The Voucher System and the Agricultural Production in Tanzania: Is the model adopted effective? Evidence from the Panel Data analysis*

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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 the 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 analyze agricultural data collected in year 2007(before NAIVS) and 2012 (during NAIVS). The study found a statistically significant difference between crop harvest by households with and without access to NAIVS. The average crop yield (production per area) is relatively higher in 2012 than the yield in 2007. On average the area cultivated by the households has increased more than double in 2012. Majority poor smallholder farmers do not access the NAIVS due to high market price of inputs not well compensated by the static low value NAIVS. Also the study found that the effect of NAIVS is significantly high to the well off households. The implication from this finding is that the NAIVS is not achieving the intended objective of increasing crop productivity by the poor smallholders. NAIVS would have the desirable results when deliberate efforts to address the institutional and market system shortfall are instituted.

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Introduction

In Tanzania, agricultural sector is one of the key sectors to the national economy. Over 80% of the population lives in rural areas and their livelihoods depend on agriculture. The sector accounts for 26.4% of the GDP, 30% of export earnings and 65% of raw material for domestic industries (World Bank, 2010). Agriculture sector employs about 74 percent of the labour force (URT, 2007). However, the sector experience low growth. Given the importance of the sector as a source income, employment and food security, this low growth has translated into little progress on poverty reduction. The proportion of people living below the basic needs poverty line remains high at more than 33% in 2007 (HBS, 2007). The 2007/2008 NSCA, the most recent agricultural census approximates 12.6 million 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 1.1 million hectares[**]. The average food crop productivity in Tanzania stood at about 1.7 tons/ha far below the potential productivity of about 3.5 to 4 ton/ha (Table 1). High dependence on rainfall is the main characteristics of the agricultural practices by the small holder farmers in the country. In addition, the crop cultivation is characterized by low mechanization where majority farmers are using poor farm inputs such as hand hoe and traditional seeds. The soils have been degraded with significant loss of nutrients and thus contributing to low productivity problem.

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

Table 1: Maize and paddy cultivation and harvesting in Tanzania

Year	Area cultivated (ha)		Production (MT)		Maize yield (ton/ha)	Paddy yield (ton/ha)
	Maize	paddy	Maize	paddy		
2000	1017600	415600	1965400	781538	1.93	1.88
2001	845950	405860	2652810	867692	3.14	2.14
2002	1718200	565600	4408420	984615	2.57	1.74
2003	3462540	620800	2613970	1096920	0.75	1.77
2004	3173070	613130	4651370	1058460	1.47	1.73
2005	3109590	701990	3131610	1167690	1.01	1.66
2006	2570150	633770	3423020	1206150	1.33	1.90
2007	2600340	557981	3659000	1341850	1.41	2.40
2008	3982280	896023	5440710	1420570	1.37	1.59
2009	2961330	805630	3326200	1334800	1.12	1.66
2010	3050710	1136290	4733070	2650120	1.55	2.33
2011	3287850	1119320	4340820	2248320	1.32	2.01

Source: FAOSTAT

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 fertilizers (AFAP, 2012). Currently Tanzania uses 9kg of nutrients/ha while Malawi uses 27kg of nutrients/ha, South Africa uses 53kg of nutrients/ha. The average usage per hectare in other regions is 41kg of nutrients in Latin America ha, Asia is 85kg of nutrients/ha and Europe is 225 kg of nutrients/ha (FAO, 1996; URT, 2010). The low use of fertilizer in Africa can be explained by demand-side as well as supply-side factors. Demand for fertilizer is often weak in Africa because incentives to use fertilizer are undermined by the low level and high variability of crop yields on the one hand and the high level of fertilizer prices relative to crop prices on the other.

Table 2: Quantity of mineral fertilizer use in Tanzania

Year	DAP	UREA	CAN	%DAP	%UREA	%CAN
1994	2,444	25,680	20,971	5.0	52.3	42.7
1995	4,058	35,327	10,058	8.2	71.4	20.3
1996	2,594	21,140	14,779	6.7	54.9	38.4
1997	3,441	28,756	9,892	8.2	68.3	23.5
1998	3,949	14,758	9,193	14.2	52.9	32.9
1999	4,035	18,390	15,460	10.7	48.5	40.8
2000	3,576	27,293	8,149	9.2	69.9	20.9
2001	8,424	30,379	16,455	15.2	55.0	29.8
2002	6,515	30,334	12,577	13.2	61.4	25.4
2003	3,897	36,150	21,494	6.3	58.7	34.9
2004	10,551	54,674	12,680	13.5	70.2	16.3
2005	26,588	46,570	15,460	30.0	52.6	17.4
2006	21,436	56,822	25,589	20.6	54.7	24.6
2007	19,408	69,133	12,079	19.3	68.7	12.0
2008	20,000	73,200	12,079	19.0	69.5	11.5
2009	41,636	90,851	23,438	26.7	58.3	15.0

