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# National Agricultural Input Voucher Scheme Impact on Productivity and Food Security of Smallholder Farmers in Tanzania

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**Abstract**
Tanzania Government introduced National Agriculture Input Voucher Scheme (NAIVS) in 2008/2009 to overcome the limitations of the previous subsidy programs. This would increase productivity and food security contributing to poverty reduction. This paper examines the voucher access impact on productivity and food security. Cross section data were collected from a random sample of 300 farmers in a survey using a semi structured questionnaire. Two stages least square (2SLS) regression was used to estimate the impact of voucher access on agricultural productivity and binary logistic model for food insecurity. Empirical results shows that farmers with access to input subsidy vouchers had higher agricultural productivity significant at *P*=0.00. Social economic variables such as age, education, land size, borrowing possibility and access to extension revealed positive contribution to aggregate agricultural productivity. Considering food security, farmers with access to voucher were less food insecure significant at *P*=0.00. Also access to village was found to decreases food insecurity significanly. Contrarily, unpredictable weather increased food insecurity significant at *P*=0.01. These findings implies positive contribution of voucher program in poverty reduction. However, sustainable agricultural productivity and food security requires improved social services, better crop management and mitigation of unpredictable weather.
**Key words** Aggregate agricultural productivity, input voucher access, smallholder farmers.

## 1.0 Background

The importance of subsidy on increasing fertilizer use for boosting agriculture productivity and economic growth set back to 1960s during Asian green revolution. The success of green revolution in Asia was associated with government support on subsidies, credits and improved infrastructure and uptake of technologies through research and extension (Danning et al., 2009). Learning from Asia, Africa green revolution was promoted during 1970s to 1980s in order to overcome limitations which were facing the agriculture sector. However, due to inefficiencies, budgetary deficit and pressure from donor institutions, subsidies were eliminated in the early 1990s following 1980s market liberalization. The consequence was higher transaction costs in input markets and complicated processes for crop-secured loans. Higher transaction costs led to higher fertilizer price affecting the farmers' input use decision (Winter – Nelson and Temu 2005). In Tanzania fertilizer use declined to an average of 9kg/ha per year, which is below Africa and world average of 21kg/ha and 100kg/ha respectively (Ricker-Gilbert and Jayne, 2009, Eboh et al., 2006). Low adoption and application of fertilizers in production was associated with low crop productivity, food insecurity and higher levels of poverty in most developing countries (Danning et al., 2009).

In order to reverse the declining trend in crop productivity and poverty, there has been resurgent interest in subsidy in Africa since mid 2000 (Ricker-Gilbert and Jayne, 2009, Chibwana et al., 2010, Danning et al., 2009). Tanzania introduced National Agriculture Input Voucher Scheme in 2008/2009 to overcome the limitations of the previous subsidy programs. The objective was to increase smallholder farmers access and use of critical agricultural inputs so as to increase production and productivity of food and cash crops, contributing to food security and poverty reduction (World Bank, 2009). Under NAIVS, the Government expenditure on fertilizer subsidy increased from 31.9 billion in 2008/2009 to 128.7 billion in 2010/2011. Also the quantity of subsidized fertilizers increased from 130 000 tonnes to 201 015 tonnes in 2010/2011 (MAFC, 2013). NAIVS entitles farmers to input voucher to acquire inputs below the market price based on voucher value. The government spending on this program is aimed to increase production of rice and maize in agro ecological areas with high production potential of these staple crops. These areas are based in the Southern Highelands, Nothern Highlands and Western regions contributing 70 percent of maize and 50 percent of rice produced in the country (URT, 2013). Initially the programme was planned to cover 65 districts in the country. However due to political influence the program was extended to 130 districts out of 152 with more cops introduced into the program including cotton, tea, coffee and cashew. Subsidy covers seeds and seedlings, fertilizers and pestcides. High productivity of target crops is expected to increase income of farmers contributing into food security and poverty reduction in the country. Despite national initiatives on subsidies, the changes in productivity at household level

 

that are attributed by subsidy are not known. It is also unknown whether the programme has successfully changed the income and food security among smallholder farmers.
This study objective was to assess the impact of National Agricultural Input Voucher Scheme on productivity and food security at household level. Findings from this study are important in informing the policy makers on whether the programme has achieved the intended objectives.

## 2.0 Research Methodology

### 2.1.1 Study location, sampling and analytical tools

Research was conducted in four regions namely; Mbeya, Morogoro, Rukwa and Shinyanga to capture NAIVS information from year 2009/2010 to 2010/2011. Mbeya and Rukwa regions were chosen because these were pilot intervention areas and main food crop producers. Recently, Morogoro and Shinyanga are new comers into the programme, moreover, Morogoro has been identified by the government as an emerging grain basket for the nation, and Shinyanga is among the major cotton producing regions, a cash crop that have benefited from NAIVS. From each region two villages were involved in the survey, one village easily accessible through road network within few kilometres from town centre and another village less accessible.
Purposive and random sampling methods were used. Regions, districts, wards and villages were purposively selected to capture subsidy information. Households as a sampling unit were obtained from farmers register, stratified in two groups of beneficiaries and non beneficiaries. Simple random sampling technique was used to obtain 5% of farmers from each stratum for interview. A total of 300 households; 169 beneficiaries and 131 non beneficiaries were involved in a cross section survey. Primary data were collected through face to face interview using a semi structured questionnaire. Data collected were on NAIVS status, regarding impact of the scheme to household livelihoods parameters like crop yields, income, access to input vouchers and socio economic characteristics. Also farmers experience on food insecurity in the last twelve months was recorded. More details on location, sampling and data collection information are according to (Aloyce et al., 2014). Both qualitative and quantitative data collected in this study were analysed with Stata 11, SPSS version 18 and excel computer packages.

