

The Impact of Agricultural Research on Poverty and Income Distribution: A Case Study of Selected On-farm Research Projects at Sokoine University of Agriculture, Morogoro, Tanzania

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Abstract

Improved technologies induce productivity growth that generates pro-poor improvement processes. However, improving welfare and equity is a difficult task. This study investigated whether interventions in agriculture benefit farmers who are more capable to derive sufficient gains than others using data from on-farm research projects in Tanzania. Data were collected during baseline and impact assessment studies using questionnaires. The distributions of income were assessed using coefficients of variation, Gini coefficients and Theil's T-statistic. Results show that the projects contributed to increase farm income through enhanced productivity and sales of products and these gains were equitably shared. To encourage adoption and sustainability of these interventions it is important to sensitize Local Government Authorities and Agricultural Sector Lead Ministries on these technologies to allow incorporation of research findings in development plans. Involvement of extension staff in research and demonstrations through farmers' shows should also be encouraged to increase adoption.

Key words: Agricultural research, Agricultural productivity; poverty and income inequality.

Introduction

The development of advanced and appropriate agricultural technologies is usually acknowledged to induce productivity growth that generates a pro-poor rural growth process (Hezell and Haddad, 2001, Lipton, 1977; Thirtle *et al.*, 2003). This growth is anticipated to benefit poor farmers directly by increasing agricultural production and enhancing access to employment opportunities. At the national level, the growth may result into lower food prices for all consumers; reduced incidences of rural to urban immigration; accelerated growth in the non-farm economy; improved consumption of products that are rich in nutrients and; greater participation of local people in decision-making processes. The growth may also lead to increased capacity for collective action and reduce people's vulnerability to shocks via asset accumulation

(Hezell and Haddad, 2001; Mellor, 2001).

Research-led technological change is considered as a cost effective intervention to alleviate poverty and policy makers in Sub-Saharan Africa (SSA) are now embracing research in their effort to alleviate poverty (Alston *et al.*, 1995; Rukuni *et al.*, 1998). In Tanzania increasing productivity in the agricultural sector is considered one of the most important prerequisites for improving the quality of life of people and it is a long-term goal for almost all development policies and strategies. The United Republic of Tanzania supports the view that technological change is the main driver for enhancing factor productivity in agriculture (URT, 2005).

In the last two decades, Tanzania has implemented several donor-supported research projects to develop and transfer technologies in agriculture and natural

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resources to target farmers, especially in rural areas. The Programme for Agricultural and Natural Resources Transformation for Improved Livelihoods (PANTIL) financed by the Royal Norwegian Government and implemented at Sokoine University of Agriculture (SUA) from 2006 aims at reducing poverty, hunger and malnutrition through improved productivity of resources in agriculture, forestry and fisheries. The central theme of the PANTIL programme is generally consistent with the empirical growth models that provide substantial support for growth strategies led by research and development (RandD) and technology generation (Dasgupta, 1998; Fan *et al.*, 1999; Irz and Roe, 2000; Mellor, 2001; Rangarajan, 1982).

However, many analysts argue that the impact of agricultural productivity and growth on poverty and equity is conditional on the fundamental element of the underlying economic structure, namely, the access of different groups to natural resources and productive assets (Deininger and Squire, 1996; Lee, 2005; Mellor, 2001; Ram, 1997; Walton, 1997). Under normal circumstances target beneficiaries are expected to differ markedly with respect to resource endowments. These differences play an important role in technology adoption because the capacity to adopt new technologies may be impeded among households with limited access to agricultural resources such as human and physical capital (Caviglia and Kann, 2001; Current *et al.*, 1998; Lee, 2005; Shively, 2001).

The foregoing discussion amplifies the trade-off between promoting efficiency and equity, which has long been recognized in economic literature (Gee, 1994; Graaf, 2006; Ng, 2008). Therefore, investment in agricultural research may generate varied outcomes to target beneficiaries. Some targeted farmers may benefit from these interventions but the 'functionally vulnerable farmers', especially those with limited access to resources and lucrative investment options may not benefit equally (Dercon, 1998; Reardon, 1997).