Source: FAOSTAT

Legend: DAP = Diammonium Phosphate; CAN=Calcium Ammonium Nitrate

In Tanzania however, government efforts are underway to revamp agricultural productivity such efforts include the introduction of the fertilizer subsidy scheme famous known as fertilizer voucher system. The current fertilizer subsidy program was introduced in 2008. The national agriculture input voucher scheme (NAIVS) is 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 year 2010 the fertilize purchased and distributed by private sector for the NAIVS program was 151,000 MT or 57% of the market. The current paper aims to present the results on the evaluation of the effectiveness of the fertilizer voucher scheme in Tanzania.

We structure the discussion as follows. Section 2 provides a brick discussion of the relevant literature on fertilizer subsidies and usage. Section 3 presents the description of the methodology employed in this study. In section 4 we discuss the study results and section 5 includes the policy implication and concluding remarks.

2. Literature review

Crop production in Tanzania and many SSA countries is faced with low use of fertilizer and consequently low crop productivity. Several factors have been pointed out as cause of low fertilizer use in SSA and Tanzania in particular. One of the factors is the high uncertainty of water availability due to temporal rainfall variability, especially in rain-fed agriculture (Van der Zaag, 2010). Water uncertainty inhibits poor farmers to invest 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 the crop yield response. It has been pointed out that the 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 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 series of efforts to address the problem. 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 Sub-Saharan Africa was 9 percent over the 1960s and 1970s, but since 1981 fertilizer use has stagnated at around 1.9–2.2 million metric tons (Morris et al., 2007; Bernson and Minot, 2009).

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, 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 more. Nwosu (1995) argued that continuing the 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 the greatest return. Fertilizers, for example, may be applied to a variety of crops. If returns to fertilizers are higher on other crops (for example cash crops) then farmers may apply subsidized fertilizers to cash crops which have much more price elastic demand and which are not consumed by the poor (Dorward, 2009).

It is pointed out that in general, where a general subsidy is applied it is difficult to channel subsidized inputs to smallholder farmers. 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 larger 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. Central point towards fevering the subsidies in agricultural development mainly focuses on the need to promote increased agricultural productivity through the adoption of up to date technologies.

The concerned by the continuing low use of fertilizer by poor rural households, including many whose members suffer from food insecurity, some have 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. The calls to reengage 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 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 during 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 on the effectiveness of the fertilizer subsidy schemes is necessary. This is to devise an alternative means to ensure the intended goals are achieved and that the past bad experience with the subsidy are not repeating. The current paper is therefore pondering around this. What follows is the description of the methodology employed to ascertain how well is the NAIVS is functioning in Tanzania in terms of increasing crop productivity by the poor smallholders.

3. Methodology

Theoretical framework and modelling

The analytical framework used in this paper is the integration of modeling components that range from the processes that are driven by the 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 the environmental information relevant in influencing crop production obtained from the 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 year 2012. Our thinking is that crop harvest by households in the study area is affected by the household characteristic (socioeconomic and demographic), government policy – fertilizer subsidy scheme and the environmental characteristics such as weather, soil properties, topography etc. Therefore, the general model to include both the socioeconomic and biophysical characteristic is appropriate in analyzing the effect of fertilizer subsidy on crop production in the study area. In this case, households that receive voucher and those who did not receive the fertilizer through voucher systems were analyzed to gauge the differences in production that could be attributed by the voucher program.

We consider a method for data in which the dependent variable linearly dependent on a set of predictor variables. We have a set of individuals (i=1,…, n), each of whom is measured at T points in time (t = 1,2,…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

$$Q_{it} = \mu_{it} + \beta X_{it} + \gamma z_i + \alpha_i + \varepsilon_{it} \quad \text{……………………………………………………………..(1)}$$

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

$$Q_{i1} = \mu_1 + \beta X_{i1} + \gamma z_i + \alpha_i + \varepsilon_{i1} \quad \text{………………………………………………………….. (2a)}$$

$$Q_{i2} = \mu_2 + \beta X_{i2} + \gamma z_i + \alpha_i + \varepsilon_{i2} \quad \text{………………………………………………………….. (2b)}$$

We form the first difference equation by subtracting 2a and 2b as shown in equation 3

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

And finally we write an estimated model 4 as

$$Q_i{}^* = \mu^* + \beta X_i{}^* + \varepsilon_i{}^* \ldots\ldots (4).$$

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

Fixed effect Model (FEM) specification

Voucher system was introduced in the country in 2007 thus in order 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 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 test for the Hausman to gauge for the suitable model.

