AN ECONOMETRIC ANALYSIS OF THE LINK BETWEEN ACCESS TO AGRICULTURAL EXTENSION SERVICES, ADOPTION OF AGRICULTURAL TECHNOLOGY AND POVERTY: EVIDENCE FOR UGANDA

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Abstract

Overall, the study investigated the impact of access to and adoption of extension services and agricultural technology in reducing poverty in Uganda. To meet this objective, the researcher analysed the relationship between poverty and access to agricultural extension services and adoption of agricultural technology. A bivariate and multivariate approach was employed to determine whether access to and adoption of agricultural technology are significant factors in influencing the household poverty in Uganda. The results revealed that there is a significant but weak, relationship between poverty and access to agricultural extension and adoption of agricultural technology, and that poor households have the least access to agricultural extension services and low adoption of agricultural technology. The simulation results showed that improving access to agricultural extension and adoption of agricultural technology result into reduction in probability of being poor. Furthermore, on average access to extension services and adoption of agricultural technology is still very poor among the poor and non-poor Ugandans. High on the priority agenda should be concerted efforts to intensify accessibility to agricultural extension services and adoption of agricultural technology.

1.0 Background

The importance of agriculture in rural development is widely acknowledged, particularly in developing countries where the majority of the population lives in rural areas. The economies of developing countries continue to be dominated by the agricultural sector (Kalyebara, 1999). In Uganda, agriculture is, and will for a long time continue to be the backbone of the economy. It accounts for 21 percent of the real GDP, 60 percent of export earnings and 80 percent of rural employment (BOU 2004). Of the population of over 27 million people (MOFPED, 2004), 85 percent live in the rural areas and mainly depend on agriculture for their livelihood. Agriculture output comes almost exclusively from the approximately 3 million rural small holders. Poverty is overwhelmingly concentrated in rural areas. According to the PEAP, 2004, declines in agricultural incomes fuelled a three percent increase in income poverty and hence widened inequality between 2000 and 2003. To this effect, many efforts have been made to improve the performance of the Agricultural sector, in Uganda. For example, Uganda's past and current medium term plan has been focused on modernizing agriculture as an engine for economic growth and poverty eradication. One area of intervention by government is agricultural extension and technologies aimed at improving productivity in farm and non-farm activities in a bid to reduce poverty.

The Plan for Modernization of Agriculture (PMA), whose overall objective is to enhance production, competitiveness and incomes, has an ambitious agenda of policy and institutional reform across seven pillars and one of these pillars is to improve the delivery of agricultural extension through the new National Agricultural Advisory Services (NAADS) program (Benin *et al,* 2007). The major features of the NAADS program approach include private delivery of extension services with public financing, it is demand driven and farmer-owned; it is decentralized services; and involves poverty and gender targeting (Mutimba, Mangheni and Matsiko, 2007).

The rationale of recent reorganization of extension service provision arrangements was failure of traditional extension approaches to bring about greater productivity and expansion of agriculture, despite costly government interventions (MAAIF 2000; Mangheni and Mubangizi, 2007). The shift towards greater private sector participation in the provision of extension services is also attributed to the perceived ineffectiveness, irrelevancy and irresponsiveness of public extension and budgetary constraints (Mangheni and Mubangaizi, 2007). Therefore, the publicly financed privately delivered extension system was adopted in Uganda to rectify past weaknesses related to rising concerns of efficiency of government-led extension such as the inability of the central government to handle the complexity of context-specificity required by extension services and the inability of the government to finance the requisite range of services as well as incorporate "best" practices in order to make extension delivery more efficient and effective (PMA 2000).

The philosophical underpinning for the NAADS design is the need to empower farmers. It is grounded into the overarching government policy of decentralization (Ministry of Agriculture, Animal Industry and Fisheries, 2000). Although, Uganda began decentralizing government services in 1992, provision of agricultural extension and other agricultural support services became the responsibility of local governments in 1997, as per the Local Government (LG) Act (Benin *et al,* 2007). According to the provisions of the Local Government Act, 1997, local government have responsibility for liaison with the Central Government, district level policy issues, planning, coordination, monitoring and implementation of development programmes including those for agricultural extension

NAADS was initiated in 2001 in six trailblazing districts (Arua, Kabale, Kibaale, Mukono, Soroti and Tororo), within which the NAADS program began working in 24 sub-counties. NAADS rolled out in 2002/03 into ten new districts (Bushenyi, Busia, Iganga, Kabarole, Kapchorwa, Kitgum, Lira, Luwero, Mbarara and Wakiso), in which it covered 46 sub-counties; it also expanded to 54 additional sub-counties in the trailblazing districts. In 2003/2004 to 2004/2005, NAADS expanded into 13 new districts (Hoima, Kamuli, Mbale, Nakapiripit, Rakai, Apac, Kanungu, Kumi, Masaka, Moyo, 3 Rukungiri, Yumbe and Bugiri), bringing NAADS coverage to a total of 29 districts and 280 sub-counties (Benin *et al,* 2007).

During the last decade the country has witnessed modest increases in agricultural production mainly as result of increase in production area and to a limited extent, use of improved technology. However, these increases have not resulted into increased profitability of agricultural production and household incomes. This has been primarily due to low adoption of existing technologies (Nsibambi, 1995; Benin *et al*, 2007). Statistics from 2002 National Population and Housing Census showed that Uganda's population of 24 million remained largely poor, with at least 40 percent of the people living in poverty. In addition, many of the rural poor still remain outside the monetary economy, mainly producing for subsistence. However, recent poverty estimates show that poverty levels dropped from 38 percent in 2002/2003 to 31 percent in 2005/2006. The results also indicate that the decline in income poverty was highest in the rural areas (8.5 % points) compared to urban areas (0.7 % points) (UBOS, 2005/06). While the results indicate that substantial growth in consumption among the rural population partly explains the significant reduction in poverty, the same report points out the need to investigate factors that explain the decline in poverty. This study thus comes in to examine whether agricultural extension services have been accessed by the targeted population (active poor) and whether access to agricultural extension services and adoption of agricultural technology has contributed to poverty reduction in Uganda. The spur for extension and agricultural technology hinges on the fact that extension services and agricultural technology constitute a substantial portion of the Plan for Modernization of Agriculture (PMA) strategy for achieving Pillar II of the Poverty Eradication Action Plan (PEAP).

