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Voucher System and Agricultural Production in Tanzania: Is the Adopted Model Effective? Evidence from Panel Data Analysis

Aloyce S. Hepelwa,* Onesmo Selejio** & John K. Mduma***

Abstract

One of the policy measures adopted in the recent past by the government of Tanzania during the implementation of the Agricultural Sector Development Program (ASDP) is to subsidize fertilizer and other agricultural inputs through the National Agricultural Input Voucher system (NAIVS). Poor smallholder farmers who are the beneficiaries of NAIVS are expected to increase crop productivity per unit area, and hence reduce extensive farming/shifting cultivation. This paper presents empirical results on the effects of the NAIVS on crop production in some selected regions in Tanzania. The study used the panel data analysis technique to analyse agricultural data collected in year 2007 (before the NAIVS) and 2012 (during the NAIVS). In addition, the propensity score matching (PSM) technique was employed to estimate the average effect of the program on maize production. The study found a statistically significant difference between crop harvest by households with and without access to the NAIVS. For the maize harvest in 2012, households who accessed fertilizer through the NAIVS had more harvest than households who did not access the NAIVS. However, the study found that a majority of poor smallholder farmers do not access the NAIVS due to high market price of inputs not well compensated by the static low value of the NAIVS. This implies that the NAIVS is benefiting more well-off households than poor ones. The implication from this finding is that the NAIVS is not achieving the intended objective of increasing crop productivity by poor smallholders.

Keywords: *fertilizer subsidy, crop productivity, panel data analysis.*

1. Introduction

In Tanzania, the agricultural sector is one of the key sectors to the national economy. Over 70% of the population lives in rural areas and their livelihoods depend on agriculture (URT, 2014). The sector accounts for about 25% of the GDP, 20% of export earnings, and 65% of raw material for domestic industries (World Bank, 2010; URT, 2016). The agricultural sector employs about 67% of the labour force (URT, 2015). However, the sector experience low growth. Given the importance of the sector as a source of income, employment and food security, this low growth has translated into little progress in poverty reduction. The proportion of people living below the basic

*Department of Economics, University of Dar es Salaam, Tanzania: ahepelwa@udsm.ac.tz

**Department of Economics, University of Dar es Salaam, Tanzania: oselejio@gmail.com (*Corresponding author*)

***Department of Economics, University of Dar es Salaam, Tanzania: e-mail:nashi@gmail.com

needs poverty line remains high at more than 28% in 2012 (HBS, 2013a). The 2007/2008 national survey census of agriculture approximates that 12.6m hectares of land to be the land under agricultural activities in the country, which includes both temporary and permanent crops, as well as livestock keeping. Smallholder farmers occupy 91% of the total area under agriculture. The remaining 9% of the land is held by large scale farmers who own a total of 1.1m hectares.[1] The average food crop productivity in Tanzania has been far below the potential productivity of about 3.5–4ton/ha (URT, 2013b). For example, the last national panel survey (NPS) report indicates that the productivity of main food crops in Tanzania, i.e., maize and paddy, was 1.06ton/ha and 1.74ton/ha, respectively (URT, 2017). This low productivity is contributed by many factors such as climate and climate variability, low mechanization and soil degradation.

High dependence on rainfall is the main characteristic of agricultural practices by smallholder farmers in the country. In addition, crop cultivation is characterized by low mechanization, where a majority of farmers are using poor farm inputs such as hand-hoe and traditional seeds. The soils have been degraded with significant loss of nutrients, thus contributing to the low productivity problem (URT, 2013b; Selejio, 2016). In Tanzania, there is still low level of technologies practiced or adopted in agriculture in terms of inputs, agricultural implements or machinery and irrigation facilities to enable both the expansion and intensification of agricultural production. The use of fertilizer in the country is far below other countries in Africa with similar conditions. It is estimated that only 12% of farmers use mineral fertilizer (AFAP, 2012). Tanzania uses 10kg of nutrients/ha, while Malawi uses 27kg of nutrients/ha. The average use of fertilizer for the SADC members is 16kg/ha, while that of Africa is about 20kg/ha. The average usage per hectare in other regions is 41kg/ha of nutrients in Latin America, 85kg of nutrients/ha in Asia, and 225kg/ha in Europe (URT, 2010; FAOSTAT, 2013). The low use of fertilizer in Africa can be explained by demand-side as well as supply-side factors. The demand for fertilizer is often weak in Africa because incentives to use fertilizer are undermined by low level and high variability of crop yields on the one hand, and high level of fertilizer prices relative to crop prices on the other.

However, government efforts are underway to revamp agricultural productivity. Such efforts include the introduction of a fertilizer subsidy scheme, famously known as the national agriculture input voucher scheme (NAIVS), which was introduced in 2008. This scheme intended to facilitate fertilizer use in targeted high-potential areas, boost the return to fertilizer use, and ultimately increase food production. Following the introduction of this scheme, total fertilizer consumption in Tanzania increased. In 2010 the fertilize purchased and distributed by the private sector for the NAIVS program was 151,000MT, or 57% of the market. The current paper aims to present the results on the evaluation of the effectiveness of this fertilizer voucher scheme in Tanzania.

