Does agricultural research reduce poverty among smallholder farmers?

The case of Tanzania

By

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CONTENTS

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Abstract

This article discusses poverty reducing effects of agricultural research, based on existing impact assessment studies from Tanzania. Agricultural research and extension in Tanzania has largely been a public undertaking, and has been characterized by frequent organizational changes. A total of 1203 agricultural research projects implemented during the 1980s and 1990s have been identified in the Southern Highlands and Eastern Zones of the country. For most of these projects, impact studies have not been made on project level.

While conventional impact assessment of agricultural research has mainly focused on adoption of technologies, increased yields and rates of return to investments in agricultural research, there is now a growing interest in seeking evidence on to what extent agricultural research contributes to poverty reduction. Existing impact studies on programme level from Tanzania show that several technologies and improved crop varieties have been released and adopted by farmers, in many cases with good impacts in terms of household economy as well as socio-cultural and environmental parameters. Through increased farm income and improvements in food security agricultural research has a potential to reduce poverty among smallholder farmers. Most of the past impact studies are however not well designed to analyse to what extent this potential is fulfilled.

Keywords: *adoption of technologies, agricultural research, environmental impacts, impact assessment, poverty reduction, rate of return, socio-cultural impacts, Tanzania.*

1. INTRODUCTION

When the Nobel Peace Prize of 1970 was awarded to the crop scientist Norman Borlaug for his contribution to the Green Revolution, the Norwegian Nobel Committee was convinced that advances in agricultural research would not only enhance yields, but also put an end to starvation and thereby reduce the basis for conflict. According to Borlaug's view, "yield-increasing technologies is a 'plus-plus' solution, since it can increase food production and farmer incomes, while reducing the cost of food to consumers and improving diets, i.e. it can

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result in economic growth and poverty reduction simultaneously" (Borlaug and Dowswell 1995:128).

Others were more critical to the green revolution, which mainly was based on high-yielding crop varieties, chemical fertilisers, pesticides and irrigation. The green revolution was accused for causing reduced genetic diversity, increased vulnerability to pests, soil erosion, water shortages, reduced soil fertility, micronutrient deficiencies, soil contamination, and reduced availability of food crops for the local population (Shiva 1991). Another position suggests that while impressive results of green revolution strategies were recorded in South and Southeast Asian countries in terms of yields and total agricultural output, the same strategies have proved unsuitable in Africa due to environmental constraints and limited availability of land with high potential for monocropping (Holden and Shanmugaratnam 1995: 247-248).

The critical voices became a challenge to the green revolution, and thereby to the international agricultural research community that developed and promoted the green revolution technologies. A need emerged to show that agricultural research was beneficial to the society and that investments in agricultural research were attractive. To meet this need applied impact assessment studies have been emphasised by international agricultural research organisations (Morris *et al*. 2003).

Tanzania is a low-income country with a gross national income per capita at 270 USD in year 2001 (World Bank 2003a: 16), meaning that the average population is well below the absolute poverty line at 1 dollar per day. Agriculture employs an estimated two thirds of the country's workforce, and is dominated by small-scale subsistence farmers on plots of 0.2-2 ha (Economist Intelligence Unit 2003:33). The combination of low income and high dependency on smallholder agriculture makes Tanzania a suitable country for testing Borlaug's hypothesis that agricultural research reduces poverty through increased food production and farmer incomes.

Poverty at household level is normally seen as a situation where income is low, and absolute poverty has been conceptualised in World Bank terminology by the simple yardstick of living on less than 1 USD per person per day. The World Bank acknowledges, however, that poverty has many dimensions, and that 'illiteracy, ill health, gender inequality, and environmental degradation are all aspects of being poor' (World Bank 2003b: 2). For the present study the focus is on income poverty, but income is defined broader than just cash income, so that it includes production of agricultural commodities for subsistence rather than sale.

Majority of Tanzanians earn their living from the land through rain-fed crop cultivation. Except for the experiment on collective agriculture between late 1960s and early 1970s, which was abandoned around mid 1970s (Lofchie 1978; Havnevik 1993) agriculture has been a private undertaking dominated by subsistent smallholders. Tanzanian agriculture grew rapidly in the 1960s and a rate of growth in agricultural production of 4.5% per annum was recorded in the period 1965-1970 (Kaduma 1994:92). The growth registered in the 1960s not only enabled the country to feed herself but also in some years to export some food (Lofchie 1978; Tapio-Biström 2001).

Agrarian crises in sub-Saharan Africa are attributed to both external and internal factors. Tanzania faced an agricultural crisis in late 1970s and early 1980s. Growth rates of agricultural production declined to 2.3%, 1.8% and 0.6% respectively during 1970-75, 1975-80 and 1980-85 (Kaduma 1994:92). These growth rates were well below the population growth rates, causing agricultural production per capita to decline during this period. The crisis was according to Tapio-Biström (2001), Lofchie (1978) and Lofchie (1989) explained by, among others, the oil crisis, war with Uganda, villagization as well as the government marketing and pricing policy. Havnevik and Skarstein (1985) argue that Tanzanian officials tend to elevate external factors as the main reasons behind poor agricultural performance and disregard more serious and fundamental internal causes. Likewise Lofchie (1989), while acknowledging the influence of external factors, attributes the agrarian crisis in Tanzania to policy failure, mainly in terms of over-taxation of agriculture, e.g. through low producer prices and overvaluation of currency.