1.1 Statement of the Problem

There has been a longstanding interest in understanding the relationship between agricultural technology adoption, productivity and poverty reduction (Minten & Barret, 2006). Nevertheless, in recent years many developing countries have reaffirmed the essential role that agricultural extension can play in agricultural development (Birner and Anderson, 2007). This renewed interest in extension is linked to the discovery of the role that agriculture needs to play in reducing persistent poverty (World Bank, 2007b; Birner and Anderson, 2007). The quantitative evidence on this crucial and longstanding matter is especially – and surprisingly – emaciated for Sub-Saharan Africa, often due to lack of reliable data. In Uganda, the enigma to both researchers and policy makers alike is that despite the availability of a backlog of improved agricultural technologies and extension services developed or made available to farmers by government, agricultural production in Uganda is still being undertaken using rudimentary technologies. Productivity in farm and non-farm activities has remained very low and, as a result, poverty in the country has continued to be a rural phenomenon (Sserunkuuma, 1999). Therefore, the most outstanding questions that need redress among policy makers and researchers are; whether there is significant impact of agricultural technologies and extension services developed so far and whether poor farmers in Uganda are able to access to agricultural extension services and adoption of agricultural technology

1.2 General objective of the study

The overall objective of the study was to investigate the impact of access to agricultural extension services and adoption of agricultural technology on poverty reduction in Uganda.

1.3 Specific objectives

i. To examine the proportion of the poor and non-poor who accessed agricultural extension services and adopted agricultural technology and those who did not.

ii. To assess the extent to which access to agricultural extension services and adoption of agricultural technology affects the wellbeing of Ugandans.

1.4 Hypothesis

(i) The majority of the poor did not access agricultural extension services.

(ii) The majority of the poor did not adopt agricultural technology.

(iii) There is no relationship between poverty status and access to agricultural extension services and adoption of agricultural technology.

1.5 Significance of the Study

This study was carried out with the objective of investigating the impact of access to agricultural extension services and adoption of agricultural technology on poverty reduction in Uganda. The findings of this study will be useful for policy makers in designing appropriate policies and strategies that would make agricultural technology and extension services provision more efficient and relevant. It is also envisaged that the findings of the study will be relevant to agricultural stakeholders' particularly local governments, farmer groups, advisory service providers, donors and others in efforts to scale up access to agricultural extension and adoption of agricultural technology in Uganda.

In addition, knowledge about poverty in Uganda has been broadened and enriched in the last decade. The Uganda Bureau of Statistics and various researchers, both public and private bodies have carried out numerous surveys and comparative studies on the scale of poverty and its forms. The measurement of poverty extent and depth are the basic stages of the study on poverty. However, it does not exhaust all aspects of poverty. The determination of factors influencing poverty is a very important issue in understanding poverty better. It can recognize mechanisms of appearance of poverty and it can help create proper policy response. Thus the study is expected to contribute to debate on poverty and agricultural investments in Uganda to better respond to the real challenges of reducing poverty.

2.0 Empirical Evidence

2.1 The link between Agricultural Technology, extension and Poverty

From the global point of view, poverty is essentially rural. Approximately 75 percent of the world's poor reside in rural areas. This proportion is not expected to fall below 50 percent by 2035 (Ravallion, 2002). Therefore, during the recent decades, a wide array of studies and researches have been undertaken to understand the root causes of poverty in developing countries. The results of these studies indicate that the poverty problem in developing countries is complex and multidimensional and is a result of a myriad of interactions between resources, technologies, institutions, strategies and actions and others (World Development Report, 2000/2001). It is now well understood that poverty in most developing countries is a result of lack of resources, information, appropriate institutions and inappropriate domestic and unfair international policies. In particular, poverty in most developing countries is largely a result of low agricultural productivity arising from very low utilization of modern inputs and technology (Nsibambi, 1995).

Empirical evidence shows that countries such as East Asia and Pacific, North Africa and Middle East have succeeded in reducing poverty because they have adopted modern agricultural technologies. It is noted that the greatest proportion of cultivated areas in these countries practice irrigation and have for instance experienced declining poverty rates (Federe & Gemechu, 2006).

Literature reveals that modernized agricultural production substantially raises crop production and household incomes where development efforts are demand driven. It has been shown that an agriculture-led development, besides contributing to strengthening food security, also increases income of the rural poor which in turn provides a natural and enlarged market for consumer goods, agro-based industries and opportunities for agricultural and manufactured exports. There are no doubts agricultural modern practices such as adoption of new technologies help people feed themselves, stimulate non-agricultural growth and lead to development of new products. Self reliance in terms of food security for a given population is directly proportionate to the ability to produce more food for own consumption, or the ability to generate additional income that determines the purchasing power for food. The role of agricultural transformation, that enhances people's ability to produce more food, is inextricably linked to the improvement in food security.

For example, farm households that use irrigation as one of the major agricultural practices that have been embraced in Asia and Pacific and North Africa and Middle East, will experience lower variability of yield (reduced climate risk), output and employment compared to those that depend on rainfall (Javier, 2001). Comparison of irrigated versus non-irrigated areas indicate that crop productivity and output tend to be much higher in irrigated systems than the non-irrigated and rain-feed areas (Datt and Ravallion 1998).

When do increased adoption of improved agricultural production technologies and higher crop yields benefit the poor? This has been one of the overwhelming questions amongst researchers. The answer to this question obviously depends on who is poor. First, there are poor farmers who have enough land and livestock that they do not need to depend on off-farm employment for income and who enjoy a net marketable surplus of food. Their incomes depend heavily upon their productivity and the price their produce fetches in the market. While net surplus farmers are not often the poorest members of rural African communities, they nonetheless often fall well below national poverty lines (Minten & Barret, 2006).

The second group is the net buyers. This sub-population includes farmers who do not produce enough to cover their own household's consumption requirements. Empirical evidence suggests that a significant fraction of farmers in low-income countries, are net buyers of the crops they produce (Barrett and Dorosh, 1996).

The third group is the unskilled workers who earn part or all of their income from wages. Unskilled labor is the dominant source of non farm income for the poorest African farmers, who commonly earn a significant share of their total income from off-farm labor, commonly in the fields of larger farmers (Barrett et al., 2001).

Poor farmers will obtain own-farm benefits from new technologies only if they adopt them. This means that the new technologies must be appropriate and profitable for farming conditions and those poor farmers must have access to the knowledge and inputs necessary to adopt the technology. In principle, improved crop varieties are scale-neutral and can be adopted by farms of all sizes, but the same is not always true of other technologies or of complementary inputs like irrigation and machines, and access to fertilizers and credit. If institutions that provide these services and inputs are biased in favor of large farms, the poor may not be able to adopt new technologies (Javier, 2001).