In order 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 dependent variable and the independent variables are the farm size, quantity of fertilizer used, household size, age of the head of household, household income.

$$Q_{it} = a_i + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + e_{it} \ldots\ldots (5)$$

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, , HL=household location, HC=cost of fertilizer, Sex of the head, t=represent tth time period.

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

$$Q_{it} = b_1 + b_2 D_{1i} + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + a_6 HE + a_7 HL + a_8 SP + a_9 HO + a_{10} CR + a_{11} HO + e_{it} \quad \text{……………………………………………………………………} (6)$$

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 $b_1 + b_2 D_{1i}$, 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 without voucher. Here Households without voucher becomes the reference category.

Thirdly, we introduce the 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 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.

$$Q_{it} = c_1 + c_2 D_{2012} + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + e_{it} \text{…………………..} (7)$$

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 c1.

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.

$$Q_{it} = d_1 + b_2D_{1i} + c_2D_{2012} + \beta_1FS_{it} + \beta_2FQ_{it} + \beta_3HS_{it} + \beta_4AH_{it} + \beta_5WC_{it} + e_{it} \ldots\ldots\ldots \quad (8)$$

By introducing the dummy variable the fixed effect model is now analyzed by the Least Square Dummy Variable (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 the dependent variables. Technically, time-invariant characteristics of the 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, Ulrich, Frauke Kreuter, Data Analysis Using Stata, 2nd ed., p.245. A time-invariant characteristic cannot cause such a change, because it is constant for each person.

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 (quantity of harvest) and thus the need for random effect model. An advantage of random effects is that we can include time invariant variables (i.e. gender)[††]. 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 above, we assume it is random variable with mean α_1. Furthermore, instead of using dummy variable to capture access to voucher system, we use the error term, ε_i. Thus the REM is

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

$$Q_{it} = \alpha_1 + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + e_{it} + \varepsilon_i \text{..............................} (9)$$

or

$$Q_{it} = \alpha_1 + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + w_{it} \text{…………….………….} (10)$$

where

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

The REM assumes that the entity's error term is not correlated with the predictors which allows for time-invariant variables to play a role as explanatory variables. Thus the final REM is specified to include time – invariant explanatory variables such as gender, location, education level, marital status, occupation of the head of the household as shown in equation 8.

$$Q_{it} = \alpha_1 + a_1 FS_{it} + a_2 FQ_{it} + a_3 HS_{it} + a_4 AH_{it} + a_5 WC_{it} + a_6 HG_i + a_7 HL_i + a_8 HO_i + a_9 HE_i + a_{10} HC_i + w_{it}$$
$$\text{………………………………………………………………} (11)$$

A test developed by Hausman in 1978 was employed to determine the appropriate model between the fixed effect model and the random effect model. 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 χ2 distribution. If the null hypothesis is rejected, the conclusion is that REF is not appropriate and that we may be better off using FEM.

Data

The study uses the panel data of householder 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 with access to fertilizer subsidy through the agricultural inputs voucher system (AIVS) in two regions. Individual household interviews were conducted on 327 smallholder farmers' households across the 49 villages within wards and districts of the selected 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 analyze 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 2012 survey. That is the household to be included in the 2012 survey was one that was covered by the 2007 census survey. According 2007 census, 15 households were sampled in each village thus in the same way, the 2012 survey purposively sample the same villages and same households. The field work took place between March 2012 and April 2012. The research team composed of three principal researchers and five research assistants. Generally, the field work was challenging in terms of logistics to access the sampled households that were interviewed during 2007 census survey. With good cooperation received from village government we managed to access and interview same households that were sampled in 2007/08 by the NBS agriculture census survey. The survey targeted to interview the head or representative of households. In addition, the study consulted and conducted the focus group discussion with other stakeholders at all levels‡‡ to gain more understanding about procedures and systems in general that governs the voucher scheme in the country. As it is common practice in rural areas, 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 reference crop to analyze the impact of the voucher system on crop production. The choice of this crop was due to two main

‡‡ Village, ward, district, region and ministry level

reason; (i) the voucher system includes two cereal crops maize and paddy (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.