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[1] Large-scale farms are considered to be farms with the size above 20 hectares (or 50 acres).

We structure the discussion as follows. Section two provides a brief discussion of the relevant literature on fertilizer subsidies and usage. Section three presents the description of the methodology employed in the study. In section four we discuss the study results, and section five includes policy implications and concluding remarks.

2. Review of Literature

Crop production in Tanzania and many Sub Sahara African (SSA) countries is faced with low use of fertilizer, and consequently low crop productivity. Several factors have been pointed out as the cause of low fertilizer use in SSA, and Tanzania in particular. One is the high uncertainty of water availability due to temporal rainfall variability, especially in rain-fed agriculture (Van der Zaag, 2010; URT, 2016). Water uncertainty inhibits poor farmers from investing in the soil, and especially in fertilizer: a bad rainy season will lead to crop loss and thus of the money invested. This is a risk that poor farming households cannot simply afford to take. Another factor that is associated with the low use of fertilizer is crop yield response. It has been pointed out that crop yield response to fertilizer use in Africa has been much lower than in Asia, and that for many farmers fertilizer use may even be uneconomic, especially to those whose farms have poor soils (Kelly, 2005).

The problem of low fertilizer use in Africa is not a recent phenomenon, and there has been a series of efforts to address it. However, the link between fertilizer policy and fertilizer use in Africa is not very direct. During the 1960s and 1970s, fertilizer use grew as rapidly in Africa as in other developing regions. According to the Food and Agriculture Organization of the United Nations (FAO), annual growth in fertilizer use in SSA was 9 percent over the 1960s and 1970s; but since 1981 it has stagnated at around 1.9–2.2m MT tons (Morris et al., 2007; Bernson & Minot, 2009; Todd et al., 2012).

During the 1970s and early 1980s fertilizer programs in Africa were often characterized by large, direct government expenditures using various entry points to stimulate fertilizer demand and ensure supply. Interventions frequently included direct subsidies that reduced fertilizer prices paid by farmers, government-financed and managed input credit programs, centralized control of fertilizer procurement and distribution activities, and centralized control of key output markets (Morris et al., 2007). However, fertilizer promotion programs based on these types of interventions generally did not lead to sustained growth in fertilizer use. Fertilizer subsidies remain controversial. Many development economists and international development agencies point to the high cost and limited effectiveness of fertilizer subsidies in the 1970s and 1980s (Benson, 2009).

It is pointed out that past subsidy programs, which often involved state monopolies in fertilizer marketing, undermined the emergence of efficient and widespread private input distribution networks. It is argued that massive subsidization led to an inadequate appreciation of fertilizer's actual value, and a complete neglect of issues like timeliness and availability. For example, during the period of heavy subsidies in many African countries (mid-1980s), growth in fertilizer consumption was not particularly rapid. Daramola (1989) concludes that chaotic and untimely fertilizer supply was one of the most important reasons for non-adoption. Moreover, the rapid growth in fertilizer consumption in the 1970s appeared to have slowed considerably in the last decade or so. Nwosu (1995) argued that continuing fertilizer subsidy cannot be justified on grounds of efficiency or equity. Furthermore, there were significant opportunity costs to devoting public funds to subsidizing fertilizer rather than investing in market development, agricultural research, transportation infrastructure, or other public goods to achieve a country's development goals (Benson, 2009).

Another major concern with input subsides was the extent of leakages and diversion of subsidized inputs away from their intended use. Farmers are likely to apply inputs to the use from which they expect to get greatest returns. Fertilizer, for example, may be applied to a variety of crops. If returns to fertilizer are higher on other crops (for example cash crops) then farmers may apply subsidized fertilizer to cash crops that have much more price elastic demand, and which are not consumed by the poor (Dorward, 2009).

It is also pointed out that it is difficult to channel subsidized inputs to smallholder farmers where a general subsidy is applied. In such as case, a limited number of tightly controlled supply chains, clear ways of identifying intended beneficiaries, and a high degree of discipline and control of private fertilizer transactions are crucial (Dorward, 2009). If subsidized inputs are used by large-scale commercial farms, this is likely to lead to increased diversion away from staple food crop production to cash crops, and a greater share of transfers to less poor producers. Similar issues arise in subsidy access between richer and poorer smallholders.

More recently, some policy makers have started to reconsider the prevailing thinking about promoting fertilizer. In this case the interest is in large-scale input subsidies, and particularly fertilizer subsidies, in agricultural development and food security policies (Dorward, 2009). The main factors influencing large-scale input subsidies include high global grain prices in the first part of 2008, and the dramatic rises in fertilizer prices. The central point in favouring subsidies in agricultural development mainly focuses on the need to promote increased agricultural productivity through the adoption of up-to-date technologies.