Farmers who adopt new technologies often succeed in lowering their production costs per unit of output (though not usually per hectare), and therefore can better compete in the market. Moreover, if the technology is widely adopted and market prices fall as a result, the decline in unit cost may be essential for maintaining farm income. In this case, farmers who do not adopt the technology will be disadvantaged not only by stagnant production but also by declining prices and tighter profit margins. This profit squeeze can be detrimental to non-adopters within technology-adopting regions and to farmers who live in regions that are inappropriate for the new technology.

Even when poor farmers benefit from significant productivity gains, these benefits are not always shared equitably among household members. In many societies, men and women have responsibility for growing different crops. Therefore, which crops benefit from technological change determines who controls the increased production within the household. Technological change for women's food crops may translate into better nutrition and well-being for women and children than technological change for men's cash crops. The initial experience with the Green Revolution in Asia stimulated a large body of empirical literature on how agricultural technological change affects poor farmers. While, critics of the Green Revolution argued that it led to an increase in inequality of income and asset distribution and worsening of absolute poverty (see Griffin 1974; Frankel 1976; Farmer 1977; ILO 1977) and a spate of household studies conducted soon after the release of Green Revolution technologies lent some support to this early criticism, more recent evidence, shows mixed outcomes (see Minten & Barret, 2006 for more references).

There is no doubt small farmers lagged behind large farmers in adopting Green Revolution technologies but those small-scale farmers who adopted benefited much from increased production, greater employment opportunities, and higher wages in the agricultural and non-farm sectors. Moreover, most small farmers were able to hold onto their land and captured significant total production increases from their holdings (Rosegrant and Hazell 2000). In some cases, small farmers and landless laborers actually ended up gaining proportionally more income than larger farmers, with a net improvement in the distribution of village income (Hazell and Ramasamy, 1991).

Notwithstanding the above, the focus of all agricultural extension endeavours is the transfer of agricultural information to enhance the productive capacity of farmers. Extension also serves as the link among farmers, in order to transfer best practices from one farmer to another, and as a channel to introduce and sometimes enforce agricultural policies (Srivastava and Jaffe, 1992). Agricultural extension economic impact studies have shown a positive effect of extension on technology adoption, farm productivity and farm profits hence poverty reduction (Foti, Nyakudya, Moyo, and Chikuvire, 2002).

Governments have traditionally taken a dominant role in the provision of agricultural extension services because of the important contribution of extension to agricultural development. However, the escalating fiscal deficits in many developing countries and, in several cases problems of poor governance of public programs over the last decade have increasingly redirected attention towards how to make extension more cost-effective and appropriate to farmers' needs. At the same time, this has generated increased attention towards the potential for the privatization of agricultural extension services. To a large extent, this is spurred by the strong global trend towards market liberalization and reinforced by the transition from planned to market economies (Foti *et al*, 2002; Birner and Anderson, 2007).

In many first and third world countries, significant changes are occurring in suppliers and level of provisioning of extension. For instance, government policy on whether or not it should provide extension, what type of extension should be provided, who should pay, and how extension should be provided plays a critical role in determining the nature and extent of extension provisioning in any particular country, developing or developed. Old aims for extension provision are disappearing, and new models are now emerging (Birner and Anderson, 2007).

3.0 Methodology

While the profiles of poverty in Uganda are a useful way of summarizing information on the levels and location of poverty and on the characteristics of the poor, they are essentially cross tabulations and no matter how imaginative their uses (see, (Gibson and Rozelle, 2002)), they are restricted in the number of dimensions that can be varied at one time (e.g., poverty rates broken down by region of residence and economic activity of the household head). To answer questions about the effect of a particular variable, conditional on the many other potential determinants of poverty, requires multivariate analysis. In particular, multivariate analysis may help show whether geographical pockets of poverty exist just because people with poor endowments cluster together (Gibson and Rozelle, 2002).

In poverty studies, the use of probability models is conceptually preferable to conventional linear regression models because parameter estimates from the former overcome most weaknesses of linear regression models, namely: they provide parameter estimates which are asymptotically consistent, and efficient. The empirical strategy to assess the extent to which access to agricultural extension services and adoption of agricultural technology affects the wellbeing of Ugandans starts with an econometric model. In this regard, econometric models of the determinants of poverty, where key variables to capture access to agricultural extension services and adoption of agricultural technology, they were entered explicitly as an argument in the model.

The standard approach in the multivariate analysis of poverty is to classify households as poor and non-poor based on consumption per capita. Denoting the i^{th} household's per capita expenditure by C_i, then a household is classified as poor if the i^{th} household's C_i is less than the poverty line (Z). Accordingly, a binary variable is constructed to classify households as poor and non-poor.

Given this type of dependent variable, some type of logit or probit function may be the most appropriate technique of analysis. Since the cumulative normal and logistic distributions are very close to each other except at the tails, we are not likely to get very different results using the probit model or the logit model, unless the samples are large (Maddala, 2002). In this study a probit method is applied. The probit estimation assumes the following functional forms:

$$pr\left(h_i = 1 \middle| X\right) = \Phi\left(X_i \beta\right) \quad \text{.........} (1)$$

where Φ is the standard cumulative normal distribution function, X is a matrix of explanatory variables such as agricultural technology and market-related variables and other determinants of consumption, and β is a vector of parameters to be estimated. Usually interest is not centered on the coefficient vector β but on the 'probability derivatives' which can be obtained from β and show the changes in the risk of poverty as the explanatory variables change (Gibson and Rozelle, 2002).

More specifically, the probit modeling is used for explaining a dichotomous dependent variable with the empirical specification formulated in terms of latent response variable (Maddala, 2000; Damisa, Samndi and Yohanna, 2007). Defining Y_i as dependent variable then $Y_{i\ is}$ a function of demographic characteristics, human capital variables, farm characteristics and technology-related variables such as agricultural technology adoption: Y_i =1 for non-poor and Y_i = 0 for poor. In a more explicit form, the probit analysis model assumes that there is an underlying response variable Y_i^* defined by the regression relationship expressed as:

$$Y_i^* = \beta_0 + \sum_{K=1}^{K} \beta_i X_{Ki} + \varepsilon_i \quad \text{.........} (2)$$

$$E\left(\bar{X}\right) = 0 \quad E(\varepsilon) = 0 \quad Var\left(\bar{X}\right) = 1 \quad Var(\varepsilon) = 1$$

Where Y^* is the latent or unobservable variable. The observable variable is a dummy representing poverty status. Y=1 if Y^* >0 and Y=0 otherwise. I is the household, X_{ki} : K=1 through k independent variables explaining the phenomenon of the household , I, β_i is the parameter that explains the effect of X_i on Y^*_i ; β_0 is the intercept that shows the expected value of Y^* when all X_k have a value of zero ε_i is the stochastic error term for household I, E = expected value and Var = variance, $\bar{X}$ = the mean of X. As such $Y^*_I \sim N(0, 1)$

3.1 Model Specification

A wide range of variables measuring the potential determinants of poverty were obtained from the Uganda National Household Survey 2005-06 and these are described under the following headings: demographics, education, employment and occupations, farm characteristics, access to extension and adoption agricultural technology, geo-climatic characteristics, and regional fixed effects. Variables that directly contribute to the construction of the dependent variable were ruled out as regressors because of the spurious relationships that may be obtained. Thus the key selection criterion for these variables was *exogeneity*.