### 2.1.2 Data Limitations

It should be noted that, the sample used in this study is not adequate to generalize the findings for the programme impact in Tanzania but provides indicative picture of the impacts at household level. Some limitations encountered during data collection were lack of uniform weighing instruments for crops harvested and sold at market. Also, we relied on the recall information on acreage owned by the household and crop production records from harvests of previous seasons. Although researchers tried to probe to be able to translate units into standard units some measurement errors might still exist. Prices information from farmers varied greatly from one location to another especially for food crops. To minimize errors the district price records were considered.

## 2.2 Empirical approach

### 2.2.1 Measures of productivity

Common measures of agricultural productivity are based on the relationship between output and conventional inputs such as land, labour and capital. Fertilizers, high yielding seeds and pesticides are complementary inputs which are determinants of productivity (Kamara, 2004). Since land is a major limiting factor in agricultural production, an increase in land productivity has been considered to be a key factor in agricultural development. Productivity as a measure in this study involves aggregate partial productivity that is overall productivity of a farm per hectare in reference period in monetary terms (Kamara, 2004, Gabagambi, 2003). Prevailing market prices for crops under subsidy (maize, rice and cotton) was involved in the estimation. The product of quantity produced for all crops in a household and average crop price in a respective district were added together and then divided by the area under respective crops providing aggregate agricultural productivity (AAP). Hence, AAP is given by;

$$AAP = \sum_{i=1}^{N} (Q_i * P_i) / \sum_{i=1}^{N} A_i / N \quad \text{.....2.1}$$

Where *AAP* is aggregate agricultural productivity in monetary value, *Q* is quantity of ith crop, *P* is average price of ith crop and *A* is area under ith crop. N is the total number of crops under consideration where *i* is subscripts which denotes output and price considerations (Gabagambi, 2003, Kamara, 2004). The values are expressed in Tanzanian Shillings (Tsh/-), where the current exchange rate is 1USD =1630Tsh/-. In estimating the impact, we used the *Y* to represent *AAP*.

### 2.2.2 Food Security

Food security *is a situation that exists when all people at all times have physical, social and access to sufficient, safe and nutritious food that meets their dietery needs and food preferences for an active and healthy life* (Bickel et al., 2000, Smith and Subandoro, 2007). Four types of food security indicators are Calorie deprivation, monetary poverty, dietay diversity and subjective/experiential indicators. All four types of food security indicators have strengths and waaknesses for cross sectional validity (Headey and Ecker 2012).

 

In assessing the impact on food security in Malawi Chirwa et al., (2013) created a dummy variable representing adequacy in food consumption where one was assigned to households that revealed adequate and more than adequate food consumption and zero if food consumption was inadequate. Food security measures in this study was more or less based on subjective/experiential indicators. Farmers were asked whether or not they have experienced the food isecurity within the last twelve months and response was compared between farmers who had access to subsidy vouchers and those with no access. Farmers response was substituted by information obtained from key informants and focus group discussion.

### 2.2.3 Empirical estimation

#### 2.2.3.1 Subsidy voucher impact on Agricultural productivity

This study was based on potential outcomes framework applied in non experimental studies in several fields including medical literature (Angrist, 2008). Potential outcome models are similar to econometric switching regression models commonly embedded to linear regression framework. Potential outcome model estimator which is two-step was developed by Heckman 1976; 1979 (Angrist, 2008).

Assuming farmers apply conventional input x to produce an aggregate output *Y*, the relationship can be expressed by the following equation;

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_n + \mu_i \quad \text{.....2.2}$$

Where $Y_i$ = Outcome or productivity of crops under subsidy obtained in 2.1 above, $X_1$= access to subsidy voucher, $X_2$... $X_n$ = production and scio-economic variables of household. Such variables are land holdings, Community variables such as membership to farmer groups or any association, borrowing ability, household characteristics including age of head of household, education and sex, $\beta$ =estimated impact and $\mu_i$ is the error term.

Households are not homogenous, and the distribution of subsidy was based on targeting criteria. This implies that the selection mechanism was not randomly assigned to farmers and farmers were endogenously involved in the programme. As a result, estimation of subsidy impact may encounter identification problem if the explanatory variable $X_1$ is correlated with $\mu_i$ such that $Cov(x_1, \mu_i) \neq 0$ (Wooldridge, 2002, Stock and Watson, 2003). Appropriate estimation models are necessary in order to obtain reliable estimates. Instrumental Variable (IV) estimator called Two Stage Least Squares (2SLS) regression model have been employed to estimate the program impact on household outcomes (Chibwana et al., 2010, Nino-Zarazua, 2007, Ricker-Gilbert and Jayne, 2008). In the first stage, endogenous regressor was related to other exogenous variables and in the second stage the rate of fertilizer application was used as dependent variable in one study while commercial fertilizer was dependent variable in the other (Ricker-Gilbert and Jayne, 2008, Chibwana et al., 2010). Contrary to their study, this study used aggregate agricultural productivity for subsidized crops in the second stage as a dependent variable.

