. The DEA was modelled to determine the level of farmers' efficiency in terms of resource allocation, relative to the minimum household food requirement for each food crops. This was followed by determining the optimum resource allocation plans which guarantees minimum household food requirement. The study considered DEA due to its ability to determine both the resource use efficiency and the optimal farm plans which guarantee sufficient food for the households till the subsequent harvesting season(Kouriati et al., 2023). The cash crop used in the study was tobacco while the food crops included maize, cassava and sweet potatoes. The farm resources included land, labour and capital. An input oriented variable returns to scale DEA is specified below;

$$\text{Min}_{\theta,\lambda}\ \theta$$

$$\begin{gathered}\text{Subject to} \quad -y_i + Y\lambda \geq 0 \\ \theta x_i - X\lambda \geq 0 \\ N1' = 1 \\ \lambda = 0 \\ \text{where } i = 1, 2, 2, 3 \ldots \ldots i\end{gathered}$$

Where;$N1'$= convexity constant, λ= N × 1constant vector,X = input, Y= output,y_i= output vector,x_i= input vector. The inputs included land, labour and capital while the outputs included harvested quantities for tobacco, maize, cassava and sweet potatoes. The efficiency scores were represented asθ.

UNDER PEER REVIEW

Tobit model

After determining the level of resource use efficiency, Tobit regression model was then used to explore the factors affecting resource use efficiency. This was done using Stata version 14 software. Tobin model, developed by Tobin(1958), has the ability to determine the relationship between censored dependent variable and set of independent variables (Danso-Abbeam et al., 2017). The resource use efficiency scores from the DEA were regressed as the dependent variable on Tobit regression model to determine the sign and magnitude of the factors influencing the resource use efficiency. The model has been successfully used in the studies conducted by Ahmad et al.(2017); Danso-Abbeam et al.(2017); Dube(2016); Hakim et al.(2021); Namome(2018); Ogundeji et al.(2018); Vu et al.(2020), among others. Tobit model is specified as;

$$Y_i = \beta X_i + \varepsilon_i$$
$$Y_i = Y_i^* \text{ if } Y_i^* > 0$$
$$Y_i = 0, \text{if } Y^* \leq 0$$
$$Y^* = \beta_0 + \beta_1(X_1) + \varepsilon_1$$

Where;

Y_i^* = Dependent variable, β_0 = Coefficient of intercept, β_1 = Regression coefficients, X_i =Explanatory variables in Table 1 while ε_i = Error term

Table 1: Explanatory variables

Variables	Measurement	Sign expectation
Age of the farmer	No. of years	+
Farmers' gender	1-Female, 0-otherwise	±
Secondary education	No. of years spent	+
Post-secondary education	Years spent in school	+
Land size	Acres	+
Sub-county of residence	1-Kigumba,0- otherwise	±
Company support	1-Yes, o-otherwise	±
Household size	No. of people	±
Extension	1-Peer farmer, 0-otherwise	+
Pesticide's usage	1-use, 0- otherwise	+
Farm income	In UGX	+
Source of labor	1-Hired,0-otherwise	+

UNDER PEER REVIEW

Input prices	Ugandan shillings	-

Results and Discussion

Socio-demographic profiles of the farmers in Kigumba and Kiryandongo sub-counties

Table 2 presents socio – demographic profiles of the farmers in the study area. The results show that the average age of the farmers was 40.73 years. The farmers in Kigumba sub-county were older than the Kiryandongo sub-county farmers by 0.64 years, however the difference was not statistically significant. The average number of years spent in school was 6.28 years. There was a statistically significant difference ($P<0.1$) between the years spent in school by the farmers in these two sub-counties. Farmers in Kigumba sub-county spent 1.22 years more than their counterparts in Kiryandongo sub-county. On average, the farming experience was 17.4 years. Farmers in Kigumba sub-county had 19.80 years of farming while their fellows in Kiryandongo sub-county had been engaged in farming for 15 years. The difference in their farming experience was statistically significant at 5% level of significance. There was no statistical difference between the distances to the nearest market, however, farmers in Kigumba were located near the markets than their counterparts in Kiryandongo sub-county. The average land size was 4.30 acres. There was statistically significant difference ($P<0.05$) between the agricultural land size in these two sub-counties. Farmers in Kiryandongo had significantly more lands than their fellows in Kigumba.

The average land allocated to tobacco farming was 2.13 acres. Farmers in Kiryandongo sub-county allocated more lands to tobacco than those in Kigumba, however, there was no statistically difference in their land allocations to tobacco. In the case of maize, there was a statistically significant ($P<0.001$) difference in the land allocations. Farmers in Kigumba allocated 0.95 acres of land while farmers in Kiryandongo allocated 1.37 acres of land to maize farming. Farmers in Kiryandongo allocated more lands to cassava (0.52 acres) than those in Kigumba (0.47 acres), there was no statistically significant difference in the land allocations to cassava. There was also no significant difference between the lands allocated to sweet potatoes in these sub-counties. However, Kiryandongo tobacco farmers allocated 0.39 acres while the farmers in Kigumba allocated 0.36 acres to sweet potatoes.