Demographics: A linear and quadratic term in household size and gender of household head, plus linear and quadratic terms in the age of the household head are included. The quadratic term of the household size squared and age of household squared were included to capture nonlinear relationships between household size, age of household and welfare.

Education: the mean years of education for those household members over the age of 15 and a binary variable for whether the household head is literate or not are used. Although correlated, something is gained by specifying these two variables separately. Literacy is a basic functioning, which may help raise living standards even of those with little connection to the market economy (e.g., semi-subsistence farmers reading food crop extension bulletins) while years of schooling may matter both for human capital and screening reasons. Moreover, informal teaching may allow literacy to improve even without raising average years of schooling, so it is interesting to separate the two variables for policy simulations (Gibson and Rozelle, 2002).

Employment and occupation: four variables were used to capture employment and occupation of the households. These included the (i) number of household members employed in primary industry (Primary industry includes agriculture, fishing, mining, quarrying), (ii) the number of household employed in secondary industry (Secondary industry include manufacturing, electricity/water, construction), (iii)number of household members employed in tertiary industry (Tertiary includes wholesale/retail business and financial services)and (iv)dummy variable of whether a household member is engaged in formal wage employment or not(any member is defined as being engaged in formal employment if she or he has a professional, technical, administrative, managerial, clerical, sales, or service occupation as a main activity).

Farm characteristics: these included the mean size of landholding of the household, a dummy for tenure type and the number of plots. The number of plots was used as proxy for the degree of crop diversification.

Access to agricultural extension services and adoption of agricultural technology: with regard to extension access two variables were considered: one a dummy whether a household had been visited by an extension worker during the past 12 months and two a dummy whether any member of the household participated in a training program organized by NAADS. For adoption of agricultural technology, a household was considered to have adopted agricultural technology if at least one type of agricultural technology was used: Crop production and marketing and animal disease production practices.

Agro eco-zones and regional dummies

In our model we also control for agro-ecological and regional fixed effects. These are the effects on household welfare which result from the location-specific endowment of an area in terms of, among others, soil fertility, climate, access to natural resources, and degree of market access. Agro-ecological factors such as good soil fertility and climate determine the productivity of the land and, therefore, the level of living standards in rural areas. It is likely that household welfare will be affected positively if the household is situated in a locale that is favorably endowed agro-ecologically.

Agro-eco zones were employed in the model for two reasons: One, to control for the effects of agro-eco zone characteristics on household welfare. This was done to allow the analysis of the effects of the other determinants on household welfare independent of the effect of the agro-eco zone location of the household. Two, to control for observed and unobserved determinants of living standards since the inclusion of the agro-eco zone dummies in the regression equation allows us to capture the effects of omitted variables (as well as other unobservable factors) that vary systematically between the agro-eco zones(Gibson and Rozelle, 2001).

To judge the validity of doing this, the researcher tested for the joint significance of agro-eco zone fixed effects. The test confirms that the coefficients in our regression model for the agro-eco zone variables jointly are significantly different from zero. Consequently, nine agro-eco-zone dummy variables were included in the model to control for agro-eco zone specific effects on household welfare levels**.**

Four regional dummies were included to control spatial effects and rural-urban dummies.

3.2 Estimation

The survey data had one serious problem which compromised both the quality and the scope of the analysis. All the explanatory variables considered had missing observations. This data quality consideration raised one model estimation issue. The subset of households with no missing data for any of the exogenous variables selected for inclusion in the model decreased in size as the number of these variables increased. In order to retain as large a number of households in the analytical data set as possible, this problem was solved by including all the missing data. Dummy variables were constructed corresponding to each of the variables with missing data. These variables took a value of one if the household was missing data for that particular variable, zero otherwise.

3.3 Data Sources and Analysis

Data used in this study was obtained from Uganda Bureau of Statistics. The particular data set used was the recent Uganda National Household Survey 2005/06 that covered all districts of the country and had questions on access to extension services and access to and demand for agricultural technology. The UNHS 2005/06 was undertaken from May 2005 to April 2006 and covered 7,400 households scientifically selected.

The UNHS 2005/06 data has been analyzed to estimate poverty statistics based on household consumption per Adult equivalent with absolute poverty line of approximately “one dollar a day” used internationally. Given the above, the data set was appropriate to investigate whether access and adoption of agricultural technology and extension services is one of the explanation of poverty reduction the country has witnessed.

In addition, the survey provides data on a wide spectrum of socio-economic variables including household composition and structure, education, use of modern technology, land ownership and parcel characteristics, household assets, employment and income, consumption expenditure (both food and non-food), health status and other welfare indicators.

Data gathered for this study was subjected to both detailed descriptive and statistical analyses. Statistical tests were carried out to confirm the difference between various categories of households. Descriptive statistical summaries are assembled for the variables of the study. The analysis was conducted to examine the proportion of the poor and non-poor who accessed extension and agricultural technology services and those who did not. The multivariate analysis involved the estimation of model specified above. The variables used in this model and descriptive statistical summaries (mean standard deviation, minimum, maximum) are illustrated in the appendix 1.

4.0 Results

To illustrate the linkage between poverty and access to agricultural extension and adoption of agricultural technology, Table 1 demonstrates the relationship between poverty, access to agricultural extension services and adoption of agricultural technology. Pearson Chi square results revealed that access to agricultural extension services represented whether a member of the household had been visited by an extension worker during the past 12 months (Extension) and whether any member of the household participated in a training program organized by NAADS (Naads_trng); and adoption to agricultural technology were all statistically significant at 5 percent level of significance.