The concern of the continuing low use of fertilizer by poor rural households, including many whose members suffer from food insecurity, has revived arguments that the role of the state should be expanded to include not only commercial marketing of fertilizer, but also targeted distribution of subsidized fertilizer to poor households that lack the resources needed to purchase fertilizer on a commercial basis. Calls to re-engage the public sector in fertilizer marketing, and especially the arguments supporting the use of fertilizer subsidies to provide a safety net for the poor, have sparked a lively policy debate that shows little sign of abating (Morris, et., 2007).

Jeffrey Sachs (Morris et al., 2007) advocates large-scale distribution of low-cost or no-cost fertilizer as a way of helping smallholders escape the so-called poverty trap. Sachs's arguments have struck a chord with some African political leaders, as evidenced in the Africa Fertilizer Summit held in Abuja, Nigeria, in June 2006, where the case in favour of fertilizer subsidies was argued by a number of participants.

Thus, the assessment and evaluation of the effectiveness of fertilizer subsidy schemes is necessary so as to devise an alternative means to ensure the intended goals are achieved, and that past bad experiences with fertilizer subsidy are not repeated. This is the objective of the current paper. What follows is a description of the methodology employed to ascertain how well is the NAIVS functioning in Tanzania in terms of increasing crop productivity by poor smallholders.

3. Methodology

3.1 Theoretical Framework and Modelling

The analytical framework used in this paper is the integration of modelling components that range from the processes that are driven by household economics, to those that are essentially biological in nature. Thus, the methodology for this study is based on the combination of the socioeconomic information obtained from the field survey, and environmental information relevant in influencing crop production obtained from secondary sources. Our main consideration is to have the model that aim to take into account the effect of voucher system in crop production since its establishment in 2008 to 2012. Our thinking is that crop harvest by households in the study area is affected by household characteristic (socioeconomic and demographic), government policy (fertilizer subsidy scheme) and environmental characteristics such as weather, soil properties, topography, etc. Therefore, the general model to include both the socioeconomic and biophysical characteristic is appropriate in analysing the effect of fertilizer subsidy on crop production in the study area. In this case, households that receive voucher and those that did not receive the fertilizer through voucher systems were analysed to gauge the differences in production that could be attributed to the voucher program.

We consider a method for data in which the dependent variable linearly depends on a set of predictor variables (Equation 1). In this study we have a set of characteristics of individuals ($i = 1, \dots, n$), measured at T points in time ($t = 1, \dots, T$). Let Q_{it} be the dependent variable. We have a set of predictor variables that vary over time, represented by the vector X_{it}, and another set of predictor variables z_i that do not vary over time. Our basic model for Q is:

$$Q_{it} = \mu_{it} + \beta X_{it} + \gamma z_i + \alpha_i + \varepsilon_{it} \qquad (1)$$

where μ_{it} is an intercept that may be different for each point in time, and β and γ are vectors of coefficients. The two 'error' terms, α_i and ε_{it}, behave somewhat differently. There is a different ε_{it} for each individual at each point in time, but α_i only varies across individuals, not over time.

We regard α_i as representing the combined effect on Q of all unobserved variables that are constant over time. On the other hand, ε_{it} represents purely random variation at each point in time.

Estimation of the model in (1) is done when the variables are observed at only two points in time ($T = 2$). We form the two equations as:

$$Q_{i1} = \mu_1 + \beta X_{i1} + \gamma z_i + \alpha_i + \varepsilon_{i1} \qquad (2a)$$
$$Q_{i2} = \mu_2 + \beta X_{i2} + \gamma z_i + \alpha_i + \varepsilon_{i2} \qquad (2b)$$

We form the first difference equation by subtracting (2a) and (2b) as in equation (3):

$$Q_{i2} - Q_{i1} = (\mu_2 - \mu_1) + \beta(X_{i2} - X_{i1}) + (\varepsilon_{i2} - \varepsilon_{i1}) \qquad (3)$$

And finally, we write an estimated model 4 as:

$$Q_i^* = \mu^* + \beta X_i^* + \varepsilon_i^* \qquad (4)$$

We obtain consistent estimate of β by regressing Q_i^* on X_i^*.

3.2 Fixed Effect Model (FEM) Specification

As mentioned earlier, the voucher system was introduced in the country in 2007. Thus, to effectively gauge the impact of the scheme on crop production, the study employed the panel data analysis technique. One way to take into account the 'individuality' of each farmer is to let the intercept vary for each farmer. The assumed variables to influence crop production in equation (1) exhibit different properties when time aspect is included in the analysis. Some variables are time-variant, and others are time-invariant. In this analysis, we run both fixed and random effect, and then the Hausman test is performed to gauge for the suitable model.