UNDER PEER REVIEW

Table 2: Socio-demographic profiles of the farmers in Kigumba and Kiryandongo

Variables	Overall N=200 Mean ± SD	Kigumba N=100 Mean	Kiryandongo N=100 Mean	Mean difference (Absolute)	P-value
Continuous variables					
Age of the Household head (Years)	40.73 ± 13.50	40.41	41.05	0.64	0.730
Education (Years)	6.28 ± 4.68	6.89	5.67	1.22	0.060*
Farming experience (Years)	17.40 ± 15.65	19.80	15.00	4.80	0.006***
Household size (Number)	7.48 ± 7.00	7.73	7.23	0.50	0.300
Distance to the nearest market (Km)	3.04 ± 2.79	3.01	3.08	0.06	0.790
Agricultural land size (Acres)	4.30 ± 1.54	4.01	4.59	0.58	0.007***
Land allocated to tobacco (Acres)	2.13 ± 1.10	2.07	2.18	0.11	0.460
Land allocated to maize (Acres)	1.17 ± 1.05	0.95	1.37	0.42	0.000***
Land allocated to cassava (Acres)	0.56 ± 0.37	0.47	0.52	0.04	0.355
Land allocated to sweet potato (Acres)	0.44 ± 0.29	0.36	0.39	0.02	0.500
Categorical variables					
Farmer is Married (1-Yes)	0.81	0.91	0.72	0.19	0.000***
Farmer is Male (1-Yes)	0.76	0.86	0.67	0.19	0.001***
Access to extension (1-Yes)	0.88	0.83	0.88	0.05	0.310
Access to credit (1-Yes)	0.73	0.66	0.81	0.15	0.016**
Group member (1-Yes)	0.81	0.84	0.78	0.06	0.279
Farmer grows maize (1-Yes)	1.00	1.00	1.00	0.00	0.453
Farmer grows cassava (1-Yes)	0.88	0.84	0.92	0.08	0.110
Farmer grows s. potato (1-Yes)	0.87	0.84	0.88	0.04	0.235
Maize food shortage (1-Yes)	0.68	0.64	0.72	0.08	0.125
Cassava food shortage (1-Yes)	0.80	0.78	0.82	0.04	0.412
Sweet potato shortage (1-Yes)	0.79	0.74	0.84	0.10	0.245

, ** & * showsignificance at 10%, 5% and 1% respectively*

The results further indicate that 81.5% of the respondents were married. There was a statistically significance difference in marital status between the two sub – counties at 5% level of significance. On average, 76.5% of the farmers were males. The difference in gender was also statistically significant at 1%. Further, the results indicate that 88.5% of the farmers had access to extension services. On average, 81% of the farmers belonged to different agricultural groups. There was no statistically difference in group membership in the two sub-counties. In terms food crop production, all the all the farmers produced maize since it was

UNDER PEER REVIEW

their staple food. However, only 88% and 87% of the farmers produced cassava. In terms of household food shortages, majority of the farmers experienced shortages of maize, cassava and sweet potatoes in their households.

Resource use efficiency for the optimal farm plans

Results presented in Table 3 show that tobacco farmers were not using resources efficiently for dual production of tobacco as a cash crop and the food crops. Strikingly, up to 37.5% of farmers were operating at the level below 50% of the economic optimum depicting a possible over-allocation of production resources to one crop at the expense of others. The results further indicate that only 21.5% of the farmers were able to achieve 90% and above of the resource use efficiency for tobacco-food crop production mix. The least farmer was only able to achieve 5% while the most efficient farmer achieved 100% resource use efficiency relative to food requirement. The mean efficiency stood at 61% of the optimal farm plan suggesting that up to 39% resource use efficiency for joint production of tobacco and food crop was lost. The results from the comparison of resource use efficiency level across the two sub - counties showed that farmers in Kiryandongo sub – county were more efficient than their counterparts in Kigumba sub – county.

When farmers allocate their resources efficiently such that they have adequate food as well as getting income from tobacco, they would score full efficiency (Bojnec et al., 2014). However, from the findings of previous studies, this has not been the case (Kostlivý & Fuksová, 2019; Weldegebriel, 2014). Indeed, the results from this study confirmed that farmers were not efficiently allocating their resources. Majority of the farmers scored less than 50% efficiency in balancing their resources among tobacco and food crops to guarantee adequate food. This was attributed to over allocation of land, labour and capital to tobacco production at the expense of staple food crops. Moreover, some farmers allocated their resources to tobacco and ended up producing only two crops; tobacco and one of the food crops yet they needed these food crops for consumption. As a result, majority of them experienced shortages of maize, cassava and sweet potatoes. This was the major cause of resource imbalance among the farmers. Similar findings were reported by Rubhara et al. (2020) who found out that farmers were apportioning their farm resources in excess to tobacco compared to food crops in Cameroon. In addition, Hussain et al. (2020) reported that farmers allocated 80% of their land to tobacco while the rest 20% was allocated to food crops leading to resource use inefficiencies and food insecurity in Bangladesh. Other studies which have found resource

UNDER PEER REVIEW

use inefficiencies among farmers include; Kostlivý & Fuksová (2019); Ngango & Kim (2019); Raheli et al. (2017); Shanmugam & Venkataramani (2006); Sherzod et al. (2018) and Tipi et al. (2009).