Tarimo *et al.* (2007) assessed the capacity of 27 projects under Tanzania Agricultural Research Project Phase II (TARP II) and found that on-farm research helped the households to become more

secure through increased agricultural output and income. Similarly they conducted a baseline survey before the inception of the PANTIL projects and mid-term impact assessment of these projects two years after inception and found that many of the target beneficiaries realized net increases in income. The increases in income were partly attributed to the adoption of improved technologies, which resulted into increased production and sales of agricultural products. However, the question of whether this change in income was fairly distributed among beneficiaries is far from certain. Therefore, there is a need to empirically test whether research activities under PANTIL projects have benefited few respondents, especially those who are relatively more knowledgeable and with ample resources to derive sufficient gains or these gains are equitably shared among beneficiaries.

The need for this investigation stems from four main reasons. Firstly, economic literature has consistently revealed that capital markets in many developing countries are imperfect (Dixit and Pindyck, 1994; Krugman, 1989; Nyakerario, 2007). These imperfections imply that unequal distribution of income may lead to skewed distribution of assets to the extent that many individuals have no access to credit and thus cannot carry out productive investments, which finally reduces the long-term growth rate. Secondly, demographic literature shows that unequal distribution of income may generate a rise in the fertility rate and discourage investment in human capital among the poor and less educated households, and this in turn reduces the future economic development (Becker and Lewis, 1973; Becker and Tomes, 1976; Kremer and Chen, 2002). Thirdly, a more unequal distribution of incomes contributes to shrinkage of demand for goods and services in domestic markets and thus discourages the economies of scale, which consequently limits the future growth potential and industrialization of the economy (Mann, 2001). Lastly, when unequal income distribution patterns are observed and persistent they encourage corruption and injustice and may intensify social conflicts between the 'poor' and the 'rich'. Social conflict over the distribution of income, land or other assets can arise through labour unrest or massive protest over rent seeking behaviour and can hinder investment as well as growth

(Benhabib and Rustichini, 1996).

in Figure 1.

Material and Methodology

Conceptual framework

Impact of agricultural research refers to broad and long-term economic, social and environmental effects resulting from research interventions (Anandajayasekeram *et al.*, 1996). These effects encompass changes in both cognition and behaviour of actors involved. Thus, in its broadest sense, impact includes direct outcome of the research activities; changes in institutional approaches and methods used by researchers and other actors in generating and transferring technology; and people's level impact, which can be economic, socio-economic, socio-cultural, and/or environmental (Ibid.).

However, measuring the impact of agricultural research is a difficult task, partly due to the complexities of the relationships between agricultural technology and the various aspects of poverty, with research having both direct and indirect effects on poverty (de Janvry and Sadoulet 2002; Kerr and Kolavalli 1999). Despite this difficulty it is important to examine the impacts and impact-pathways of different types of agricultural technologies to guide future research in ways that will make the greatest contribution to poverty reduction. One of the critical aspects in this assessment is the impact of agricultural research on poverty alleviation and the distribution of benefits derived from research across different socioeconomic groups (Alwang and Siegel 2003; Kerr and Kolavalli 1999). To realistically measure this impact in such a scenario there is a need to examine how agricultural investment affects the economy.