To run the fixed effect model, the study employs the least square dummy variable (LSDV) approach. What follows is the description of the procedures to specify the LSDV. At first the FEM is specified to include the quantity of harvest as a dependent variable; and the independent variables are farm size, quantity of fertilizer used, household size, age of the head of household, education level of the head of household, marital status, main occupation, household location, sex of the head of household, cost of fertilizes, cost of improved seeds and household income.

$$Q_{it} = a_i + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 ED_{it} + a_6 HO_{it} + a_7 HL_i + a_8 HM_{it} + a_9 HI_{it} + a_{10} HCF_{it} + a_{11} HMS_i + a_{12} CIS_{it} + e_{it} \qquad (5)$$

where: Q_{it} = quantity harvested (kg/acre); FS_{it} = farm size (acre); FQ_{it} = quantity of fertilizer (kg); HS_{it} = household size (number); AH_{it} = age of the head of the household (number); Ed_i = education level; HM = marital status, HO = main occupation; HI_{it}= household income; HL = household location; HCF_{it} = cost of fertilizer; HMS = male sex of the head; CIS_{it} = cost of improved seeds; and t represents t^{th} time period.

Secondly, a dummy variable to represent household receiving and those not receiving fertilizer through the voucher system is included in our modelling work. The included dummy variable represents the effect of the voucher scheme on crop production at the household level in the study area.

$$Q_{it} = b_1 + b_2D_{1i} + a_1FS_{it} + a_2FQ_{it} + a_3HS_{it} + a_4AH_{it} + a_5ED_{it} + a_6HO_{it} + a_7HL_i + a_8HM_{it} + a_9HI_{it} + a_{10}HCF_{it} + a_{11}HMS_i + a_{12}CIS_{it} + e_{it} \quad (6)$$

where $D_{1i} = 1$ if the observation belongs to households with voucher, 0 otherwise. In this model, a_i in equation (5) is now represented by $b_1 + b_2D_{1i}$, b_1 represents the intercept of household with voucher, and b_2 represents the differential intercept coefficient, which tell by how much the intercept of household with voucher differ from the intercept of household without voucher. Here households without voucher becomes the reference category.

Thirdly, we introduce a dummy variable to capture the effect of time passage on the dependent variable. Just as we used the dummy variable to account for individual (voucher) effect, we can allow for time effect because of factors such as technological changes, changes in government regulatory measures, and external effects such as weather. Such time effects are accounted for by introducing time dummies. Since we have two years we introduce one dummy as indicated in equation (7).

$$Q_{it} = c_1 + c_2D_{2012} + a_1FS_{it} + a_2FQ_{it} + a_3HS_{it} + a_4AH_{it} + a_5ED_{it} + a_6HO_{it} + a_7HL_i + a_8HM_{it} + a_9HI_{it} + a_{10}HCF_{it} + a_{11}HMS_i + a_{12}CIS_{it} + e_{it} \quad (7)$$

where D_{2012} takes a value of 1 for observation in year 2012, and 0 otherwise. We are treating the year 2007 as the base year, whose intercept value is given by c_1.

Finally, we obtain the full fixed effect model in the LSDV approach. This is achieved by combining model (6) and (7) with individual characteristics and time effects respectively and form one model represented in equation (8).

$$Q_{it} = d_1 + b_2D_{1i} + c_2D_{2012} + \beta_1FS_{it} + \beta_2FQ_{it} + \beta_3HS_{it} + \beta_4AH_{it} + \beta_5ED_{it} + \beta_6HO_{it} + \beta_7HL_i + \beta_8HM_{it} + \beta_9HI_{it} + \beta_{10}HCF_{it} + \beta_{11}HMS_i + \beta_{12}CIS_{it} + e_{it} \quad (8)$$

By introducing the dummy variable, the fixed effect model is now analysed by the LSDV approach. The fixed-effects model controls for all time-invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time-invariant characteristics like culture, religion, gender, race, etc. However, one side effect of the features of fixed-effects models is that they cannot be used to investigate time-invariant causes of dependent variables. Technically, time-invariant characteristics of individuals are perfectly collinear with the person (or entity) dummies. Substantively, fixed-effects models are designed to study the causes of changes within a person (or entity) (Kohler et al., 2011). A time-invariant characteristic cannot cause such a change because it is constant for each person.