Table 3: Distribution of resource use efficiency scores per sub-county

Range	Kiryandongo (N=100)	Kigumba (N=100)	Pooled (N =200)	Percentage (%)	Cumulative percentage (%)
≤ 0.50	40	35	75	37.50	37.50
0.51 – 0.60	10	14	24	12.00	49.50
0.61 – 0.70	20	16	36	18.00	67.50
0.71 – 0.80	7	4	11	5.50	73.00
0.81 – 0.90	3	8	11	5.50	78.50
≥ 0.90	23	20	43	21.50	100.00
Other statistics			**Efficiency**		
Min	0.20	0.05	0.05		
Mean	0.63	0.59	0.61		
Max	1.00	1.00	1.00		

Optimal allocation of farm resources

Results on optimal allocation of farm resources (Table 4) revealed that farmers were over allocating land, labour and capital resources to tobacco production at the expense of food crops.First, farmers' actual land allocation to tobacco production exceeded the optimal allocation plan by 17.8%. A similar pattern of results was also observed for labour and capital at 11.30% and 10.2% respectively. Turning to resource allocation to food crops, cassava had the highest land deficit standing at 30.0% off the optimal allocation plan while its labour and capital allocation had a deficit by 25.0% and 41.5% respectively. Notably, sweet potatoes and maize resources were also in less quantities. Sweet potatoes had a land deficit by 21.41% while maize land deficit stood at 8.38%. A similar pattern was also observed in labour and capital allocation for maize and sweet potatoes.

On food crops resource allocation plans, maize also had resource deficit, even though it was a staple food for all the farmers. However, the results indicate that they allocated less resources to maize production than the optimal farm plans. Due to the resource deficit, majority of the farmers (68%) experienced shortages of maize at some periods of the year. However, the optimal resource allocation plans suggest that they need to increase land, labour and capital allocation to maize by 9%, 13% and 66% respectively. The increment of these farm resources to maize production would cater for the additional food required by the household. Besides getting income from tobacco, the optimal resource allocation plans would ensure that farmers

UNDER PEER REVIEW

produce sufficient maize to consume till the subsequent harvesting season. A study conducted in Uganda by Igwe et al.(2015), indicated that failure to optimize farm resources would lead to reduction in food crops production.

Similarly, cassava was grown by majority of the farmers (88%). This implies that many smallholder farmers depend on cassava as a source of their foods. However, the results indicate that it was the crop with the highest resource deficit. As a result, the optimal resource allocation plans suggest that farmers should increase their land, labour and capital by 30%, 25% and 42% respectively. When they adopt the optimal resource allocation plans, they are most likely to increase cassava quantities harvested by 46%. The increase in the quantity harvested meets the minimum household consumption requirement, implying that the optimal farm plans guarantee sufficient food for the farmers. This is in line with the findings by Hamba & Nuwamanya (2017) who found out that cassava shortages in Northern Uganda was caused by poor farming skills including resource misallocation.

This study found out that majority of the farmers (87%) were engaged in sweet potatoes production. However, due to poor resource allocation, 78% of the farmers to experience its shortages. This was also attributed by over-allocation of land, labour and capital to tobacco. From the results, the optimum allocation plans suggest that they need to increase the land, labour and capital allocated to sweet potatoes by 21%, 37% and 51% respectively. Similarly, the optimal resource allocation plans would guarantee sufficient quantities of sweet potatoes to the farmers till the subsequent harvesting season. This conforms to the findings by Epeju & Rukundo (2017) who found out that there was sweet potatoes shortages in Kiryandongo and Teso districts in Uganda, attributed to resource misallocation among cash and food crops.

Table 4: Optimal allocation of factors of production

	Land (Acres)			**Labor (Hours)**			**Capital (UGX)**		
Crops	**Current Plans**	**Optimal Plans**	**Percentage Change**	**Current Plans**	**Optimal Plans**	**Percentage Change**	**Current Plans**	**Optimal Plans**	**Percentage Change**
Tobacco	2.13	1.75	-17.83	79.14	70.20	-11.30	971,998.00	872,445.80	-10.24
Maize	1.17	1.27	8.38	45.64	51.67	13.21	109,920.10	182,397.10	65.94
Cassava	0.56	0.73	29.50	46.35	57.96	25.05	31,013.25	43,868.45	41.45

UNDER PEER REVIEW

Sweet P.	0.44	0.54	21.41	37.98	51.88	36.60	27,654.75	41,874.80	51.42

Optimal output versus household food requirement

The results show that cassava presents the most economic gains, standing at 46.3%, if farmers adopt the optimal resource use plan (Table 5). For sweet potatoes and maize, the optimal resource use plan would result into economic gains of 22.7% and 7.7% respectively. Lastly, the optimal resource use plan yields only 18.0% of the overall income loss in tobacco. The value gained from producing the additional food crops would be more than the foregone income from reduced tobacco acreage. Therefore, adoption of the optimal farm plans is a way of increasing food availability among tobacco farmers. It would ensure that farmers are have sufficient food as well as income from tobacco to cater for other financial obligations, hence reducing poverty and food insecurity.