Instrumental variable estimator begins with regression linking x onto instruments Z not included in equation *2.2* and all explanatory variables in equation *2.2* which are not correlated with $\mu_i$ given in a reduced form equation *2.3*. The reduced form in single linear equation is a terminology adopted from simultaneous equation that is used in all IV contexts to imply the endogenous variable is linearly related onto all exogenous variables. *Z* must be partially correlated with $X_i$ in equation *2.2* such that $Cov(Z_i, X_i) \neq 0$, and uncorrelated with $\mu_i$ ; ( $Cov(Z_i, \mu_i) = 0$ .

$$x_i = \gamma_0 + \gamma_1 x_1 + \gamma_2 x_2 + \gamma_3 x_3 + \gamma_n x_n + \pi_1 Z_i + v \quad \text{.....2.3}$$

$v$ is uncorrelated with all explanatory variables in the right hand side and has zero mean. It is the part of $x_i$ that is correlated with $\mu_i$ in equation *2.2*.

$$\overset{*}{X}_i = \gamma_0 + \gamma_1 x_1 + \gamma_2 x_2 + \gamma_3 x_3 + \gamma_n x_n + \pi_1 Z_i \quad \text{.....2.4}$$

$\overset{*}{X}_i$ is a problem free component of $x_i$ where $\gamma_j$ and $\pi_j$ are population parameters.

In the second stage, the problem free component $\overset{*}{X}_i$ of $X_i$ could be used to estimate the coefficient $\beta_1$ in equation 2.2. However, $\overset{*}{X}_i$ value is unknown and is not a usable instrument (Wooldridge, 2002, Stock and Watson, 2003, Ettner, 2004). TSLS method therefore applies OLS in equation 2.4 to predict $\hat{x}_i$ given in equation 2.5.

$$\hat{x}_i = \hat{\gamma}_0 + \hat{\gamma}_1 x_1 + \hat{\gamma}_2 x_2 + \hat{\gamma}_3 x_3 + \hat{\gamma}_n x_n + \hat{\pi}_1 Z_i \quad \text{.....2.5}$$

 

The predicted $\hat{x}_i$ will be used in the second stage of TSLS. Regression of $Y$ (equation 2.2) on $\hat{x}_i$ is done using OLS, to estimate the coefficients $\beta_0$ and $\beta_1$ which explains the impact of agricultural input vouchers access on outcome.

Alternatively, Heckman two stage estimation procedure and treatment effect models which also uses identifying instrumental variable (IV) is suitable to address bias resulting from potential endogeneity problem (Nino-Zarazua, 2007, Vella, 1998, Ettner, 2004, Guo and Fraser, 2010). TSLS model will be employed in this study according to (Guo and Fraser, 2010).

**2.2.3.2 Selecting the instruments**

Valid instruments are crux for meaningful regression results. In estimating the impact of Farm Input Subsidy Programme on fertilizer use; some instruments have been highlighted. (Chibwana et al., 2010) considered the program targeting design to be the source of instruments. In study by Chibwana et al 2010, four identified instruments were female headed households, the poor, permanent residents and the population of the village. These instruments were used in the first equation and not in the subsequent equation by lacking independent effect on fertilizer purchase decision although its influence is only through coupons. Contrarily, Ricker-Gilbert and Jayne (2008), considered existence of the Member of Parliament in the community and the years the household has stayed in the village as instruments. Also, in controlling the selection bias during estimation of demands for commercial fertilizer market, Chirwa et al., (2013) used two-step estimation procedure with the distance to the main road as the identification variable and other household characteristics and quantity of subsidized fertilizer received by the household.

(Angrist and Imbens, 1995) considered student' quarter of birth as an instrument for schooling in an earning equation as the quarter of birth is correlated with schooling and does not have direct influence on earning. A good instrument is correlated with the endogenous regressor that can be verified and explained by researcher and not correlated with the outcome variable directly (Angrist and Krueger, 2001).

In Tanzania NAIVS, official selection criteria for voucher beneficiaries were ability to contribute the 50 percent top up and possession of land in the village preferably less than one hectare and gender of head of household where female headed households were given priority (Pan and Christiaensen, 2012). Unofficial criteria were human capital such as education and relationship to village leaders termed as elite capture in the pilot study by(Pan and Christiaensen, 2012). Ability for top up is likely to be associated with household wealth situation. In this study the total value of household assets were obtained and was used to represent the wealth situation of household where households with large total asset value possesion were considered more wealth. It is likely to consider four instruments which are household assets, land ownership, female headed household and education. However, existing literature shows that some of these variables have direct influence on productivity.

Since the study was done in accessible and less accessible villages, we hypothesize that vouchers were subject to whether the village is accessible or less accessible posing a good instrument for this study. Also, the length of residence measured by number of years the household has resided in the village was regarded as an instrument. Instruments used in this study were access to the village, length of residence in the village and the wealth situation of the household. These instruments are hypothesized to influence vouchers allocation to households positively and have no direct influence on productivity. These three variables were predicted instruments that were entered in the reduced form regression equation 2.3. If the instruments are not weak, the residual of the reduced form equation are entered in structural equation 2.2 to test statistical significance of its coefficients; a Housman specification test according to (Belloc, 2009). Hausman specification test is commonly applied in IV regression models to identify whether there is omitted variable bias, measurement error and reverse causality in the regression.

Even so, Ettner (2004) has pointed out that these instruments are not necessary but helps to identify the effect of treatment on outcome that is more robust. It is the fundamental exclusion restriction under which IV manages to identify causal parameters (Cerulli, 2012). It is difficult to find the instrument that is exogenous and relevant. As a result Heckit treatment effect models (*treatreg*) are recommended where IV approach appears interesting (Guo and Fraser, 2010).