3.3 Random Effect Model (REM) Specification

In this paper we also argue that the variation across households is assumed to be random and uncorrelated with the predictor variables included in the model. We believe that differences across households have some influence on the dependent variable (quantity of harvest), and thus the need for a random effect model. The advantage of using a random effect model is that it can include time-invariant variables (i.e., gender).[2] What follows is the specification of the REM for this study. In the random effect model, instead of treating a_i as fixed as done in equation (5), we assume it is a random variable with mean α_1. Furthermore, instead of using a dummy variable to capture access to the voucher system, we use the error term ε_i. Thus, the REM is:

$$Q_{it} = \alpha_1 + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 ED_{it} + a_6 HO_{it} + a_7 HL_i + a_8 HM_{it} + a_9 HI_{it} + a_{10} HCF_{it} + a_{11} HMS_i + a_{12} CIS_{it} + e_{it} + \varepsilon_i \quad (9)$$

or

$$Q_{it} = \alpha_1 + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 ED_{it} + a_6 HO_{it} + a_7 HL_i + a_8 HM_{it} + a_9 HI_{it} + a_{10} HCF_{it} + a_{11} HMS_i + a_{12} CIS_{it} + w_{it} \quad (10)$$

where: $w_{it} = e_{it} + \varepsilon_i$, representing the within entity-error and between entity-error.

A test developed by Hausman in 1978 was employed to determine the appropriate model between the fixed effect model (FEM) and the random effect model (REF). The null hypothesis underlying the Hausman test is that the FEM and REF estimators do not differ substantially. The test statistic developed by Hausman has an asymptotic χ^2 distribution. If the null hypothesis is rejected, the conclusion is that REF is not appropriate; and that we may be better off using FEM.

3.5 Data and Data Collection

The study uses a panel data of household farmers collected in two waves. The first wave was collected by the NBS in 2007, and the second wave was collected by this study. Direct observations, group discussions and semi-structured questionnaires were the main data collection approaches employed in 49 villages in Tabora and Ruvuma regions. The field work targeted villages with farmers having access to fertilizer subsidy through the AIVS in the two regions. Individual household interviews were conducted on 327 smallholder farmers' households across the 49 villages within the wards and districts of the two regions. The information gathered during the year 2012 was matched with the same households that were surveyed in 2007 by the NBS.

The 2012 survey was conducted to collect both qualitative and quantitative data to analyse the impact of the fertilizer subsidy on cereal crops production and environment conservation. The sampling strategy for the 2012 survey was that purposive sampling technique was employed to select regions, districts, wards, villages and households. The 2007 census survey provided the sampling frame that was used in the 2012 survey. That is, household to be included in the 2012 survey was the ones that were covered by the 2007 census survey. According to the 2007 census, 15 households were sampled in each village. Thus, in the same way, the 2012 survey purposively sample the same households and villages. The field work took place between March 2012 and April 2012. Generally, the field work was challenging in terms of logistics to access the sampled households that were

[2] In the fixed effects model these variables are absorbed by the intercept

interviewed during the 2007 census survey. With good cooperation from the village governments we managed to access and interview the same households that were sampled in 2007/08 by the NBS agriculture census survey. The survey targeted to interview the heads or representatives of households. In addition, the study consulted and conducted focus group discussion with other stakeholders at all levels—village, ward, district, region and ministry levels—to gain more understanding about procedures and systems in general that govern the voucher scheme in the country. As commonly practised in rural areas, a majority of household do not keep records, and therefore the information/data collected from them depended much on their memory recall.

In this paper, the maize crop was used as a reference crop to analyse the impact of the voucher system on crop production. The choice of this crop was due to two main reason: (i) the voucher system includes two cereal crops—maize and paddy; and (ii) most households cultivate maize and paddy for both food and commercial purposes. In both surveys small proportion of households cultivated paddy, and thus were not used in the analysis.

3.5.1 Construction of Panel Data

The panel data analysis was based on 654 observations consisting of 327 households from the first wave and second wave, respectively. Before the analysis, the study first made an attempt to match households and the respective information for the two periods of interests. Thereafter, the merging of the two datasets was done in STATA. This identification was created based on the codes created by the NBS for the location (region, district, ward and village) and the household number that a household was given during the 2007 survey.

5. Results and Discussion

5.1 Descriptive Statistics

The descriptive analysis of the variables from both survey data (Table 1) were used in the panel data analysis. The rest of the variables are also available in Annex1. The average quantity of maize harvested per household was 1,526.5kg and 3,806kg during the 2007 and 2012 survey periods, respectively. The crop production in 2007 (during the time before the introduction of the voucher system) was found to differ significantly with the crop production in 2012 (during the voucher system). The F-test rejected the null hypothesis of no difference (F = 23.49, Sig. 0.000) between the mean maize harvest in 2007 and 2012. The average farm size was 2.3acres and 3.6 acres during the year 2007 and 2012, respectively. The difference between farm size in 2007 and 2012 was found to be statistically significant as confirmed by the F-test (F = 33.3, Sig. 0.000). There was relatively smaller increase in the average area cultivated as compared to the increase of the quantity of harvests by households from 2007 to 2012, implying that there was improvement of maize productivity in 2012. This difference in production and productivity between the 2007 and 2012 is attributed to the increased use of inorganic fertilizer and improved seeds through the NAIVS as was expected.