Table 5: Optimal output versus household food requirement

Crops	Current Quantity(Kg)	Optimal Quantity(Kg)	Gained/Lost Quantity(Kg)	Percentage (%) Gain/ Loss	Minimum household food requirement(kg)
Tobacco	1,141.00	936.50	-204.52 (Lost)	-17.97 (Loss)	----
Maize	716.38	771.50	55.12 (Gained)	7.69 (Gain)	748.50
Cassava	421.38	616.33	194.50 (Gained)	46.26 (Gain)	602.12
Sweet P.	410.42	503.70	93.28 (Gained)	22.73 (Gain)	502.10

Factors affectingresource use efficiency

Based on the model fit, the results (Table 6) showed that the model was significant at 1%. The pseudo R squared valued of 0.26 also met the acceptable range according to Mbachu et al.(2012). The log likelihood value of -58.81 also confirmed the fitness of the model. Similarly, the test of correlation between the independent variables (VIF) shown a mean VIF of 0.89, with minimum and maximum values ranging from more than 1 and less than 10 respectively, which showed that there was no multicollinearity among the independent variables (Akinwande et al., 2015). The study therefore proceeded to present the results from the model.

The results from Tobit regression on the factors affecting resource use efficiency are presented in Table 6. The study found that different socio-economic had different effects on resource use efficiency. The negative relationship between gender of the farmer and resource use efficiency depicted less chances for female farmers of allocating farm resources for

UNDER PEER REVIEW

optimal dual purpose of tobacco and food crops' output. Furthermore, female farmers are mostly not the heads of the households and so they may not make decisions on which crop to grow and how to allocate farm resources between tobacco and food crops. This conforms to the findings reported by Mwaura & Adong (2016) that belonging to female gender among farmers was negatively associated with resource allocation efficiency for banana, beans, cassava, sweet potato, maize and coffee crop enterprises in Uganda.

The negative effect of land size on resource use efficiency can be explained by the fact that farmers are tempted to allocate more land to tobacco production given its lucrativeness in the study area. It implies that resource use efficiency for cash – food crop production declines as more land is committed to tobacco farming at the expense of other food crops. This is because the more land the farmer allocates to tobacco, the more income he receives. Related findings were also reported in the study by Adjimoti (2018), who found out that land size had a negative influence on the resource use efficiency between food and cash crops in Benin. It is also similar to the findings by Geta et al. (2013), who found that land size has a negative relationship with resource use efficiency among Ethiopian farmers. In contrary, Amodu et al.(2011) reported a positive influence of farm size on resource use efficiency in food crop production among smallholder farmers in Nigeria.

The positive association between household size and resource use efficiency may be due to the fact that families with many household members require more food than those with few members. Therefore, the requirement for food increases with the household size. As a result, households with many members need additional food which is obtained through allocating resources to food crops production to meet the household food requirement. Therefore, farmers with many household members are most likely to allocate their resources to food crops as a way of obtaining food to feed their families. In addition, family members are sources of farm labour, those with many family members are able to provide enough labour in their farms than the families with few members. This is similar to the findings by Adjimoti (2018), who found a positive relationship between resource use efficiency and household size. Furthermore, it also conforms to the findings by Asefa (2011) who found out that household size positively influenced resource use efficiency among wheat farmers.

The results further revealed that resource use efficiency was positively influenced by pesticides usage among the farmers. This may be attributed by the fact that farmers who had pesticides for the food crops were able to allocate their farm resources optimally among

UNDER PEER REVIEW

tobacco and the food crops since they were sure of reduced losses from pests and diseases. Among the chemicals the farmers used to kill the fall army worm in maize include Cypermethrin, Thiamethoxam and Lambda-Cyhalothrin pesticides. Farmers also needed pesticides to grow cassava to its maturity to curb the spread of pests and disease. The pesticides used in cassava production included; Dimenthoate, used to kill cassava mealybug (*PhenacoccusManihoti*) pests, Cypermethrin, Lambola and Lindane, which are used to kill the cassava green mite (*Mononychellus Tanajoa*).

The positive influence of support from contract companies on resource use efficiency was attributed by the fact that farmers received farm inputs from the contract companies. These inputs included tobacco seeds, pesticides and fertilizers for tobacco production. The farmers used a portion of these fertilizers and pesticides to produce maize, cassava and sweet potatoes. As a result, the more support the farmers received, the more they allocate their resources to produce food crops A similar finding was reported by Namome (2018), who reported that the support from the tobacco companies in West Nile Uganda had a positive influence on the efficiency. Additionally, according to a study done by Hossain (2013), 65% of the farmers were receiving support from tobacco companies in Bangladesh, the support were in terms of seeds, fertilizers, access to market and access to extension services, among others.

Similarly, the positive influence of farm income on resource use efficiency may be due to the fact that if the food crops also perform well and yield more income then farmers would allocate their resources to food crops. This is because they are driven by income maximization but not food production. They would therefore allocate their resources to any crop whether cash or food crop provided that it yields high income. A study done by Namome (2018) confirmed that farm income had a positive association with resource use efficiency among banana, beans, cassava, sweet potatoes, maize and coffee crop enterprises.