### 2.2.4 Food security estimation

Whether or not farmers had adequate food consumption before, during and after the subsidy programme was estimated by chi-square statistics. In addition, binary logistic model was employed in quantitative estimation. Household food insecurity experience in last twelve months was treated as dependent variable and voucher access as independent variable such that;

$$\text{logit}[p(x)] = \log\left[\frac{p(x)}{1-p(x)}\right] = b_0 + b_1x_1 + b_2x_2 + \ldots b_nx_n + \varepsilon_i \quad \ldots\ldots 2.6$$

 

Where; p ranges from 0 to 1; with 1 representing farmers experience in food isecurity in last twelve months, $x_1$= farmers access to input voucher, $x_2$=socio-economic characteristic, $X_n$=environmental and biographic factors, b*i*= parameters to estmate and $\varepsilon_i$ = error term.

## 3.0 Results and discussion

### 3.1 Characteristics of smallholder Farmers in surveyed communities

Social economic variables that were considered in this study include age of the head of household, sex, education and marital status (Table 1). Households with age between 30-44 years were higher 52% in Bariadi and 40% for both Mbozi and Mvomero compare to other age groups. The next age group with higher number of household respondents was between 45-64 years 38% both for sumbawanga and Mbozi. Low number of respondents was observed for both age group between 14-29 years and above 65 years. This implies that, the majority of farming households are in the active age. It is also possible that; population of under 30 years are still dependants. Low number of respondents for age group above 65 is likely caused by retirement from agriculture activities or delegation of production activities to young family members. In most cases, older famers in Tanzania tend to be under the care of their children who inherits farms and productive assets of parents.

The sample was dominated by male respondents as most households are headed by male although wives were encouraged to be around during the interview. Agriculture activities are managed by both male and female in a household. Standard seven was the dominant education level attained by large percent (67% to 75%) of respondents in all study locations. However, in Sumbawanga and Mbozi there were high percent of respondents with no formal education 24% and 20% respectively compare to other locations. Most farmers were married in all locations although in mbozi there were large percent of widow households (13%) compare to other locations. These results are likely possible due to reported higher prevalence of HIV/AIDS and malaria in Mbozi compare to other study locations. In addition, HIV/AIDS prevalence was reported higher among widowed compare to other marital status category (NBS 2012).

**Table 1: Characteristics of smallholder Farmers in surveyed communities**

| Parameter | Sumbawanga | Mvomero | Mbozi | Bariadi |
|---|---|---|---|---|
| **Number** | **63** | **50** | **86** | **101** |
| | **Percent** | **Percent** | **Percent** | **Percent** |
| **Age (Years)** | | | | |
| 14 - 29 | 19 | 18 | 8 | 7 |
| 30 - 44 | 35 | 40 | 40 | 52 |
| 45 - 64 | 38 | 36 | 38 | 33 |
| 65 and above | 8 | 6 | 14 | 8 |
| **Sex** | | | | |
| Female | 8 | 4 | 15 | 8 |
| Male | 92 | 96 | 85 | 92 |
| **Education Level** | | | | |
| No formal education | 24 | 12 | 20 | 9 |
| Standard Seven | 67 | 68 | 67 | 75 |
| Form four | 5 | 10 | 5 | 9 |
| Form six | 0 | 2 | 0 | 2 |
| College level/Others | 5 | 8 | 8 | 5 |
| **Marital status** | | | | |
| Married | 92 | 94 | 83 | 95 |
| Single | 3 | 2 | 2 | 1 |
| Divorced/Separated | 2 | 2 | 2 | 3 |
| Widow | 3 | 2 | 13 | 1 |

 

**3.2. Descriptive results indicating variation among non voucher and voucher beneficiary farmers**.

Voucher beneficiary households had less total land hectares 3.72 compare to non voucher beneficiary households who had 4.02 total land hectares (Table 2). Apart from land, voucher beneficiary households had less minute's walk 53.98 to the nearest subsidy procurement stockist compare to non voucher recipients who had more minutes walk 59.13.

Considering the household total asset value, voucher beneficiary households had more assets possession 755 682.90 Tsh than non voucher beneficiary household who had 279 859.10 Tsh assets possesion. Furthermore, statistics indicates differences in years of education where voucher beneficiary households had more years of education (7.09) than non voucher beneficiary households (6.33). Likewise voucher beneficiary households had more years of farming experience (23.11) and more number of household members (7.18) than non voucher beneficiary households 21.15 and 6.32 respectively. These statistics also suggests more aggregate agricultural productivity 658 121.80 Tsh/ha attained by voucher receiving households than non voucher recipients 505 032.70 Tsh/ha. However percapita expenditure in food consumption was low among voucher beneficiary households 87 740.60 Tsh than non voucher beneficiary households 94 979.20 Tsh.

**Table 2: Descriptive Statistics**

| Variable | Variable Description | Non beneficiaries (Voucher = 0) | | Beneficiaries (Voucher = 1) | |
|---|---|---|---|---|---|
| | | Mean | Std. Dev. | Mean | Std. Dev. |
| aaptshha09_11 | Aggregate agriculture Productivity (Tsh/ha) | 505032.70 | 409863.8000 | 658121.80 | 383019.7000 |
| percapitfexp | Percapita husehold expenditure in food consumption in Tsh | 94979.20 | 114682.0000 | 87740.60 | 93293.5000 |
| age | Age of household head in years | 43.91 | 13.9154 | 45.36 | 13.2330 |
| Education | Education level of household head in years | 6.33 | 4.0085 | 7.09 | 3.3109 |
| hhsize | Total number of household members | 6.32 | 2.9175 | 7.18 | 4.1816 |
| dur_liv | Length of residence in the village in years | 33.18 | 16.2123 | 34.97 | 14.5620 |
| Dur_farm | Farming experience in years | 21.15 | 13.4663 | 23.11 | 12.6766 |
| Totlandhectare | Owned land size in hectare | 4.03 | 6.7129 | 3.72 | 3.9177 |
| totasval | Total assets value in Tsh | 279859.10 | 502960.9000 | 755682.90 | 1572914.0000 |
| hhsizeabove5 | Number of people in household with age above 5years | 5.03 | 2.5749 | 5.53 | 2.5683 |
| Walkminutes | Time to the nearest stockist in minutes | 59.13 | 62.8283 | 53.98 | 43.8826 |