The role of agricultural research is to generate new technologies that increase agricultural productivity. The resulting productivity has far reaching consequences on GDP growth, both directly and through spill over effects attributed to the linkages between agriculture and other sectors of the economy (the non-farm sectors). Therefore, agricultural growth and GDP growth have impacts on inequality, poverty and nutritional status of the targeted population. These direct and indirect effects of agricultural research could be summarized as shown

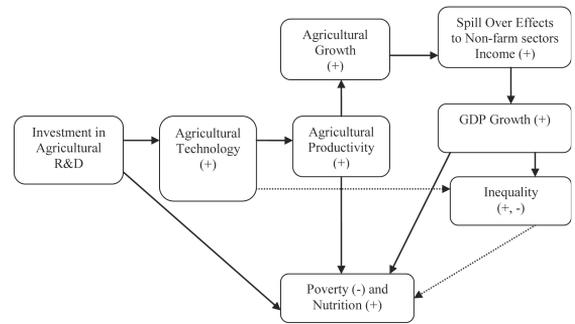


Figure 1: Linkages between research and development (RandD), technology, growth, productivity and poverty

Figure 1 shows that there is a link from agricultural research directly to poverty and from RandD to productivity through generation of new technologies. Also this figure shows that agricultural technologies have effects on income realized by poor, economic growth as well as poverty and nutrition. Under normal circumstances improved agricultural technologies should lead to poverty alleviation through positive effects on consumers' food prices, producers' incomes, and labourers' wage (Winkelmann, 1998). Higher productivity, better natural resource management, and poverty alleviation are mutually reinforcing and they result into sustainable food system. However, households tend to pursue unique livelihood strategies that cross the simple boundaries of being farmers, or labourers, or consumers and they may engage in all these activities. This overlap implies that the effects of changes in output, prices and wages will generate different impacts at farm level.

To empirically investigate the research question raised in the introduction i.e. whether or not changes in income at farm-level observed during the mid-term impact assessment of the PANTIL projects are equitably distributed, the welfare of the targeted beneficiaries before and after the implementation of the projects are measured and compared. In essence this analysis captures economic impacts and is generally perceived as partial assessment of the effects of new technologies on farm productivity and farmers' welfare. A comprehensive economic impact

assessment goes beyond yield and income effects to wider economic effects of the introduced technologies such as return to funds invested in research (Evenson, 2001).

In this study income before and after two years of PANTIL research work are compared to measure changes in income and assess how equitable the distributions are. This approach provides valuable information on the potential impact of the technologies developed and helps to make the case for continued efforts and investments in technology generation and promotion.

Data sources and analysis

Data used in this study were collected during the baseline and mid-term impact assessment of the PANTIL projects. In total there were 12 projects under the PANTIL programme. However, projects included in this study are those which were anticipated to generate tangible financial outcomes in a short period. The baseline data were collected in 2005 while the mid-term impact assessment was conducted in 2007. During these two surveys similar questionnaires were administered to respondents. The total sample size was 240 and respondents were randomly selected and interviewed to solicit information on various indicators of the impact such as changes in agronomic practices, productivity, income, consumption, health status, perceptions and gender relations. Data collected during these surveys were entered in Statistical Package for Social Science (SPSS) spreadsheets and are used in this study to compute measures of dispersion within the distribution of incomes and gauge the welfare implication of the observed changes in income.

One of the critical issues in welfare analysis is to identify the actual level of well being of each member of the targeted beneficiaries before and after the projects. Indeed, well being is not directly observable and is conveniently measured using proxy variables, which are normally correlated with people's welfare such as income, health status and education level (Massari, 2005). Furthermore income is also considered a measure of available resources, apart from preferences and constraints that could affect consumption decisions and is a good indicator of the level of improvements in well being achieved by each household after the project

(Chaudhuri and Ravallion, 1994). Thus, income levels are used to measure the welfare change after the interventions. To measure the welfare changes farmers' income before and after interventions are compared and tested for mean differences using paired t-statistics. When significant differences are observed the distributions of income are analysed to assess equity. Inferences regarding income distributions are derived from coefficients of variation (CV), Gini coefficients and Theil's T-statistic. The need to blend these measures of inequality revolves around comparative advantages of each measure as detailed below:

Income inequality could be measured using simple measures such as the range and range ratios, the four-firm concentration ratio, and McLoone index. However, these measures are inherently weak because they do not make use of all information in the data set (Adams Jr and White II, 1997).