Table 1: Descriptive Statistics for Wave1 and Wave 2 Datasets

	WAVE1 _ 2007					WAVE2 _ 2012				
Variable	**Obs1**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs2**	**Mean**	**Std. Dev.**	**Min**	**Max**
Maizeq	324	1526.5	1942.5	24.0	24000	324	3806.2	8240.2	34.0	66000.0
fsize	327	2.3	2.3	0.2	28.5	327	3.6	3.4	0.5	40.0
qty_fert	207	123.45	724.83	2.0	95000	278	265.4	586	16.0	6400.0
cost_fertilizer	205	108544	113175	60.0	98000	235	268476	329953	3200	1800000
cost_seeds	326	14176	21991	150	200000	157	41848	51962.0	10000	299000.0
o_farmer	327	0.9	0.3	0	1	327	0.9	0.3	0	1
edn_none	327	0.1	0.3	0	1	327	0.1	0.3	0	1
edn_pr	327	0.9	0.3	0	1	327	0.9	0.3	0	1
edn_sec	327	0.1	0.2	0	1	327	0.1	0.2	0	1
edn_tert	327	0.0	0.1	0	1	327	0.0	0.1	0	1
sex	327	0.9	0.4	0	1	327	0.9	0.4	0	1
marital	327	0.8	0.4	0	1	327	0.8	0.4	0	1
Age	327	47.0	14.7	20.0	89.0	327	49.7	14.2	19	95

Legend: Maizeq = quantity of maize harvested (kg); fsize = farm size cultivated (acre); qty_fert = quantity of inorganic fertilizer used (kg); cost_fert = cost of inorganic fertilizer incurred (Tshs); cost_seed = cost of improved seeds (Tshs); o_farmer = farming as main occupation (binary 1 or 0); edc_none = not gone to school (binary 0 or 1); edn_pr = primary level of education with schooling years 1 to 8 (binary 1 or 0), edn_sec = secondary school level of education (binary (0 or 1); edn_tert = tertiary level of education (binary 1 or 0); sex = sex of the head of the household; marital = marital status of the head binary 1 or 0); age = age of the head of household.

The use of inorganic fertilizer has been found by other studies to improve greatly maize yield in Tanzania and other developing countries (Benson, 2009; URT, 2013; Hepelwa, 2013; Selejio, 2016). The major inputs used were inorganic fertilizer, labour (family and hired) and seeds. The average cost of inorganic fertilizer incurred by household farmers were TZS108,000 and TZS268,400 during 2007 and 2012, respectively. The increased cost of inorganic fertilizer in 2012 was not only caused by price increase of the inorganic fertilizer as noted during interviews, but also due to the increase of the amount of fertilizer used per household; possibly as result of NAIVS facilitating the availability and promotion of the use of inorganic fertilizer.

On average, household expenditure on farm inputs were higher during 2012 than the average costs incurred in 2007. This is a reflection of the changes in the cost of production due to inflation. Most of the demographic characteristics are time-invariant; and as such the household head marital status and gender were similar for both surveys. This is an indication that the composition of household heads did not change during the period of five years. On the other hand, the average age of the household head increased from 47 to 50 years.

5.2 Fertilizer Voucher System and Procedures

For the 2012 survey, additional variables were included to obtain information relevant to the voucher system. The descriptive analysis shows that 80% of the respondents indicated to have accessed the voucher system since its inception in 2008. However, due to the shortage of fertilizer under the scheme, households were alternating in accessing it. That is, if a household receives fertilizer this year, then the following year it goes without it so that the next household that missed in the previous year gets it this year. For the year 2012, about 59% of the respondents reported to access fertilizer under the voucher system (Table A1). In general, the households surveyed use inorganic fertilizer in their fields. About 90% of the respondents cultivate and apply inorganic fertilizer. It could be inferred that more than 30% of the users of inorganic fertilizer did not benefit from the voucher system. It was apparent from focus group discussions that the quantity of fertilizer available to famers via the voucher system was low compared to the actual demand.

The arrangement was that each household in a village is entitled to get one bag for basal and one bag for top dressing, which only cover one acre of cultivated land. From the descriptive analysis, on average households cultivate 3.6 acres (Table 1); implying that more than two-thirds of cultivated areas need to be fertilized using fertilizer outside the voucher system. The average quantity of fertilizer accessed via the voucher system was 160kg per household (Table A1), while the average fertilizer used was 265kg in 2012 (Table 1). This implies that the quantity of fertilizer obtained via the voucher system is low.

5.3 Voucher System and Household Expenditure

We made an assessment to ascertain if differences exist between those who accessed the voucher system and those who did not. The non-parametric Mann Whitney U test failed to reject the null hypotheses of no differences in farm size, expenditure in food, communication, and on farming equipment at 5% level of significance between farmers who accessed the fertilizer voucher system and those who did not in the study area (Table 2).