**3.3 Empirical results**

**3.3.1 Possible instruments and Houseman specification test**

Voucher impact on productivity and food security is suspected to encounter bias due to unobserved omitted variables. Three predicted instruments were tested; length of residence in the village, access to the village and total household assets entered in reduced form equation 2.3. Results was significant (P=0.02). This suggests that the instruments were not weak and predicted residual in equation 2.3 were entered in the structural equation 2.2 to test whether $Cov(x_1, \mu_i) \neq 0$. Housman specification test results in Table 3 confirms that the coefficient of residual in equation 2.2 is highly significant (p=0.00). This result implies that farmers were endogenously involved in the voucher scheme. If estimation is done in OLS may lead to omitted variable bias. Two stage least square (2SLS) is therefore a consistent model for estimation of impact of voucher on aggregate agricultural productivity in this study.

 

**Table 3: Housman specification test results**

| Source | SS | df | MS | Number of obs | = | 268.00 |
|---|---|---|---|---|---|---|
| | | | | F( 13, 254) | = | 535.09 |
| Model | 4.25E+13 | 13 | 3.27E+12 | Prob > F | = | 0.00 |
| Residual | 1.55E+12 | 254 | 6.12E+09 | R-squared | = | 0.96 |
| | | | | Adj R-squared | = | 0.96 |
| Total | 4.41E+13 | 267 | 1.65E+11 | Root MSE | = | 78209.00 |

| aaptshha0~11 (aggregate agric. productivity Tsh/ha) | Coef. | Std. Err. | t | P>t | [95% Conf. | |
|---|---|---|---|---|---|---|
| voucher (use=1, non use=0) | 124018.8000 | 10496.82 | 11.81 | 0.00 | 103346.90 | 144690.70 |
| sex (Male=1,Female=0) | 92219.3300 | 17601.29 | 5.24 | 0.00 | 57556.27 | 126882.40 |
| age | -87.4783 | 647.87 | -0.14 | 0.89 | -1363.36 | 1188.40 |
| educyears | 13126.5100 | 1525.40 | 8.61 | 0.00 | 10122.47 | 16130.55 |
| dur_farm | 1854.5220 | 698.12 | 2.66 | 0.01 | 479.69 | 3229.36 |
| association (member=1,non=0) | -12999.6400 | 10355.58 | -1.26 | 0.21 | -33393.39 | 7394.10 |
| walkminutes | -757.6910 | 97.89 | -7.74 | 0.00 | -950.47 | -564.91 |
| q136extens (access=1, non=0) | 55190.0300 | 11124.72 | 4.96 | 0.00 | 33281.60 | 77098.46 |
| q170borrow(borrowing=1,None=0) | 153646.1000 | 16305.10 | 9.42 | 0.00 | 121535.60 | 185756.50 |
| q45_normfa~w(fallowing=1, None=0) | -96245.3000 | 10265.94 | -9.38 | 0.00 | -116462.50 | -76028.11 |
| Anmanure(manure aplication=1,None=) | -8737.0370 | 10452.67 | -0.84 | 0.40 | -29321.97 | 11847.90 |
| q57_rows (rows planting=1,None=0) | -27435.6500 | 14500.86 | -1.89 | 0.06 | -55992.87 | 1121.58 |
| residue | 1.0000 | 0.01 | 79.71 | 0.00 | 0.98 | 1.02 |
| _cons | 439719.0000 | 31479.55 | 13.97 | 0.00 | 377724.80 | 501713.20 |

### 3.3.2 Treatment effect model results

#### 3.3.2.1 (a) Impact of voucher in aggregate agricultural productivity

Table 4 presents results of two stage regression model on impact of voucher in agricultural productivity. Hypothesis in treatment effect model is that correlation between error term in equation 2.2 and 2.3 is non zero "$Cov(x_1, \mu_i) \neq 0$". Violation of that assumption leads into bias estimation. The likelihood test against the $H_0$: rho=0 result is chi-square 11.48 (P= 0.00). This lead us to reject rho=0 at less than 5% significance level. We conclude that TSLS is the appropriate model as $Cov(x_1, \mu_i) \neq 0$ similar to Housman specification test results. Also, Wald test results are significant at $X^2$ =40.71 (P= 0.00).This reveals that at least one variable entered in the model except constant has coefficient different from zero. Since Wald test is used to gauge the goodness of fit of the model; we have confidence to conclude that the variables fit our model.

Following TSLS; vouchers that households receive are determined in equation 2.3 and predicted value used in equation 2.2 to determine the impact. Vouchers received by household depend on other variables including household assets, association membership, land holding, agronomical practices and time taken to the nearest input stockist. Results in Table 4 show that, total assets possession is positive and significant (P= 0.00). Households with more assets had more chance to receive voucher than households with poor assets. It is contrary to targeting criteria which was designed to encourage participation of smallholders and poor resource farmers (World Bank, 2009). This implies that input voucher was received by rich endowment households and less by vulnerable households as stipulated in the guidelines of NAIVS. This is possibly due to targeting criteria of cash top up. Households with more assets possession were in good position to afford cash top up where poor assets possessing households did not afford. According to World Bank (2009), the very poor households were not expected to meet the cash top up and require support through other intervention mechanisms such as public safety nets. Theoretically, the safety net programs are implemented through TASAF II additional financing in food insecure areas by providing cash or food through public works or other programs. However, it was not clear whether or not these programs exists and to what extent they serve the very poor households.