Another measure of variation, which is commonly used in statistics, is the CV. This coefficient is simply defined as the ratio of standard deviation of a variable to its expected value, the mean. The CV describes the peakedness of a unimodal frequency distribution. When the dataset is closely bunched around the mean, the peak will be high and the CV will be small. In contrast when data is more dispersed, the peak will be shorter and the coefficient will be large. *Ceteris paribus*, the smaller the CV, the more equitable the distribution is. The relative advantage of this measure is that it is a unit free measure of variation and is not affected by inflation. Therefore, it can be used to compare streams of cash realized in different periods. However, despite its merit, its value can assume any number between zero and infinity, and therefore there is no universally accepted standard that defines reasonable values of the coefficient for particular phenomena and thus it is merely used to compare two or more data sets.

The Gini coefficient is another measure of inequality, which is based on the deviation between the actual distribution of income within a sample and a hypothetical distribution in which income is completely equally distributed (Tziafetas, 2007). The actual distribution is normally represented using a Lorenz curve which is derived by ranking incomes in ascending order, and then plotting the cumulative

percentage of total income received against the income share. When the distribution is discrete, the Gini coefficient (G) can be calculated by taking one half of the average of the absolute values of differences between all income pairs, such that:

$$G = 1 - \sum_{i=0}^n (\sigma Y_{i-1} + \sigma Y_i) (\sigma X_{i-1} - \sigma X_i) \dots\dots\dots(1)$$

Where σX and σY are cumulative percentages of X and Y (in fractions) and n is the number of elements (observations). In the empirical model X represents income earners and Y stands for income levels.

The inequality measures discussed above are each appropriate in certain circumstances. Theil's T-statistic is also used to measure inequality and its use does not undermine the relevance of CV and Gini coefficients but it underscores the fact that it has a more flexible structure that often makes it more appropriate when panel data is used (Foster, 1983; Theil, 1967). Data used in this study have some degree of an underlying hierarchy i.e. collected from villages in different Districts and Regions. Thus this statistic is also adopted in the analysis and is mathematically defined as:

$$T = \sum_{p=1}^n \left\{ \left(\frac{1}{n} \right) \left(\frac{y_p}{\mu_y} \right) \ln \left(\frac{y_p}{\mu_y} \right) \right\} \dots\dots\dots(2)$$

where n is the number of individuals in the population, y_p is the income of the person indexed by p , and μ_y is the population's average income. When income is equitably shared, T will approach zero, which is the minimum value of Theil's T-statistic. If one individual has all of the income, T will equal the natural logarithm of n and it represents utmost inequality and is the maximum value of Theil's T-statistic.

Results and discussion

Income statistics for PANTIL Projects before and after intervention are summarized in Table 1. On the other hand measures of inequality for all projects in which the difference between farmers' income before and after the project implementation were significantly different are presented in Table 2.

Results presented in Table 1 show that the New-PANTIL projects have contributed to increase the farmers' earnings. The percentage increase in

Table 1: Income statistics for farmers under PANTIL projects two years after implementation

No	Project Title	Mean income before the Project (TAS)	Mean income after the Project (TAS)	t-statistic for paired samples
1	Cassava (n=24)	198,750.00	382,083.30	3.190 ^b
2	Nutrition (n=15)	905,624.30	1,115,866.70	2.5 ^c
3	Irrigation (n=15)	419,066.70	1,018,566.70	5.00 ^a
4	Dairy Goat (n=28)	675,158.93	1,577,792.90	4.00 ^a
5	Vanilla (n=20)	127,345.00	211,716.50	2.73 ^b
6	Commercialization of Technology (n=11)	406,181.80	478,181.80	0.84 N.S
7	Draught Animal Power (DAP)-Chicken (n=12)	208,333.30	725,000	2.07 NS
8	Dairy cattle (n=46)	956,804.35	3,060,502.20	1.81 NS
9	Banana (n=34)	723,470.60	2,002,173.50	2.08 NS

NB: NS means not significant at all levels of significance a means significant at 1 percent where as b and c mean significant at 5 and 10 percent, respectively.