Construction of the panel data

The panel data analysis was based on the 654 observations consisting 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. There after 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

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 was 1,526.5 kg and 3,806 kg during 2007 and 2012 survey periods respectively.

The crop production in 2007 (during the time before the introduction of the voucher system) found to differ significant 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 2.3 acre and 3.6 acre during the year 2007 and 2012 respectively. The difference between farm size in 2007 and 2012 found to be statistically significant as confirmed by the F-test

(F=33.3, sig. 0.000). There was an increase in both the average area cultivated and the quantity of harvests by households in 2007 and 2012. The major inputs used were inorganic fertilizer, labour (family and hired labour) and seeds. The average cost of inorganic fertilizer incurred by households farmers were Tsh 108,000 and 268,400 during 2007 and 2012 respectively. On average, household expenditure on farm inputs were higher during 2012 than 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 as such the household head marital status and gender are similar for both surveys. This is an indication that during the period of five years, the households' heads composition did not change. On the other hand, the average age of the head of the household have increased from 47 to 50 years (Table3).

Table 3: Descriptive statistics for wave1 and wave 2 datasets

	WAVE1 _ 2007					WAVE2 _ 2012				
Variable	Obs 1	Mean	Std. Dev.	Min	Max	Obs 2	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	1234.5	7248.3	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

Fertilizer voucher system and Procedures

For the 2012 survey, additional variables were included in the survey to obtain information relevant to the voucher system. The descriptive analysis shows that 80% of the respondents indicated to have accessed the voucher since its inception in 2008; however, because of the shortage of the fertilizers under the scheme, households were alternating in accessing it. That is if a household receives this year, then the following year goes without it so that the next household who missed in the previous year gets this year. For the year 2012, about 59% of respondents reported to access the fertilizer under the voucher system (Annex 1). In general, households surveyed uses inorganic fertilizers in their fields. About 90% of respondents cultivates and applies inorganic fertilizers. It could be inferred that the 30% of the users of the inorganic fertilizers did not benefit from the voucher system. From the focus group discussion, the quantity of fertilizer available to famers via the voucher system is low compared to the actual demand.

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

Voucher system and household expenditure

Assessment was made to ascertain if differences exists between those who accessed the voucher and those who did not. The non-parametric - The Mann Whitney U test fail to reject the null hypotheses of no differences in farm size, expenditure in food, communication and on farming equipments at 5% level of significance between farmers accessed and those not accessed the fertilizer voucher in the study area (Table 4).

On the other hand, the study has analyzed household expenditure as proxy to the welfare measure. Most of the expenditure items by households in the study area were found to differ significantly (Table 4 and Annex 2). Households who accessed the voucher system also reported to have higher expenditures than those who did not access. We found significant difference in expenditure in terms of fertilizer, where those without access to voucher spent on average smaller amount of money than those with access to voucher system. This implies that well off families buy fertilizer more frequently than the poor families. Furthermore, households who accessed voucher found to have more expenditure on labour than those who did not access. The high expenditure in labour is associated by the use of hired labour. Also the quantity of fertilizer used between the two groups differs significantly. The average is larger for the households who accessed fertilizer voucher system than those who did not access. It has been revealed that, on average well off households are able to access the fertilizer under the voucher system. These results are consistent with the reported claims in the focus group discussion. That is because of low voucher value, majority poor households cannot afford to purchase fertilizers from the supplier - agents. Thus the well off families tends to buy the vouchers from those who are unable to top. The bought vouchers are then used to buy fertilizers from agents.

Table 4: 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 equipments	98.6	97.2	0.018	0.89197
Expenditure on inorganic fertilizer	112.1	182.8	36.477	0.00000
Quantity of inorganic fertilizers	102.9	146.9	12.010	0.00053

Source: Estimation by authors

Panel data analysis results

The panel data analysis employed to establish factors influencing crop production using the fixed and random effete models. However, following the results obtained after the Hausman test, the random effect model found to be the appropriate and thus was used to estimate model parameters and variable coefficients (Table 5). The result from the panel analysis shows that maize crop during the period 2007 and 2012 has been influenced by farm size, quantity of inorganic fertilizer, expenditure on the inorganic fertilizer, access to the voucher system, expenditure on improved seed and location specific factors. The demographic factors influencing significantly the 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 found to be insignificant (Table 5). The use of improved seeds has resulted to an increase in crop production in the study area. The increased of use of improved seeds by 10% results to an increase in maize harvest by 0.8% holding other factors. An increase purchase of inorganic fertilizers by 10% would result to an increase of maize harvest by 13% of maize harvest. In addition, the increase in farm size by 10% results to an increase in maize harvest by 12%. The location specific factors were found to influence maize production in the study area (Table 5).