 

Membership to association was also positive and significant (P=0.02), consistent to existing literature where membership to association was reported to increase participation in agricultural extension programmes (Elias et al., 2013). Membership to association increases the chance of household to receive voucher. Membership to association is a social networking where people are likely to receive information on various development aspects. This is possible as was noted in Bariadi where farmers were given inputs if they are only in farmer groups. Although not statistically significant, borrowing reduces the household vouchers access. Probably households that are able to borrow can purchase the inputs at free market price without subsidy support from government. Land size was significant (P=0.01) and negatively related to voucher access. This result is consistent with the targeting criteria where eligible farmers are preferably those with less than one hectare of land holding (Pan and Christiaensen, 2012). Also voucher bnefficiary households are likely to intensify production by reducing the area under production. These findings are compatible to study by Chibwana *et al*. (2010) who founds that, households access to both improved maize seeds and fertilizer reduced pressure on forest clearing to 1.5 acres per household's expansion for agriculture production by intensifying the production of maize and tobacco. These findings have positive implication to environment especially under current climate changes. Agronomical practices considered were planting rows, land fallowing and use of manure. Manure application reduces voucher access although not statistically significant. Substitution effect is likely between use of manure and inorganic fertilizers (Kamara, 2004). However, normal fallowing increases the use of voucher access significantly (P=0.05). This is possible since farmers practicing normal fallowing reduces the land under production to allow land resting and are likely to remain with small land area under production. Such farmers are likely to intensify their production through use of improved production technologies such as fertilizer, high yielding seeds and pesticides. In addition planting in rows increases voucher access statistically significant (P=0.00). Although not statistically significant, time taken to nearest stockist reduces the vocher access. These findings are not suprising as access to makets has been reported to increase use of inputs (Kamara, 2004).

**3.3.2.1 (b) Impact of vouchers access on aggregate agricultural productivity**

Results for outcome equation 2.2 are also reported in Table 4. Access to voucher indicates positive and significant (P=0.00) contribution in aggregate agricultural productivity. Voucher beneficiary farmers have more aggregate agricultural productivity (604 587.50 Tsh) than non voucher beneficiaries. These findings imply that vouchers enable farmers to afford the use of fertilizers, high yielding seeds and pesticides in production. Bulk literature reports increased agricultural productivity achieved through use of improved production technologies (Gabagambi, 2003, Holden and Lunduka, 2010, Ogada et al., 2010). In Ghana 49% subsidy and established 400 fertilizer retail outlets increased the use of fertilizers by smallholder farmers. This was associated to the decrease in the number of people living under extreme poverty. In line with that, small scale farmers support for about seven years in Malawi increased staple food production attributing to the drop of under-five child death rates from 222 to 92 (Carr, 2013). These findings implication is that agricultural input subsidies contribute to improved welfare.

Apart from voucher, other social demographic variables that influence productivity were considered. Sex of respondent had an influence on household farm productivity where the male has more productivity than females although not statistically significant. Furthermore, educated households experience higher aggregate agricultural productivity than low educated households although not statistically significant. Trained smallholders are able to apply inputs more efficiently, increasing productivity (Seini et al., 2011). Contrarily, increase in the age of household head reduces aggregate agricultural although not statistically significant. This might be related to tendency of old farmers to stick in the technologies they are already familiar with and unwilling to accept new changes. Some studies have revealed more adoption of improved agriculture production technologies by young farmers than older farmers as they have risk taking behaviour (Simtowe et al., 2009).

Possibility of household to borrow reveals significant (P=0.05) and positive relationship to the aggregate agricultural productivity. Access to credit increases aggregate productivity by 178 737.10 Tsh keeping everything else constant. Credits facilitate farmers to purchase inputs such as fertilizers, high yielding seeds and pesticides if farmers are financially constrained. On the otherhand, membership to association was significant (P=0.09) and negatively related to agricultural productivity. These findings are incontrary to expected outcome, probably due poorly developed farmers networks.

Furthermore, land size indicates positive and significant (P=0.09) contribution to aggregate agricultural productivity. Increased productivity is also reported occur from land expansion (Akanda and Ito, 2008). These findings implication is that the changes in agricultural productivity in the country are also attributed to expansion of area under production. Surprisingly some agronomical practices such as normal fallowing and row planting were significant (P=0.00) and (P=0.03) respectively although was negatively related to aggregate agricultural productivity. These results are contrary to expectations as applications of improved technologies are expected to increase aggregate agricultural productivity. However, these practices might be poorly done by farmers in the study location. Row planting requires appropriate spacing, and violation may lead to inadequate plant

 

population. If spacing is very small it leads to competition for soil nutrients and light lowering the yield. On the other hand, too much spacing reduces plant population hence yield reduction. Poor agronomic practices are likely to happen in study location as farmers acces to extension service is still limited.

Interestingly, manure application shows positive relationship to aggregate agricultural productivity although not statistically significant. This results implies that; manure can supplement soil nutrients in crop production. However, bulky manure is required to meet soil nutrients requirement for efficient production. Most small holder farmers are not able to apply adequate rates of manure in large fields. Also several households treat manure as substitute rather than complementary (Holden and Lunduka, 2010).