Table 1: Relationship between poverty and access to agricultural extension and adoption of agricultural technology

Variables	n	Poor	Non-Poor	Pearson Chi –square	P-value
Extension	5657				
Yes		70 (1.2%)	359 (6.4%)	45.6524	0.000
No		1,669 (29.5%)	3,559 (62.9%)		
NAADS training	5657				
Yes		89(1.6%)	419(7.4%)	46.0912	0.000
No		1,650(29.2%)	3,499(61.9%)		
Adoption of technology	5657				
Adopters		582 (10.3%)	1,842 (32.6%)	90.2842	0.000
Non-adopters		1,157 (20.5%)	2,076 (36.7%)		

The effect of access to agricultural extension services and adoption of agricultural technology on poverty can most clearly be illustrated by the marked differences in access to agricultural extension and adoption of agricultural technology among poverty groups.

Table 2: Percentage distribution of access to agricultural extensions services and poverty status

Poverty Status	Extension		Total
	No	Yes	
Non-poor	3,559 (62.9%)	359 (6.4%)	3,918 (69.3%)
Poor	1,669 (29.5%)	70 (1.2%)	1,739 (30.7%)
Total	**5,228 (92.4%)**	**429 (7.6%)**	**5657 (100.0)**

Table 3: Percentage distribution of access to agricultural extensions services and poverty status

Poverty Status	Naads_trng		Total
	No	**Yes**	
Non-poor	3,499 (61.9%)	419 (7.4%)	3,918 (69.3%)
Poor	1,650 (29.2%)	89 (1.6%)	1,739 (30.7%)
Total	**5,149 (91.02%)**	**508 (9%)**	**5657 (100.0)**

Tables 2 and 3 show that more non-poor households were visited by an extension worker (6.4%) as compared to slightly above 1 percent of the poor households. Regarding participation in training program organized by NAADs, the non-poor households were over 7 percent compared to 1.6 percent of the poor households. These results also revealed that very few households both for the poor and non-poor who had accessed agricultural extension. That is to say more than 90 percent of households in the survey had not been visited by an extension worker or had participated in training programs organized by NAADs.

Table 4: Percentage distribution of adoption of agricultural technology and poverty status

Poverty Status	Adoption		Total
	Non-adopters	**Adopters**	
Non-poor	2,076 (36.7%)	1,842 (32.6%)	3,918 (69.3%)
Poor	1,157 (20.5%)	582 (10.3%)	1,739 (30.7%)
Total	**3,233 (57.2%)**	**2,424 (42.9%)**	**5657 (100.0)**

The results in table 4 reveal that more of the non-poor households had adopted at least an agricultural technology (32.6%) compared to slightly above 10 percent of the poor households who had adopted. When compared with access to agricultural extension, the results revealed marked difference between adoption of agriculture technology and access to agricultural extension services.

A simple regression of poverty status against extension demonstrates that poverty status is negatively correlated with whether a household had been visited by an extension worker or not {Appendix 2}. A 100 percent increase in number of households that are visited by an extension worker reduces the probability of being poor by more than 15.6 percent. This suggests that measures that improve the access of households to agricultural extension workers could be an important aspect of poverty alleviation in Uganda. Other two regressions were estimated for naads_trng and adoption {see appendix 3 and 4}. The results reveals that household participation in training programs organized by NAADs reduces the probability of being poor by more than 14.6 percent for a 100 percent increase in number of households who participate in training programs. The results also reveals that increase in household participation in training programs by NAADs less than reduces the probability of being poor when compared with increasing the number of households to be visited by the extension worker. Evidence shows that NAADS extension programs have positive impact on the value of crop production per acre (Nkonya, Pender and Kaizzi, 2006). It is not surprising therefore that increasing access to NAADs programs reduces the probability of being poor.

The results for adoption, however, demonstrate also that poverty status is negatively correlated with whether a household had adopted at least one agricultural technology or not. A 100 percent increase in number of households who adopted at least an agricultural technology reduces the probability of being poor by more than 11.8 percent. This suggests that measures that improve the adoption of agricultural technology could also be an important aspect of poverty alleviation in Uganda.

To illustrate the impact of access to agricultural extension and adoption of agricultural technology on poverty, a poverty regression model augmented with access to agricultural extension and adoption of agricultural technology was estimated**.** The estimated regression results are shown in appendix 5. In general, the model performed well. The goodness of fit measure, R-squared, was 0.18, although fairly low, it is sufficient since discrete choice models are usually associated with low goodness-of fit (Verbeek, 2005)[1].

In addition, with a few exceptions many coefficients of control variables were of the expected sign and statistically significant. The results shows that except for gender of the household head, age of the household head, number of household members employed in primary industry, living in western Uganda and tenure, all the coefficients in the regression are significantly different from zero at the 95 percent confidence level. The variables that are positively correlated with the probability of being poor are: gender, age of the household head squared, and size of the household, living in eastern and northern regions, leasehold land ownership and any member of household working in formal employment. The variables that are negatively correlated with the probability of being poor are: age of the household head, mean years of education, literacy, number of household members employed in primary industry, number of household employed in secondary industry, number of household members employed in tertiary industry, living in western Uganda, agro-eco zones, mean size of landholding of the household, number of plots, a dummy whether a household had been visited by an extension worker during the past 12 months, a dummy whether any member of the household participated in a training program organized by NAADS, a dummy whether a any member of the household adopted at least one agricultural technology, and residence.

Since the probit model is not linear, the marginal effects of each independent variable on the dependent variable are not constant but are dependent on the values of the independent variables (Greene, 1993). Thus, as opposed to the linear regression case, it is not possible to interpret the

[1] Other details on the model's predictive power, see appendix 6

estimated parameters as the effect of the independent variables upon poverty. This study therefore computed the marginal effects[2]. Appendix 7 shows the marginal effects for each independent variable as well as its corresponding standard error and confidence intervals**.**

Even after controlling for the demographic, educational, employment, household assets and agro ecological factors, the estimations results show that access to agricultural extensions services and adoption of agricultural technology are negative and significant. The probability of being poor decreases by 11%, 9% and 9% for every 10 percent increase in the number of household who are visited by an extension worker, attend the NAADs training program and adopt at least an agricultural technology respectively.

Gender of household head is and not statistically different from zero at the 95 percent confidence level. Studies have found that there is no evidence that female-headed households are more likely to be poor than male-headed household (Rodríguez, 2000; Székely, 1998). Rodríguez cited Székely (1998) that, this conclusion should be viewed with care because female-headed households could be under-represented in the sample because there are cultural reasons to believe that many of the households that declared to be headed by males are in fact headed by women. In deed in the sample, female headed households accounted only 26 percent.