Source: Mid-term Impact Assessment Data, 2008

Table 2: Income distribution for targeted beneficiaries under PANTIL projects two years after implementation

No	Project Title	CV (%)		Gini Coefficient		Theil's T-statistic	
		Before	After	Before	After	Before	After
1	Cassava (n=24)	82.83	100.35	0.45	0.47	0.33	0.37
2	Nutrition (n=15)	301.63	242.04	0.82	0.74	1.74	1.27
3	Irrigation (n=15)	74.00	60.18	0.40	0.30	0.26	0.16
4	Dairy Goat (n=28)	120.40	104.06	0.57	0.52	0.56	0.47
5	Vanilla (n=20)	142.68	105.68	0.49	0.54	0.45	0.50

Source: Mid-term Impact Assessment Data, 2008

income for Cassava, Nutrition and in Vanilla projects were about 92, 23 and 66, respectively. Earnings for farmers under Irrigation; Dairy Goat; DAP-Chicken; Dairy Cattle and Banana Projects, increased by more than 100 percent. These changes reflect differences in market values across product lines as well as

productivities that come with these technologies.

It is possible to argue that the observed changes might have emanated from sources other than products produced using the introduced technologies. However there is evidence from project sites suggesting that productivities had increased by as much as 50 percent. Also the composition of crops produced by farmers and their income portfolios cannot change dramatically in a short-run period. Furthermore many of these farmers are exposed to similar markets and consequently they experience common shocks. Therefore, under these assumptions, any increase in productivity is expected to change income portfolios proportionally.

Table 1 also presents paired t-tests for mean differences between income before and after intervention. These statistics reveal that the mean differences for 5 projects were statistically significant at levels specified in this table. These test statistics mean that income for farmers under these projects increased after the interventions and the increase was statistically significant at the specified significance levels.

The coefficients of variation presented in Table 2 seem to suggest that for many projects, earnings at farm-level became less variable after implementing the projects. Gini coefficients and Theil's T-statistic suggest that income inequality increased in Cassava and Vanilla projects but decreased in Nutrition, Irrigation and Dairy Goat projects. However, the weighted averages of Gini coefficients before and after the interventions were 0.54 and 0.51, respectively, while the weighted averages of Theil-T statistics over the same periods were 0.61 and 0.52. The decreases in weighted averages imply that income inequality had decreased after the interventions. These coefficients suggest that the benefits realized from research (e.g. increased productivity) generated additional earning to target farmers and these earnings were equitably distributed across the sampled farmers.

Conclusion

Descriptive and inferential statistics show that the PANTIL Projects have contributed to increase farm income through enhanced productivity, which

increased sales and marketability of agricultural products in project areas. Statistics show that crop yields (e.g. maize) increased by as much as 50 percent and value adding activities (e.g. processing in vanilla and cassava projects) were promoted and practiced. Measures of income inequality suggest that benefits derived from research were equitably distributed across the sample of beneficiaries. The observed decreases in weighted averages of Gini coefficients and Theil-T statistics after two years of project implementation mean that the distribution of income became more equitable after the intervention.

The short-term outcomes of these interventions demonstrate that on-farm research can enable farmers to increase production and earnings and improve their livelihoods. However, challenges for these projects relate to increasing the feasibility of research findings and stimulating the adoption of the developed technologies. To encourage continued adoption and sustainability of these interventions there is a need to scale-up the technologies to non-participating farmers as well as other actors and stakeholders. In practice this objective could be achieved through sensitizing Local Government Authorities (LGAs) and Agricultural Sector Lead Ministries (ASLMs) on these technologies to allow the incorporation of research findings in their development agenda. Involvement of extension staff in project activities and demonstration of technologies through farmers' shows (e.g. Nane Nane show) should also be promoted to increase adoption.

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