There was a negative and statistically significant relationship between the input prices and resource use efficiency. The inputs considered included seeds, fertilizers, the cost of renting the land, cassava planting stakes, sweet potatoes planting vines and the cost of hiring labour for farm activities. The negative influence of input prices on resource use efficiency could be because farmers would allocate most of their resources to tobacco if the input prices increase. For instance, if the prices of cassava planting stakes, maize seeds, sweet potatoes vines and fertilizers increases, farmers would use their finances to purchase tobacco inputs instead of

UNDER PEER REVIEW

the food crops inputs due to the high income from tobacco. However, this would result into resource use inefficiencies. This result is in agreement with the findings by Science(2018) who found out that the input prices negatively influenced rice-livestock integrated farming system. Additionally, Briner & Finger (2013) observed a negative association between input prices and resource use efficiency in Swiss dairy production system.

Table 6: Tobit regression results for the factors affecting resource use efficiency

Variables	Coefficient	Std error	P - Value	Marginal effects
Farmer's gender (Female)	-0.165	0.048	0.001***	-0.053***
Total agricultural land size	-0.181	0.061	0.004***	-0.158***
Sub-county of residence	0.023	0.042	0.575	0.028
Household size	0.084	0.045	0.062*	0.068*
Pesticide's use	0.079	0.037	0.035**	0.082**
Farm income	0.067	0.028	0.021**	0.060**
Secondary education	-0.049	0.052	0.348	-0.06
Post-secondary Education	0.041	0.075	0.585	0.059
Source of labor (Hired)	0.061	0.111	0.581	0.067
Peer farmer extension	-0.052	0.041	0.206	0.058
Farmer's age	0.036	0.071	0.608	0.053
Company support	0.100	0.044	0.023**	0.089**
Input prices	-0.109	0.042	0.011**	-0.098**
Constant	1.134	0.701	0.100*	--
Pseudo R^2				0.2637
Log likelihood				-58.817
Prob>Chi^2				0.000
N				200
Mean VIF				0.89
*,**,***				10, 1 and 5% SLs

Conclusion and Recommendation

Under the prevailing conditions at the time of the study, the findings of this study showed that tobacco farmers were inefficient in allocating their farm resources for tobacco and food crops to guarantee sufficient food among the households. Specifically, they allocated excess resources to tobacco at the expense of food crops. Notably, farmers allocated excess land, labour and capital resources for tobacco while only able to provide inadequate levels of the same resources for food crops, depicting resource wastage and thus a risk of food shortages at

UNDER PEER REVIEW

household level. However, the results from the optimal resource allocation plans suggests that farmers need to increase the land allocation to food crops while reducing the land allocated to tobacco so as to increase the quantities of the food crops (maize, cassava and sweet potato) among their households. Based on the results from Data Envelopment Analysis, this study concluded that tobacco farmers are inefficient in allocating farm resources namely land, labour and capital between tobacco and food crops production and thus they risk shortages of food crops in their households. The results from Tobit regression model showed that out of the 13 hypothesized factors, 7 of them presented themselves as the significant factors having positive and negative significant effect on resource use efficiency. Specifically, farmers' gender, total farm size and input prices presented themselves as the factors having negative effect on resource use efficiency for the optimal farm plans. On the other hand, household size, use of pesticides, farm income and support from the contract companies in terms of farm inputs had a positive association with resource use efficiency for the optimal farm plans. This study therefore concluded that farmers' gender, total farm size, household size, use of pesticides, farm income, support from tobacco contract companies and input prices are the main factors affecting resource use efficiency for the optimal farm plans among tobacco growing households in Uganda.

Policy recommendations

This study found out that farmers were allocating excess of their resources to tobacco, leading to food shortages among the smallholder farmers. In order to increase household food production, this study recommends that extension workers should train farmers and encourage them to adopt optimal farm plans. This allocation would ensure that they receive income from tobacco to cater for other financial obligations and still have sufficient foods for their families.

The inverse relationship between input prices and resource use efficiency suggests that farmers have limited inputs to be balanced to these crops. Therefore, this study recommends that the ministry of agriculture, animal industry and fisheries should subsidize inputs such as seeds, pesticides and fertilizers so that farmers can access them easily to help produce the food crops.

Similarly, female farmers were found to be less efficient in allocating their resources than male farmers. Therefore, this study recommends that, the extension workers should empower

UNDER PEER REVIEW

and train women on resource efficiency so that they can increase their efficiency levels for dual tobacco and food crops production.

More trainings by extension officers targeting optimum use of farm resources in order to increase household food production is strongly recommended.

Data availability

The data that support the findings of this study are available from the corresponding author, [Dick ChuneMidamba,] upon reasonable request.