Age of the household head was found to be statistically insignificant at the 95 percent confidence level hence not relevant in explaining poverty. The same finding was reached by Székely (1998) for Mexico using 1984, 1989 and 1992 Surveys. However, age of the household head was statistically significant in explaining poverty at 90 percent confidence level. The effect, however, is not very strong, since as can be seen in Table 6 above, an increase of one year in the age of the head decreases the probability of being poor by only 1.4 percent.

Household size has a significant positive effect probability of being poor. The results show that a one increase in the household size increases the probability of being poor by 6.2 percent. Evidence shows that large households tend to be associated with poverty (Lanjouw and Ravallion, 1994; World Bank, 1991a, b). The quadratic term is significant and negative.

The mean year's education of the household and literacy are both negative and statistically significant at 95 percent confidence level. Increasing the mean years of age by 10 percent reduces the

[2] Other studies on determinants of poverty have reported odds ratio. The odds ratio is defined as the ratio of the probability of being poor divided by the probability of not being poor.

probability of being poor by 0.5 percent, whereas literacy by 7.3 percent. Evidence has shown that education has a significant effect on the probability of being poor and that low education is one of the most important causes of poverty. This is because education increases the stock of human capital, which in turn increases labor productivity and wages. Since labor is by far the most important asset of the poor, increasing the education of the poor will tend to reduce poverty (Rodríguez 2000).

Rodríguez argued that occupation has a high correlation with poverty because occupations which require low amounts of capital, either human or physical, will be associated with low earnings and therefore with higher poverty rates. However, in model working formal employment by any member of the household increases the probability of being poor. This implies that a one increase in number of household working in the formal employment increases the probability of being poor by 9.8 points. This result is surprising because working in formal employment like professional work, technical, administrative, managerial, clerical, sales or service occupation would be expected to reduce the probability of being poor. This though, may be due to under representative of households with members working in the formal employment in the sample (13%).

Rodríguez argued that occupation has a high correlation with poverty because occupations which require low amounts of capital, either human or physical, will be associated with low earnings and therefore with higher poverty rates. However, in model working formal employment by any member of the household increases the probability of being poor. This implies that a one increase in number of household working in the formal employment increases the probability of being poor by 9.8 points. This result is surprising because working in formal employment like professional work, technical, administrative, managerial, clerical, sales or service occupation would be expected to reduce the probability of being poor. This though, may be due to under representative of households with members working in the formal employment in the sample (13%). However, the coefficients for the number of household members employed in primary sector, secondary and tertiary are all negative and significant. However, the effect of primary-sector employment on probability of being poor is lower than that of secondary and that of secondary is lower than tertiary-sector employment. That is to say, a 10 percent increase in the number of household working in primary, secondary and tertiary employment reduces the probability of being poor by 0.4%, 3% and 3.5% respectively. This may because the wages of primary-sector workers are relatively low.

Rodríguez (2000) argued that one of the salient facts about poverty in developing countries is that it is higher in rural areas than in urban areas. In this study, the rural-urban variable was negative and statistically significant, implying that living in the urban area reduces the probability of being poor. Geda and Niek de Jong (2005) concluded that the likelihood of being poor is smaller in urban areas than in rural areas and this because people living rural households mainly engaged in agricultural activities compared to households in urban areas who engage in manufacturing activities.

The model results show that the coefficients of agro-eco zones are negative and statistically significant. The marginal effect of being located in agro-eco zone 1 (intensive banana-coffee), agro zone 2 (western banana –coffee-cattle), agro zone 3 (montane), agro zone 4 (animal cropping and cattle northern), agrozone 5 (west nile cereal-cassava-tobacco), , agro zone 7 (animal cropping and cattle –teso), agrozone 8 (banana – millet –cotton), agrozone 9 (medium altitude intensive banana) other than agro zone 6 (pastoral and some cereal crops) reduces poverty. However, it is noted that accounting for the pattern revealed by these coefficients requires a close knowledge of the conditions in the agro-eco zones. The policies which might be drawn from these coefficients would also depend on such knowledge.

The coefficient for the mean size of landholding of the household, tenure and number of plots are negative. However, that of tenure is not significant at 95 percent confidence level. This implies that the larger the average size of land area cultivated reduces by the probability of being poor. However, the degree of crop diversification has more effect in explaining poverty than the mean size of land owned by the household. This may be due to the welfare gains possible from engaging in risk-diversifying crop cultivation

4.4 Poverty Alleviation and Access to Agricultural Extension and Adoption

Table 5 reports the results of various poverty simulations done with the model in 5. The simulations are generated simulations to predict the reductions or increases in probability of being poor that result from unit changes in selected variables. These changes are such as those which may result from the implementation of specific government policy aimed at reducing poverty. Change is measured as the difference between predicted values from the simulation less predicted values from the base model.

The beneficial effect of increasing average years of education of household, and access to agricultural extension services and adoption of agricultural technology is readily apparent from these simulations. The probability of being poor would fall by 25 percent if 50% of households who did not access agricultural extension access.

Expanding adoption of agricultural technology simulation: In this experiment, the researcher examined the poverty effects of making 50 percent of those households who did not adopt agricultural technology, to adopt at least one agricultural technology. Introducing adoption of agricultural technology to 50 percent of households who did not adopt involves changing this binary variable to a value of one for 50 percent of households in which it is zero in the UNHS data. The results show that the probability of being poor would fall by 7 percent.

Table 5: Simulated Results

Poverty alleviation strategy	**% change in probability of being poor**
Increasing access to agricultural extension to 50% of households who did not access	-25
Introducing adoption of agricultural technology to 50 percent of households who did not adopt	-7
Increase in the average years of education by 10 percent	-0.04

Note: Each simulated change is considered in isolation of the other changes. The model used to predict the probability of being poor. The percent change from base is calculated from the *predicted* baseline values.

5.0 Conclusions

The results appear to support the argument that poor households have the least access to agricultural technology and low adoption rate of agricultural technologies; and so poor households could benefit most from investments geared towards increasing access and adoption of agricultural technology. Thus, investments geared towards increasing access and adoption of agricultural technology, whether on new technologies or maintenance of existing technologies, can provide a form of targeted interventions that favors the poor. This is particularly pertinent for Uganda in part because the productivity in farm and non-farm activities has remained very low in rural areas where majority of the poor live. However more importantly, investment spending geared towards increasing access and adoption of agricultural technology may be one of the few feasible means for policy interventions to reach the poor in Uganda.