Generally increased agricultural productivity has several pathways towards economic development (Haji, 2008). Increased productivity may lead to reduced real food prices and increased on-farm employment which creates increased demands for food. In addition it increases rural non-farm income multiplier effects contributing to poverty reduction (Schneider and Gugerty, 2011, Dorward, 2009). Doward (2009) reports empirical evidence on the role of input subsdies to development and poverty reduction in the initial stages of Green revolution in India. Increased agriculture productivity revealed in this study has positive implication to Tanzania economy.

**Table 4: Impact of voucher on aggregate agricultural productivity**

Log likelihood = -3975.5265, N=268, Wald $chi^2$=40.71, P=0.00

| | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| aaptshha0~11 | | | | | | |
| sex | 88084.1000 | 100058.80 | 0.88 | 0.38 | -108027.60 | 284195.80 |
| age | -1102.7790 | 2260.66 | -0.49 | 0.63 | -5533.60 | 3328.04 |
| edyears | 6872.1880 | 8712.87 | 0.79 | 0.43 | -10204.72 | 23949.10 |
| associatn | -105372.4000 | 62240.21 | -1.69 | 0.09 | -227361.00 | 16616.18 |
| walkminutes | -547.0478 | 555.66 | -0.98 | 0.33 | -1636.12 | 542.02 |
| q136extens | 76935.6300 | 63263.78 | 1.22 | 0.22 | -47059.10 | 200930.40 |
| q170borrow | 178737.1000 | 92522.23 | 1.93 | 0.05 | -2603.16 | 360077.30 |
| hhdhectare | 8922.1270 | 5263.59 | 1.70 | 0.09 | -1394.32 | 19238.57 |
| q45_normfa~w | -173605.5000 | 60590.35 | -2.87 | 0.00 | -292360.40 | -54850.58 |
| anmanure | 14980.0500 | 59290.20 | 0.25 | 0.80 | -101226.60 | 131186.70 |
| q57_rows | -189203.0000 | 89262.70 | -2.12 | 0.03 | -364154.70 | -14251.33 |
| land_own | -5156.2180 | 83510.40 | -0.06 | 0.95 | -168833.60 | 158521.20 |
| voucher | 604587.5000 | 117687.30 | 5.14 | 0.00 | 373924.70 | 835250.30 |
| _cons | 436858.4000 | 185593.10 | 2.35 | 0.02 | 73102.61 | 800614.10 |
| voucher | | | | | | |
| sex | -0.0936 | 0.29 | -0.32 | 0.75 | -0.67 | 0.48 |
| age | 0.0086 | 0.01 | 1.14 | 0.26 | -0.01 | 0.02 |
| edyears | 0.0045 | 0.03 | 0.17 | 0.87 | -0.05 | 0.06 |
| dur_liv | 0.0081 | 0.01 | 1.34 | 0.18 | 0.00 | 0.02 |
| totasval | 0.0000 | 0.00 | 4.51 | 0.00 | 0.00 | 0.00 |
| associatn | 0.4252 | 0.18 | 2.37 | 0.02 | 0.07 | 0.78 |
| walkminutes | -0.0018 | 0.00 | -1.08 | 0.28 | -0.01 | 0.00 |
| q136extens | -0.2322 | 0.19 | -1.23 | 0.22 | -0.60 | 0.14 |
| accesvill | 0.1785 | 0.15 | 1.21 | 0.23 | -0.11 | 0.47 |
| q170borrow | -0.0592 | 0.29 | -0.21 | 0.84 | -0.63 | 0.51 |
| hhdhectare | -0.0486 | 0.02 | -2.82 | 0.01 | -0.08 | -0.01 |
| q45_normfa~w | 0.3594 | 0.18 | 1.99 | 0.05 | 0.01 | 0.71 |
| anmanure | -0.0483 | 0.18 | -0.27 | 0.79 | -0.40 | 0.30 |
| q57_rows | 0.7655 | 0.25 | 3.06 | 0.00 | 0.28 | 1.26 |
| land_own | 0.0049 | 0.26 | 0.02 | 0.99 | -0.50 | 0.51 |
| _cons | -1.3415 | 0.57 | -2.35 | 0.02 | -2.46 | -0.22 |
| /athrho | -0.8451 | 0.21 | -4.01 | 0.00 | -1.26 | -0.43 |
| /lnsigma | 13.0018 | 0.07 | 179.52 | 0.00 | 12.86 | 13.14 |
| rho | -0.6885 | 0.11 | | | -0.85 | -0.41 |
| sigma | 443195.9000 | 32097.89 | | | 384546.20 | 510790.60 |
| lambda | -305133.6000 | 68171.29 | | | -438746.90 | -171520.30 |

LR test of indep. eqns. (rho = 0): chi2(1) = 11.48 Prob > chi2 = 0.0007

 

### 3.3.3 Impact of voucher on food security

#### 3.3.3.1 Differences in voucher access on food access

Whether or not there is a differences in number of meals per day between beneficiary and non beneficiary farmers revealed significant difference of P=0.05 (Table 5). Households with access to voucher were leading in number of three meals per day by 70% during off season. Contrarily non beneficiary households were leading in one number of meal per day by 56% during off seaon. Interestingly, there were no significant differences in number of meals between voucher beneficiary and non beneficiary households at harvest. These findings implies that farmers with access to voucher are likely to harvest more crop yields and store for use in off seoson. It is also possible that beneficiary farmers have more income acquired from sale of surplus yield and were able to access food all the time. In such situation non beneficiary households were likely to encounter under nutrition problems, especially stunted growth in children and anaemia in women. Its possible that number of more meals taken per day may contributes to reduction of malnutrition problems. However, the extent of changes in starvation attributed to voucher access are uncertain and need more research.