References

Abdulai, S., Nkegbe, P. K., & Donkoh, S. A. (2018). Assessing the technical efficiency of maize production in northern Ghana: The data envelopment analysis approach. *Cogent Food & Agriculture*, *4*(1), 1512390. https://doi.org/10.1080/23311932.2018.1512390

Adjimoti, G. O. (2018). Analysis of cropland allocation in rural areas Benin: A fractional multinomial approach. *Cogent Food & Agriculture*, *4*(1), 1–13. https://doi.org/10.1080/23311932.2018.1488339

Ahmad, M. F., Ishtiaq, M., Hamid, K., Usman Khurram, M., & Nawaz, A. (2017). Data Envelopment Analysis and Tobit Analysis for Firm Efficiency in Perspective of Working Capital Management in Manufacturing Sector of Pakistan. *SSRN Electronic Journal*, *April*. https://doi.org/10.2139/ssrn.2911577

Akinwande, M. O., Dikko, H. G., & Samson, A. (2015). Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis. *Open Journal of Statistics*, *05*(07), 754–767. https://doi.org/10.4236/ojs.2015.57075

Alderete, E., Livaudais-Toman, J., Kaplan, C., Gregorich, S. E., Mejía, R., & Pérez-Stable, E. J. (2020). Youth working in tobacco farming: Effects on smoking behavior and association with health status. *BMC Public Health*, *20*(1), 1–9. https://doi.org/10.1186/s12889-020-8169-z

Amodu, M., Owolabi, J., & Adeola, S. (2011). Resource Use Efficiency in Part-time Food Crop Production: The Stochastic Frontier Approach. *Nigerian Journal of Basic and Applied Sciences*, *19*(1), 102–110. https://doi.org/10.4314/njbas.v19i1.69353

Asefa, S. (2011). Analysis of technical efficiency of crop producing smallholder farmers in Tigray,Ethiopia. *Munich Personal Repec Archive*, *January 2011*, 26p. http://mpra.ub.uni-muenchen.de/id/eprint/40461

Bojnec, Š., Ferto, I., Jámbor, A., & Tóth, J. (2014). Determinants of technical efficiency in agriculture in new EU member states from Central and Eastern Europe. *Acta Oeconomica*, *64*(2), 197–217. https://doi.org/10.1556/AOecon.64.2014.2.4

Briner, S., & Finger, R. (2013). The effect of price and production risks on optimal farm plans in Swiss dairy production considering 2 different milk quota systems. *Journal of Dairy Science*, *96*(4), 2234–2246. https://doi.org/10.3168/jds.2012-6086

Chune, M. D. (2022). Analysis of technical efficiency and its determinants among Tobacco producers in Uganda : An application of Data Envelopment Analysis. *International Journal of Agricultural Research, Innovation and Technology*, *12*(June), 1–3. https://doi.org/https://doi.org/10.3329/ijarit.v11i2.57249

Cochran, W. G. (1963). *Sampling Techniques* (2nd Ed). John Wiley and Sons, Inc.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). Data envelopment analysis: History, models, and interpretations. In *International Series in Operations Research and*

UNDER PEER REVIEW

Management Science (Vol. 164, Issue August 2011). https://doi.org/10.1007/978-1-4419-6151-8_1

Danso-Abbeam, G., Bosiako, J. A., Ehiakpor, D. S., & Mabe, F. N. (2017). Adoption of improved maize variety among farm households in the northern region of Ghana. *Cogent Economics and Finance*, *5*(1). https://doi.org/10.1080/23322039.2017.1416896

Dube, L. (2016). Factors Influencing Smallholder Crop Diversification: A Case Study of Manicaland and Masvingo Provinces in Zimbabwe. *International Journal of Regional Development*, *3*(2), 1. https://doi.org/10.5296/ijrd.v3i2.9194

Epeju, W. F., & Rukundo, P. M. (2017). Food Security and Income through Sweet Potato Production in Teso, Uganda. *Sustainable Agriculture Research*, *7*(1), 146. https://doi.org/10.5539/sar.v7n1p146

FAO. (2009). *Global agriculture towards 2050*. 46–58. https://doi.org/10.5822/978-1-61091-885-5

Geta, E., Bogale, A., Kassa, B., & Elias, E. (2013). Productivity and Efficiency Analysis of Smallholder Maize Producers in Southern Ethiopia. *Journal of Human Ecology*, *41*(1), 67–75. https://doi.org/10.1080/09709274.2013.11906554

Gomez, S. (2020). The Role of Smallholder Farms in Food and Nutrition Security. In *The Role of Smallholder Farms in Food and Nutrition Security*. https://doi.org/10.1007/978-3-030-42148-9

Hakim, R., Haryanto, T., & Sari, D. W. (2021). Technical efficiency among agricultural households and determinants of food security in East Java, Indonesia. *Scientific Reports*, *11*(1), 1–9. https://doi.org/10.1038/s41598-021-83670-7

Heidari, M. D., Omid, M., & Akram, A. (2011). Using nonparametric analysis (DEA) for measuring technical efficiency in poultry farms. *Revista Brasileira de Ciencia Avicola*, *13*(4), 271–277. https://doi.org/10.1590/S1516-635X2011000400009

Hossain, M. M. (2013). A Socioeconomic Analysis on Tobacco Cultivation in Kushtia District of Bangladesh. *Social Sciences*, *2*(3), 128. https://doi.org/10.11648/j.ss.20130203.14