The results further show that on average access and adoption of agricultural technology is very poor among Ugandans both poor and non-poor. This shows that there are barriers to access to agricultural extension services and adoption of agricultural technology. Barriers to access to agricultural extension services and adoption of agricultural technology may be related to the content, accessibility or delivery of the agricultural extension services presented to the individual, efforts to intensify accessibility and adoption of agricultural technologies are paramount. The policy implications of these findings suggest a need for restructuring the provision and delivery of agricultural extension and technology to favour farmers both poor and non-poor. For instance, while the current agriculture extension services delivery system for Uganda under NAADS is supposed to work along the principle of decentralization and privatization hence making extension services more easily accessible and relevant to the small holder farmers and the system more accountable to the end user. The government has a crucial role to play in guaranteeing that some Ugandans are not deprived of such services, such as those in remote rural areas where the majority of the poor farmers live. This study suggests development of new mechanisms for streamlining current agriculture extension services delivery system to ensure that supply of agricultural extension and technology is more transparent and efficiency.

The bivariate and multivariate analysis demonstrated a strong correlation between poverty, access to agricultural technology and adoption of agricultural technology. The variables that are positively correlated with the probability of being poor are in addition to extension and adoption of agricultural technology are: gender, age of the household head and size of the household, living in eastern and northern regions, leasehold land ownership and any member of household working in formal employment. The variables that are negatively correlated with the probability of being poor are: age of the household head, mean years of education, literacy, number of household members employed in primary industry, number of household employed in secondary industry, number of household members employed in tertiary industry, living in western Uganda, agro-eco zones, mean size of landholding of the household, number of plots, and residence.

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APPENDICES

Appendix 1: Descriptive statistical summaries of variables

variable	mean	standard deviation	min	max
poor06	.3074068	.4614602	0	1
urban	.121796	.327079	0	1
region	2.500795	1.108684	1	4
sex	1.260209	.4387871	1	2
ageHH	43.83419	15.6834	13	99
hhsize	5.679689	2.908421	1	30
literacy	.8486663	.3584064	0	1
educ	8.266867	3.46431	0	14
formal	.8729008	.3331135	0	1
primary	2.642637	1.956411	0	21
secondary	.2922927	.7217259	0	10
tertiary	1.259678	1.884798	0	30
extension	.0758352	.2647577	0	1
naads_trng	.0898002	.2859206	0	1
adoption	.4284957	.4949045	0	1
agrozone	4.195687	2.942229	1	9
meansize	2.606781	11.3721	0	600
tenure	3.877143	.8716839	1	5
plots	6.575747	4.246693	1	30
ageHHsq	2167.361	1570.139	169	9801
hhsizesq	40.71628	45.02353	1	900

Appendix 2: Probit estimates of poverty status against access to agricultural extension services

Probit estimates
Number of obs = 5657
LR chi2(1) = 50.57
Prob > chi2 = 0.0000
Log likelihood = -3465.1393
Pseudo R2 = 0.0072

poor06	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
extension	-.511694	.074608	-6.86	0.000	-.6579229	-.3654651
_cons	-.469818	.0180472	-26.03	0.000	-.5051898	-.4344461
Dy/dx	-0.156	0.01893	-8.26	0.000		

Appendix 3: Probit estimates of poverty status against Adoption of agricultural technologies and Naads_trng

Probit estimates
Number of obs = 5657
LR chi2(1) = 91.64
Prob > chi2 = 0.0000
Log likelihood = -3444.605
Pseudo R2 = 0.0131

poor06	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
adoption	-.3418313	.0358946	-9.52	0.000	-.4121834	-.2714792
_cons	-.3641528	.0225817	-16.13	0.000	-.4084122	-.3198935
Dy/dx	-0.146	0.01805	-8.06	0.000		

Appendix 4: Probit estimates of poverty status against access to Naads training programs

Probit estimates			Number of obs = 5657			
			LR chi2(1) = 50.40			
			Prob > chi2 = 0.0000			
Log likelihood = -3465.2252			Pseudo R2 = 0.0072			
poor06	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
naads_trng	-.4673867	.0678606	-6.89	0.000	-.6003911	-.3343823
_cons |	-.4664392	.0181745	-25.66	0.000	-.5020607	-.4308178
Dy/dx	-0.118	0.1209	-9.74	0.000		

Appendix 5: Probit Regression Results for determinants of poverty

Number of observations=5511
LR 2(32) 1235.28
Prob > chi2=0.0000
Log Likelihood =-2787.466
Pseudo R^2=0.1814

Poor06	Coeff	Std.Err	Z	P>|z|	[95% Conf.	Interval]
Sex	.0129223	.0474292	0.27	0.785	-.0800372	.1058819
ageHH	-.0139596	.0073898	-1.89	0.059	-.0284434	.0005242
ageHHsq	.0001674	.0000734	2.28	0.023	.0000235	.0003112
hhsize	.1868414	.0190473	9.81	0.000	.1495094	.2241733
hhsizesq	-.0048387	.0011478	-4.22	0.000	-.0070883	-.0025891
literacy	-.2119891	.0568141	-3.73	0.000	-.3233427	-.1006355
educ	-.0152029	.0065455	-2.32	0.020	-.0280318	-.002374
formal	.3211066	.0752151	4.27	0.000	.1736878	.4685254
primary	-.0132957	.0128718	-1.03	0.302	-.038524	.0119326
secondary	-.0929097	.0284195	-3.27	0.001	-.1486109	-.0372086
tertiary	-.1059621	.0140128	-7.56	0.000	-.1334267	-.0784975
region2	.1521637	.0935446	1.63	0.104	-.0311804	.3355078
region3	.1982964	.174984	1.13	0.257	-.1446659	.5412586
region4	-.2158467	.1319133	-1.64	0.102	-.474392	.0426986
extension	-.3591485	.0869127	-4.13	0.000	-.5294944	-.1888027
naads_trng	-.2991878	.0790545	-3.78	0.000	-.4541318	-.1442438
adoption	-.2840237	.04278	-6.64	0.000	-.367871	-.2001764
agrozone1	-1.3859	.2205803	-6.28	0.000	-1.818229	-.9535703
agrozone2	-1.452713	.2345414	-6.19	0.000	-1.912406	-.9930207
agrozone3	-.9309651	.2388928	-3.90	0.000	-1.399186	-.4627438
agrozone4	-.5970759	.164339	-3.63	0.000	-.9191744	-.2749773
agrozone5	-.8875466	.1569863	-5.65	0.000	-1.195234	-.579859
agrozone7	-.9791667	.2256957	-4.34	0.000	-1.421522	-.5368113
agrozone8	-1.302535	.2171465	-6.00	0.000	-1.728134	-.8769353
agrozone9	-1.198001	.1980322	-6.05	0.000	-1.586137	-.8098647
meansize	-.0053955	.0026825	-2.01	0.044	-.0106531	-.0001379
Plots	-.0476967	.0056847	-8.39	0.000	-.0588386	-.0365548
tenure1 (freehold)	-.1857906	.115231	-1.61	0.107	-.4116392	.0400581
tenure2 (leasehold)	.0963774	.1823218	0.53	0.597	-.2609669	.4537216
tenure3 (mailo)	-.1305468	.0857049	-1.52	0.128	-.2985252	.0374316
tenure4 (customary)	-.0665783	.0631256	-1.05	0.292	-.1903023	.0571457