Table 2: Farm Investments and Other Expenditures by Household With and Without Access to Voucher System

	Mean Rank			
Variable	**Without Voucher**	**With Voucher**	**Chi-Square**	**Asymp. Sig.**
Farm size	164.3	162.5	0.023	0.87936
Maize harvest	120.5	177.7	23.555	0.00000
Expenditure on labour	135.8	174.2	13.662	0.00022
Expenditure on seeds	113.5	182.3	39.338	0.00000
Expenditure on food	136.3	132.6	0.113	0.73625
Expenditure on communication	102.6	119.1	2.422	0.11963
Expenditure on medical	136.1	158.2	3.674	0.05527
Expenditure on education	106.4	144.9	12.204	0.00048
Expenditure on Transport	100.0	125.7	5.724	0.01674
Expenditure on farm equipment	98.6	97.2	0.018	0.89197
Expenditure on inorganic fertilizer	112.1	182.8	36.477	0.00000
Quantity of inorganic fertilizer	102.9	146.9	12.010	0.00053

Source: Estimation by authors

On the other hand, the study analysed household expenditure as a proxy to the welfare measure. Most of the expenditure items by households in the study area were found to differ significantly (Table 2 and Table A2). Households that accessed the voucher system also reported to have higher expenditures than those that did not. We found significant differences in expenditure in terms of fertilizer and other basic needs (medical and education items), where those without access to the voucher system spent on average smaller amount of money than those with access to it. This implies that well-off families buy fertilizer more frequently and spend more on welfare items/services than poor families. These study findings concur with other studies that found that adopters of inorganic fertilizer are better-off (in terms of welfare) than their counterparts of non-users of inorganic fertilizer (Benson & Minot, 2009; Todd et al., 2013; Selejio, 2016).

Furthermore, households that accessed the voucher system were found to have more expenditure on labour than those that did not. The high expenditure in labour is associated to the use of hired labour. Also, the quantity of fertilizer used between the two groups differs significantly. The average is larger for households that accessed the fertilizer voucher system than those that did not. It has been revealed that, on average, well-off households are able to access fertilizer under the voucher system. These results are consistent with the reported claims in the focus group discussions in that, because of the low voucher value, a majority of poor households cannot afford to purchase fertilizer from suppliers/agents. Thus, well-off families tend to buy the vouchers from those who are unable to top-up and use them, and then use them to buy fertilizer from suppliers/agents. This situation has also been seen by Dorward (2009).

5.4 Panel Data Analysis Results

In this paper, the panel data analysis is employed to establish factors influencing crop production using the fixed and random effect models. However, following the results obtained after the Hausman test, the REM was found to be the most appropriate, and thus we used it to estimate model parameters and variable coefficients (Table 3). The result from the panel analysis shows that during the period 2007 and 2012 the maize crop has been influenced by farm size, quantity of inorganic fertilizer, expenditure on inorganic fertilizer, access to the voucher system, expenditure on improved seed and location-specific factors. The demographic factor significantly influencing maize production was only head of the household. Others such as household size, marital status, sex of the head of the head of the household were found to be insignificant (Table 3).

Also, the use of improved seeds resulted into an increase in crop production in the study area. The increased use of improved seeds by 10% resulted into an increase in maize harvest by 0.8%, holding for other factors. An increased purchase of inorganic fertilizer by 10% would result to an increase of maize harvest by 13% of maize harvest. In addition, an increase in farm size by 10% results into an increase of maize harvest by 12%. The location-specific factors were also found to influence maize production (Table 3). On the other hand, variables representing the voucher system were found to influence the increase of maize harvest by only 0.4%.

Table 3: Factors Influencing Maize Crop Production in the Study Area

Variable	Description	RE Model
hsize	Household size	-0.0030806 (-0.22)
fsize	Farm size	0.1159985* (6.36)
heada	Age of the head of the household	-0.0059357** (-1.91)
edn_sec	Secondary level of education	0.1813747 (0.9)
o_farmer	Farming occupation	0.1938075 (1.32)
lcseeds	Expenditure on improved seeds	0.0757453** (1.9)
sex	Male headed household	0.0858411 (0.54)
marital	Marital status	0.1153614 (0.73)
lcfert	Expenditure on inorganic fertilizer	0.1322354* (3.55)
lqfert	Quantity of inorganic fertilizer	0.1600793* (4.29)
voucher	Access to fertilizer under voucher	0.4379782* (4.24)
location	Location (Namtumbo district)	0.3130504* (2.26)
_cons	Constant	3.726135 (6.76)

6. Conclusion and Policy Implications

In principle, the voucher system enables a farmer to get a maximum of two bags of fertilizer to be used in only one acre. This amount is insufficient given the average farm sizes owned and cultivated by households in the area. In addition, it was reported that fertilizers under the voucher system were not available to farmers on time. Thus, in most cases farmers end up not using fertilizer, especially for the basal application. The study found a statistically significant difference between maize harvest by households with and without access to the NAIVS. For the maize harvest in 2012, households that accessed fertilizer through the NAIVS had more harvest, welfare expenditure (on medical and education items) and investment in farm inputs (labour, inorganic fertilizer, seeds) than those that did not access the NAIVS.