Hussain, A. K. M. G., Rouf, A. S. S., Shimul, S. N., Nargis, N., Kessaram, T. M., Huq, S. M., Kaur, J., Shiekh, M. K. A., & Drope, J. (2020). The economic cost of tobacco farming in Bangladesh. *International Journal of Environmental Research and Public Health*, *17*(24), 1–21. https://doi.org/10.3390/ijerph17249447

Igwe, K., Nwaru, J., Igwe, C., & Asumugha, G. (2015). Optimizing crop land allocation for smallholder farmers in central Uganda. *Wageningenur for Quality of Life*, *15 Np. 5*(March), 1–71. https://edepot.wur.nl/410452

IMF. (2022). Climate change and SSA's intensified food insecurity. *International Monetory Fund*, *2022*(016), 1–48. 10.5089/9798400218507.087

James Tobin. (1958). Estimation of Relationships for Limited Dependent Variables. *Econometrica*, *26*(1), 24–36.

Kibwage, J. K., Netondo, G. W., Odondo, A. J., Momanyi, G. M., Awadh, A. H., & Magati, P. O. (2014). Diversification of Household Livelihood Strategies for Tobacco Small-holder Farmers: A Case Study of Introducing Bamboo in South Nyanza Region, Kenya. *Idrc*, *21*(1), 1–18. https://repository.maseno.ac.ke/bitstream/handle/123456789/353/Kibwage_Diversification of Household....PDF?sequence=1&isAllowed=y

Kim-Mozeleski, J. E., & Pandey, R. (2020). The Intersection of Food Insecurity and Tobacco Use: A Scoping Review. *Health Promotion Practice*, *21*(1_suppl), 124S-138S. https://doi.org/10.1177/1524839919874054

Kostlivý, V., & Fuksová, Z. (2019). Technical efficiency and its determinants for Czech livestock farms. *Agricultural Economics (Czech Republic)*, *65*(4), 175–184.

UNDER PEER REVIEW

https://doi.org/10.17221/162/2018

Kouriati, A., Tafidou, A., Lialia, E., Prentzas, A., Moulogianni, C., Dimitriadou, E., & Bournaris, T. (2023). The Impact of Data Envelopment Analysis on Effective Management of Inputs: The Case of Farms Located in the Regional Unit of Pieria. *Agronomy*, *13*(8). https://doi.org/10.3390/agronomy13082109

LI, M., GAN, C., MA, W., & JIANG, W. (2020). Impact of cash crop cultivation on household income and migration decisions: Evidence from low-income regions in China. *Journal of Integrative Agriculture*, *19*(10), 2571–2581. https://doi.org/10.1016/S2095-3119(20)63161-6

Lindawati, L., Kusnadi, N., Kuntjoro, S. U., & Swastika, D. K. S. (2018). *The Impact of Input and Output Prices on The Household Economic Behavior of Rice-Livestock Integrated Farming System (Rlifs) and Non Rlifs Farmers The Impact of Input and Output Prices on The House*. 0–9.

MAAIF. (2020). *The Republic of Uganda Ministry of Agriculture , Animal Industry and Fisheries,Draft Anual Report*. *1–150*(October), 150. https://www.agriculture.go.ug/wp-content/uploads/2020/10/MAAIF-Annual-Performance-Report-FY-2019-2020-Draft-D.pdf

Madau, F. A. (2012). Technical and scale efficiency in the Italian Citrus Farming: A comparison between Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis(DEA) Models. *MPRA Paper No. 41403, Posted 18 Sep 2012 13:34 UTC Online at Https://Mpra.Ub.Uni-Muenchen.de/41403/*, *41403*. http://mpra.ub.uni-muenchen.de/41403/

Mayer, M., Gueorguieva, R., Ma, X., & White, M. A. (2019). Tobacco use increases risk of food insecurity: An analysis of continuous NHANES data from 1999 to 2014. *Preventive Medicine*, *126*(May), 105765. https://doi.org/10.1016/j.ypmed.2019.105765

Mbachu, H. I., Nduka, E. C., & Nja, M. E. (2012). Designing a Pseudo R-Squared Goodness-of-Fit Measure in Generalized Linear Models. *Journal of Mathematics Research*, *4*(2). https://doi.org/10.5539/jmr.v4n2p148

Mwaura, F. M., & Adong, A. (2016). Determinants of Households' Land Allocation for Crop Production in Uganda. *Journal of Sustainable Development*, *9*(5), 229. https://doi.org/10.5539/jsd.v9n5p229

Namome, C. (2018). The economics of tobacco production and feasible alternatives in Uganda. *Agricultural and Food Economics*, *2*(1), 302. https://doi.org/https://doi.org/10.1017/9781108656184.0037378478907

Ngango, J., & Kim, S. G. (2019). Assessment of technical efficiency and its potential determinants among small-scale coffee farmers in rwanda. *Agriculture (Switzerland)*, *9*(7), 1–12. https://doi.org/10.3390/agriculture9070161

Ogundeji, A. A., Donkor, E., Motsoari, C., & Onakuse, S. (2018). Impact of access to credit on farm income: policy implications for rural agricultural development in Lesotho. *Agrekon*, *57*(2), 152–166. https://doi.org/10.1080/03031853.2018.1483251

Okao-Okuja G , Hamba S , Omara J , Nuwamanya E, K. R. and A. T. (2017). Cassava applied research for food and income security in Northern Uganda project, A baseline survey repoert. *National Crops Resources Research Institute*, *1*.