Urban	-.3266571	.0697931	-4.68	0.000	-.463449	-.1898652
_cons	.7352837	.3008328	2.44	0.015	.1456622	1.324905

Appendix 6: Model's Predictive Power

In order to assess the predictive power of the model, a classification table of correct and incorrect predictions was constructed, based on the predicted probability of being poor. A probability equal or greater than 0.5 was interpreted as a prediction of a household being extremely poor. While a probability lower than 0.5 was interpreted as a prediction of a household not being extremely poor. Table 5 shows the classification table for the model. In this table, "D" represents the number of poor households in the sample while "~D" represents the number of non poor cases in the sample. The symbol "+" represents the number of households predicted as poor by the model while"-"represents the number of non poor cases predicted by the model.

Predictive power of the model

	True		
Classified	**D**	**~D**	**Total**
+	755	370	1125
-	945	3441	4386
Total	1700	3811	5511
Classified + if predicted Pr(D) >= .5 True D defined as poor06 != 0			
Sensitivity	Pr(+| D)		44.41%
Specificity	Pr(-|~D)		90.29%
Positive predictive value	Pr(D| +)		67.11%
Negative predictive value	Pr(~D| -)		78.45%
False + rate for true ~D	Pr(+|~D)		9.71%
False - rate for true D	Pr(-| D)		55.59%
False + rate for classified +	Pr(~D| +)		32.89%
False - rate for classified -	Pr(D| -)		21.55%
Correctly classified			76.14%

The results in the table 5 show that the model's sensitivity rate (percent of poor cases correctly predicted by the model) is 44 percent, while the model's specify rate (percent of non-poor cases correctly predicted by the model) is 90 percent.

The false positive rate for households classified as poor by the model is 33 percent, which means that 33 percent of the number of households predicted as poor by the model are in fact not poor. The false negative rate for households classified as not poor by the model is 22 percent, which means that 22 percent of households predicted as not poor by the model are in fact poor.

The positive predictive value rate of the model is 67 percent, which means that 67 percent of the total number of predicted poor households is in fact poor. Negative predictive rate is 79 percent, meaning that 79 percent of the total number of not poor cases predicted by the model is in fact not poor. However, as a whole, the model correctly predicts 76 percent of cases.

Appendix 7: Marginal effect Results

Number of observations=5511
LR 2(32) 1235.28
Prob > chi2=0.0000
Log Likelihood =-2787.466
Pseudo R^2=0.1814

Poor06	**Dy / dx**	**Std.Err**	**Z**	**P>|z|**	**[95% Conf.**	**Interval]**	X
sex	.0042735	.01568	0.27	0.785	-.026468	.035015	1.25331
ageHH	-.0046165	.00244	-1.89	0.059	-.009405	.000172	43.6814
ageHHsq	.0000553	.00002	2.28	0.023	7.8e-06	.000103	2149.55
hhsize	.0617899	.00628	9.84	0.000	.049477	.074103	5.69679
Hhsizesq	-.0016002	.00038	-4.22	0.000	-.002344	-.000857	40.9245
Literacy	-.0730561	.02031	-3.60	0.000	-.112868	-.033245	.848666
educ	-.0050277	.00216	-2.32	0.020	-.009266	-.000789	8.17241
formal	.0977685	.02076	4.71	0.000	.057074	.138463	.873526
primary	-.004397	.00426	-1.03	0.302	-.01274	.003946	2.6479
secondary	-.030726	.0094	-3.27	0.001	-.049142	-.01231	.292851
Tertiary	-.0350425	.00461	-7.60	0.000	-.044079	-.026006	1.25825
region2	.0512985	.0321	1.60	0.110	-.011623	.11422	.280893
region3	.0675959	.0613	1.10	0.270	-.052546	.187738	.229359
region4	-.0689246	.04054	-1.70	0.089	-.148377	.010527	.253856
extension	-.1066898	.02267	-4.71	0.000	-.151131	-.062249	.075304
naads_trng	-.0909489	.02176	-4.18	0.000	-.133592	-.048306	.090546
Adoption	-.0925756	.01369	-6.76	0.000	-.119415	-.065736	.429323
Agrozone1	-.3561976	.04142	-8.60	0.000	-.437386	-.275009	.276538
Agrozone2	-.321364	.02996	-10.7	0.000	-.380081	-.262647	.166576
Agrozone3	-.2184852	.03395	-6.43	0.000	-.285035	-.151935	.0499
Agrozone4	-.1623872	.03479	-4.67	0.000	-.230567	-.094208	.066776
Agrozone5	-.2251736	.02803	-8.03	0.000	-.280104	-.170243	.122664
Agrozone7	-.2242815	.02992	-7.50	0.000	-.282931	-.165632	.046271
Agrozone8	-.2990103	.0303	-9.87	0.000	-.358402	-.239619	.159681
Agrozone9	-.2631371	.02397	-10.98	0.000	-.310121	-.216153	.091816
Meansize	-.0017843	.00089	-2.01	0.044	-.003522	-.000047	2.61614
plots	-.0157737	.00187	-8.42	0.000	-.019446	-.012101	6.58345
tenure1	-.0580787	.03386	-1.72	0.086	-.124437	.00828	.043368
tenure2	.0327578	.06358	0.52	0.606	-.091853	.157368	.012883
tenure3	-.0419033	.02665	-1.57	0.116	-.094145	.010338	.145164
tenure4	-.0221216	.02108	-1.05	0.294	-.063437	.019194	.618762
urban	-.0991689	.01917	-5.17	0.000	-.136736	-.061602	.12085