The result from the panel analysis further confirmed that maize crop yields during the period 2007 and 2012 were influenced by the amount of inorganic fertilizer used, expenditure on inorganic fertilizer, access to the voucher system, as well as expenditure on improved seeds. This implies that the promotion of the use of inorganic fertilizer and improved seeds through a well-managed NAIVS will increase both crop production and productivity to address household food security and poverty as intended by the programme.

However, the study found that a majority of poor smallholder farmers do not access the NAIVS due to high market prices of inputs that are not well compensated by the static low value of the NAIVS. This implies that the NAIVS is benefiting more well-off households than poor ones. The implication from this finding is that the NAIVS is not achieving the intended objective of increasing crop productivity by poor smallholders. Therefore, it is imperative to review the NAIVS to address the current challenges for better results of the programme.

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Table A1: Variables for Wave1 and Wave 2

	WAVE1 _ 2007					WAVE2 _ 2012				
Variable	**Obs1**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs2**	**Mean**	**Std. Dev.**	**Min**	**Max**
maizeq	324	1526.5	1942.5	24.0	24000.0	324	3806.2	8240.2	4.0	66000
fsize	327	2.3	2.3	0.2	28.5	325	3.6	3.4	0.5	40
qty_fert	207	123.45	724.83	2.0	95000.0	278	265.4	586.0	16.0	6400
cost_fertilizer	205	108543.6	113174.7	60.0	980000.0	235	268476.0	329952.8	3200.0	1800000
cost_seeds	326	14175.4	21991.3	150.0	200000.0	157	41848.1	51962.0	1000.0	299000
o_farmer	327	0.9	0.3	0	1	327	0.9	0.3	0	1
edn_none	327	0.1	0.3	0	1	327	0.1	0.3	0	1
edn_pr	327	0.9	0.3	0	1	327	0.9	0.3	0	1
edn_sec	327	0.1	0.2	0	1	327	0.1	0.2	0	1
edn_tert	327	0.0	0.1	0	1	327	0.0	0.1	0	1
sex	327	0.9	0.4	0	1	327	0.9	0.4	0	1
marital	327	0.8	0.4	0	1	327	0.8	0.4	0	1
Age of head	327	47.0	14.7	20.0	89.0	323	49.7	14.2	19.0	95
qty_seed	326	84.3	884.6	2.0	14400.0					
credit	327	0.2	0.4	0	1					
hsize						327	7.8	4.4	1	40
adult						326	3.9	2.3	1	18
child						273	3.4	2.2	1	15
qty_basal						94	163.8	230.2	1	2000
qty_top						271	215.4	499.9	5.0	6000
qty_tot						278	265.4	586.0	16.0	6400
fert_use						185	9.4	6.4	1.0	34
use_freq						304	0.9	0.3	0	1
yieldm						324	1107.2	2633.6	4	33000
cost_labour						128	150061.7	213446.9	50	1625000
voucher						327	0.8	0.4	0	1
start_voucher						238	2009.7	0.9	2008	2012
voucher_percent						198	68.2	29.9	3	100
fert_voucher						192	160.8	255.9	2	2090
cost_seeds2						131	55573.7	91092.8	1600	700000
exp_food						266	263919.5	287479.0	1200	2000000
exp_comm						230	109206.1	145686.9	1000	1500000
exp_medical						304	111790.3	185792.1	1200	2000000
exp_edc						270	181242.2	417261.5	1000	4000000
exp_transport						239	127299.2	328638.9	1000	3800000
exp_farm equipment						194	24105.2	41050.5	800	350000
exp_house						79	815031.6	2177436.0	3000	17000000

Table A2: Farm, Harvests and Expenditures by Households With and Without Voucher

Item	With Voucher (Mean)	Without Voucher (Mean)	All (Mean)
Farm size (acre)	3.5	4.0	3.6
Quantity of fertilizer used (kg)	285.7	144.5	265.4
Expenditure on fertilizer (TZS)	271,174.5	251,957.6	268,476.0
Expenditure on farm equipments (TZS)	23,429.7	27,069.4	24,105.2
Expenditure on Labour (TZS)	159,144.6	94,555.6	150,061.7
Quantity harvested (kg/household)	4,109.4	2,744.9	3,806.2
Expenditure on Food (TZS)	269,389.5	243,863.2	263,919.6
Expenditure on communication(TZS)	115,940.5	81,520.0	109,206.1
Expenditure on Transport (TZS)	143,391.8	57,922.2	127,299.2
Expenditure on medical (TZS)	116,653.4	94,253.9	111,790.3
Expenditure on education (TZS)	207,281.94	77,083.33	181,242.22