Raheli, H., Rezaei, R. M., Jadidi, M. R., & Mobtaker, H. G. (2017). A two-stage DEA model to evaluate sustainability and energy efficiency of tomato production. *Information Processing in Agriculture*, *4*(4), 342–350. https://doi.org/10.1016/j.inpa.2017.02.004

Rowing, T. O. G., Ampala, M. E. I. N. K., & Ganda, U. (2012). Alternative livelihoods to tobacco growing and Environmental conservation in kampala, Uganda. *Agricultural and Food Economics*, *2*, 9.

Rubhara, T. T., Mudhara, M., Oduniyi, O. S., & Antwi, M. A. (2020). Impacts of Cash Crop

UNDER PEER REVIEW

Production on Household Food Security for Smallholder Farmers : A Case of Shamva. *Agriculture (Switzerland)*.

Shanmugam, K. R., & Venkataramani, A. (2006). *Technical Efficiency in Agricultural Production and Its Determinants : An Exploratory Study at the District Level*. *61*(2).

Sherzod, B., Kim, K. R., & Lee, S. H. (2018). Agricultural transition and technical efficiency: An empirical analysis of wheat-cultivating farms in Samarkand Region, Uzbekistan. *Sustainability (Switzerland)*, *10*(9). https://doi.org/10.3390/su10093232

Sreeramareddy, C. T., & Ramakrishnareddy, N. (2017). Association of adult tobacco use with household food access insecurity: Results from Nepal demographic and health survey, 2011. *BMC Public Health*, *18*(1), 1–8. https://doi.org/10.1186/s12889-017-4579-y

Steiner, G., Babel, A., & Operators, I. (1968). *C hapter O ne B eginnings*. 94–104.

Tipi, T., Yildiz, N., Nargeleçekenler, M., & Çetin, B. (2009). Measuring the technical efficiency and determinants of efficiency of rice (Oryza sativa) farms in marmara region, Turkey. *New Zealand Journal of Crop and Horticultural Science*, *37*(2), 121–129. https://doi.org/10.1080/01140670909510257

Toma, E., Dobre, C., Dona, I., & Cofas, E. (2015). DEA Applicability in Assessment of Agriculture Efficiency on Areas with Similar Geographically Patterns. *Agriculture and Agricultural Science Procedia*, *6*, 704–711. https://doi.org/10.1016/j.aaspro.2015.08.127

UBOS. (2018). *Uganda Bureau of Statistics. The 2018 Statistical report*. 345.

van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. *Nature Food*, *2*(7), 494–501. https://doi.org/10.1038/s43016-021-00322-9

von Grebmer, K., Headey, D., Olofinbiyi, T., Wiesmann, D., Yin, S., Yohannes, Y., Foley, C., von Oppeln, C., Iseli, B., Béné, C., & Haddad, L. (2013). 2013 Global hunger index : The challenge of hunger : Building resilience to achieve food and nutrition security: *Issue Briefs*.

Vu, H. Van, Ho, H., & Le, Q. H. (2020). Impact of Farmers' Associations on Household Income: Evidence from Tea Farms in Vietnam. *Economies*, *8*(4), 92. https://doi.org/10.3390/economies8040092

Wang, Y., Shi, L., Zhang, H., & Sun, S. (2017). A data envelopment analysis of agricultural technical efficiency of Northwest Arid Areas in China. *Frontiers of Agricultural Science and Engineering*, *4*(2), 195–207. https://doi.org/10.15302/J-FASE-2017153

Weldegebriel, H. (2014). The Determinants of Technical Efficiency of Farmers in Teff, Maize and Sorghum Production: Empirical Evidence from Central Zone of Tigray Region. *The Impact of Trade Openness on Poverty via Agricultural TFP in Ethiopia: A Sequential Dynamic Computable General Equilibrium Micro Simulation Analysis*, *23*(1), 1–30. https://doi.org/10.4314/eje.v23i1

WHO. (2015). *Policy options and recommendations on economically sustainable alternatives to tobacco growing*. *2015*(11 August). http://www.who.int/fctc/guidelines/adopted/Policy_options_reccommendations_Articles 17_18_COP6.pdf?ua=1

World Bank Group. (2017). The Economics of Tobacco Farming in Indonesia. *The Economics of Tobacco Farming in Indonesia*. https://doi.org/10.1596/28568

Yannick, G. Z. S., Hongzhong, Z., & Thierry, B. (2016). Technical Efficiency Assessment Using Data Envelopment Analysis: An Application to the Banking Sector of Côte D'Ivoire. *Procedia - Social and Behavioral Sciences*, *235*(October), 198–207. https://doi.org/10.1016/j.sbspro.2016.11.015

Yilmaz, B., & Yurdusev, M. A. (2011). Use of data envelopment analysis as a multi criteria decision tool - A case of irrigation management. *Mathematical and Computational Applications*, *16*(3), 669–679. https://doi.org/10.3390/mca16030669

UNDER PEER REVIEW

UNDER PEER REVIEW