**Table 5 Percent response on number of meals per day at household**

| | Number of meals per day during off- season | | | Number of meals per day at harvest | | |
|---|---|---|---|---|---|---|
| | Non voucher beneficiary farmers | Voucher beneficiary farmers | Total | Non voucher beneficiary farmers | Voucher beneficiary farmers | Total |
| 1 | 19(56) | 15(44) | 34(100) | 2(50) | 2(50) | 4(100) |
| 2 | 95(45) | 118(55) | 213(100) | 94(47) | 107(53) | 201(100) |
| 3 | 14(30) | 33(70) | 47(100) | 32(36) | 57(64) | 89(100) |
| Total | 128(43) | 166(57) | 294(100) | 128(43) | 166(57) | 294(100) |
| | $X^2$(2,N=294)=5.82, P=0.05 | | | $X^2$(2,N=294)=3.03, P=0.22 | | |

Note: Number in the parenthesis is in percentages.

#### 3.3.3.2 Changes in household food consumption situation

Response on food consumption situation at household shows that, majority of voucher beneficiary households (89%) had adequate food consumption after the programme (Table 6). Also response on food adequacy was higher for voucher beneficiary households in almost all categories except “do not know” (39%). Contrarily; majority (61%) of non voucher beneficiary farmers were not sure of the food adequacy. These findings implies that, voucher beneficiary farmers had noted clear differences in food consumption situation and had sufficient food after the programme. On the other hand, beneficiary famers likely, wealth farmers who could manage to aquire adequate food regardless of the voucher access. Voucher access has contribution to food security among smallholder farmers and net food perchasers. Even when non voucher beneficiary farmers were uncertain on food consumption adequacy, there was different indirect ways the population benefited from the programme. Use of voucher may lead to more labor demand for crop management and post harvest value chain operations. Potential employment opportunities increase earnings important for food security. Food secured population has energy that can be employed in other productive works overcoming the nutrition poverty trap undermining poor farmers.

**Table 6: Food consumption situation at household before and after introduction of NAIVS**

| | Non voucher beneficiary farmers | Voucher beneficiary farmers | Total |
|---|---|---|---|
| Food was adequate before the programme | 12(41) | 17(59) | 29(100) |
| Food is adequate after the programme | 13(11) | 106(89) | 119(100) |
| No changes before and after the programme | 17(38) | 28(62) | 45(100) |
| Do not know | 20(61) | 13(39) | 33(100) |
| Total | 62(27) | 164(73) | 226(100) |

$X^2$(3,N=226)=39.79, P=0.00 Note: Number in the parenthesis is in percentages.

#### 3.3.3.3 Imput voucher access and impact on food security

Results Table 7 shows that; voucher access contributed significantly (P=0.00) to the prediction of food insecurity where households with voucher access had 43 percent less chance to suffer food insecurity. Also, access to village and land ownership contributed to prediction of food insecurity significantly at P=0.09 and P=0.00 respectively. Access to village reduced the chances of food insecurity at household by 64%, whereas land ownership reduced the chances to suffer food security by 33%. On the other hand, unpredictable weather

 

increased the chances 1.96 times of of household to suffer food security significantly (P=0.01). These findings implies that the program has positive contribution to food security. However, social and environmental factors were also important for food security.

**Table 7: Logistic regression model results on imput voucher access impact on food security**

| Dependent variable =1 if household experienced food insecurity in last 12 months | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Voucher (voucher access =1) | -.84 | .26 | 10.31 | 1.00 | .00 | .43 |
| Unpdctable weather (unpr. Weather=1) | .67 | .26 | 6.71 | 1.00 | .01 | 1.96 |
| cropestdis | .53 | .40 | 1.76 | 1.00 | .18 | 1.71 |
| Accesible village (access=1) | -.44 | .26 | 2.88 | 1.00 | .09 | .64 |
| Land ownership (land own=1) | -1.12 | .40 | 7.94 | 1.00 | .00 | .33 |

## 4.0 Conclusion and recommendations

NAIVS has increased productivity and food security of smallholder farmers. Beneficiary households seem to have more income and are more food secure than non beneficiaries. Other factors that were found to contribute to productivity were land holding, extension service and availability of credits to farmers. Also accessible roads contributed both to voucher availability and aggregate productivity. Accessible villages had more chances to receive inputs than inaccessible villages. Conversely increase in time taken from homestead to nearest voucher procurement stockists reduced the chances of household to receive vouchers. Access to input voucher was influenced by household wealth assets possession, membership to association and land fallowing practices. Nevertheless increase in land size and borrowing ability negatively influenced household input voucher access. On the other hand, social and environmental factors influenced food security.

It's therefore recommended that, the government should promote subsidy as it increases productivity. However, it is important to revise the targeting criteria especially on top up contribution. Assets poor households seem not able to afford top up contribution. Targeting criteria should be categorized such that farmers who are not able to contribute the top up are provided with free voucher that covers the whole cost of inputs. Alternatively there should be alternative arrangements of lending the vouchers to farmers who are not able to afford the cash top up where they repay the money after harvest. Ability of household to borrow reduced the household access to voucher although it contributed to increase in productivity. Its recommended to strengthen both formal and informal credit institutions in the rural areas to ensure farmers access to credits. Additionally infrastructure should be improved as it has influence on access to improved production technologies which improves aggregate agricultural productivity. Government should support research activities to improve crop cultivars for mitigation of adverse environmental factors on crop production. Extension service should be strengthened to build farmers capacity so that they are able to apply recommended farm production technologies appropriately. Also farmers should be encouraged to use manure as soil nutrient supplementary option where possible.

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