Table 5 : 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)

On the other hand variables representing the voucher system found to influence maize harvest increase by 0.4%.

Conclusion

In principle, the voucher system enables a farmer to get maximum of two bags of fertilizers to be used in only one acre. This amount allocated is insufficient given the farm sizes owned and cultivated by the households in the area. In addition, the fertilizer under the voucher system is reported to be available to farmers not at right time. The Agents delays to take fertilizers to the villages and this affect negatively farmers. In most cases, farmers end up not using fertilizer especially for the basal application. The crop production during the time before the introduction of the voucher system found to differ significant with the crop production during the voucher system. It could be noted that the average production in 2012 is high compared to the harvest in 2007 (Table 3). This difference is also brought about by the differences in the area cultivated during the two periods. On average the area cultivated by the same households increased more than double in 2012. The average crop yield (production per area) is relatively higher in 2012 than yield in 2007. Thus the fertilizer voucher system is beneficial to farmers and this will be maintained if the implementation huddles are rectified. For example, the value of the voucher if is indexed with the market price of the fertilizer would make more sense to poor farmers who fail to top up the additional money required to get a bag of fertilizer.

Annex 1: 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	1234.5	7248.3	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

Annex 2: 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 (Tsh)	271,174.5	251,957.6	268,476.0
Expenditure on farm equipments (Tsh)	23,429.7	27,069.4	24,105.2
Expenditure on Labour (Tsh)	159,144.6	94,555.6	150,061.7
Quantity harvested (kg)	4,109.4	2,744.9	3,806.2
Expenditure on Food (Tsh)	269,389.5	243,863.2	263,919.6
Expenditure on communication(Tsh)	115,940.5	81,520.0	109,206.1
Expenditure on Transport (Tsh)	143,391.8	57,922.2	127,299.2
Expenditure on medical (Tsh)	116,653.4	94,253.9	111,790.3
Expenditure on education (Tsh)	207,281.94	77,083.33	181,242.22

Annex 3: Descriptive statistics of variables used in the Panel regression

Variable		Mean	Std. Dev.	Min	Max	Observations
maizeq	overall	2666.333	6089.611	4	66000	N = 648
	between		4186.978	202	33150	n = 327
	within		4408.957	-30183.7	35516.33	T = 2
fsize	overall	2.97	2.976131	0.2	40	N = 652
	between		2.128529	0.75	23.375	n = 327
	within		2.078423	-13.655	19.595	T = 2
cost_s~s	overall	17112.13	33374.1	0	299000	N = 654

	between		23494.84	0	156000	n = 327
	within		23720.64	-130638	164862.1	T = 2
marital	overall	0.840979	0.365976	0	1	N = 654
	between		0.264058	0	1	n = 327
	within		0.253611	0.340979	1.340979	T = 2
sex	overall	0.856269	0.351085	0	1	N = 654
	between		0.246102	0	1	n = 327
	within		0.250574	0.356269	1.356269	T = 2
edn_pr	overall	0.905199	0.293164	0	1	N = 654
	between		0.293389	0	1	n = 327
	within		0	0.905199	0.905199	T = 2
heada	overall	48.32308	14.49117	19	95	N = 650
	between		10.40732	20.5	88	n = 327
	within		10.07705	15.82308	80.82308	T = 2
fert_v~r	overall	47.21365	156.6232	0	2090	N = 654
	between		105.6704	0	1045	n = 327
	within		115.6792	-997.786	1092.214	T = 2
cost_l~r	overall	29369.88	111404.1	0	1625000	N = 654
	between		76041.7	0	812500	n = 327
	within		81470.22	-783130	841869.9	T = 2
cost_f~t	overall	130494.3	235791.7	0	1800000	N = 654
	between		164967.9	0	952000	n = 327
	within		168597.1	-717506	978494.3	T = 2
voucher	overall	0.388379	0.487755	0	1	N = 654
	between		0.208529	0	0.5	n = 327
	within		0.441007	-0.11162	0.888379	T = 2
location	overall	0.110092	0.313244	0	1	N = 654
	between		0.218309	0	1	n = 327
	within		0.224802	-0.38991	0.610092	T = 2

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