The adoption of economic reforms in the mid 1980s was an attempt to improve economic performance in line with the view that poor performance could mainly be attributed to internal causes, which is in agreement with the International Monetary Fund (IMF) and the World Bank policies. Following the implementation of the agricultural adjustment programme most domestic market controls on food crops were abolished in 1989, producer prices for the main agricultural products were liberalised between fiscal years 1991/92 and 1993/94 and marketing of export crops was liberalized in the late 1980s and 1990s (Wobst 2001). Growth in cash crop production occurred between 1988/89 and 1995/96 and the country again became a net exporter of maize in 1989/90 and 1992/93 respectively (Ministry of Agriculture 1993). Overall growth rates in agricultural production were about 4.5%-5.5% during 1986-91 (Kaduma 1994:92).

The good performance of both export and food crops in the late 1980s and early 1990s is attributable to good weather and markedly improved availability and distribution of inputs. The latter occurred as a result of improved availability of foreign exchange under structural adjustment programme and availability of consumer goods (Havnevik 1993; Ministry of Agriculture 1993). However, there is concern that the removal of input subsidies, coupled with the financial problems confronting Marketing Boards and Cooperatives, along with the collapse of the seasonal input credit system are likely to have negative impact on agricultural production (Ministry of Agriculture 1993). Indeed, there are reports of decline in the use of inputs like fertilizer in maize production, lack of organised markets for food, low prices of commodities and high prices of inputs (Ibid).

Despite improvement in aggregate production, agricultural productivity on small farms is generally low compared to results obtained from research stations (Msambichaka 1994). In most cases increase in production is attained through expansion of farmland. Low and stagnant yields in smallholder agriculture is mainly attributed to low use of research-based technologies and farm inputs associated with such technologies. Thus adoption of research-based technologies is considered essential to increase agricultural productivity.

Based on available impact studies, this article discusses the impact of agricultural research conducted in the Southern Highlands Zone (SHZ) and Eastern Zone (EZ) of Tanzania in the period 1980-2000, with a focus on the capacity of agricultural research in reducing poverty among smallholder farmers. The article also discusses the capacity of existing impact studies to give adequate information on the poverty reducing effect of agricultural research. The remainder of the article is organised as follows: Section two gives an overview of agricultural research and extension in Tanzania. In section three, agricultural research done in the Southern Highlands Zone and Eastern Zone of Tanzania is presented based on recent research inventories. Section four presents available knowledge on impacts of agricultural research on poverty among smallholder farmers, based on available international impact studies. Section five discusses existing impact studies of the agricultural research in SHZ and EZ of Tanzania. Section six concludes the article.

2. TANZANIA'S AGRICULTURAL RESEARCH AND EXTENSION SYSTEMS: PAST AND PRESENT

2.1 AGRICULTURAL RESEARCH

In Tanzania crops research started in 1892 when the German colonial administration established the first agricultural institute at Amani in the Usambara Mountains (Liwenga 1988). Further developments took place in 1947 and 1955 respectively when the British colonial administration established a scientific section and appointed the first Chief Research Officer to coordinate all agricultural research in Tanganyika[1]. During the colonial period and the early years of independence agricultural research was geared to supporting the development of plantation export crops (sisal, coffee, tobacco and groundnuts) grown either by foreign companies or individual settler farmers. Research support was also extended to cotton grown by smallholders.

It was only from mid 1960s that the promotion of food crops became the major preoccupation of agricultural research. To reach smallholders who produce most of the food crops in the country, the Farming Systems Research approach was adopted during the 1970s instead of the commodity approach adopted earlier. Furthermore, from 1980s and especially after reorganisation of the research system in the 1990s the research policy emphasises the use of this approach to properly address the constraints faced by smallholder farmers.

Tanzania's agricultural research has been characterized by frequent organizational changes. During the past three decades, three main organisational changes have been implemented. The first major change was implemented in the late 1970s. It involved regrouping and bringing livestock and crop research centres under the control of the Ministry of Agriculture. This was followed by another change in 1980 when the Government created parastatal bodies with specific research mandates. These were the Tanzania Agricultural Research Organization, Tanzania Livestock Research Organization and Tanzania Pesticide Research Institute for crops, livestock and pesticide research respectively. In addition, Uyole Agricultural Centre was established as a semi-autonomous research and training institute (Liwenga 1988). The latest change in the organisational set up of research was executed in the early 1990s. The

[1] In 1964 Tanzania Mainland (formerly Tanganyika) merged with Zanzibar (Tanzania Islands) to form the United Republic of Tanzania.

change was caused by problems inherent in the previous institutional arrangement (Directorate of Research and Training, Ministry of Agriculture and Cooperatives 1991). Following the reorganisation, the Directorate of Research and Development (DRD) of the Ministry of Agriculture and Food Security is the lead institution of the National Agricultural Research System (NARS) for both crops and livestock even though livestock falls under the mandate of the Ministry of Water and Livestock Development.

The DRD operates a network of institutions, centres and sub-stations for crops research and livestock research (Shao 1994). Public universities (e.g. Sokoine University of Agriculture), parastatals (e.g. Tanzania Pesticide Research Institute) and the private sector bodies are also constituent part of the NARS. Mainstream research under NARS is conducted in seven agro-ecological zones - Eastern, Western, Northern, Central, Lake, Southern and Southern Highlands. Each zone has a mandate for certain priority research programmes (Table 1). Within the zonal research organisational set up, research is also organised along commodity lines with each of the zonal centres being assigned a major responsibility for conducting and coordinating adaptive and applied research on specific commodities (Ravnborg 1996). A few institutes are outside the zonal set-up performing specialized research work, e.g. the Animal Diseases Research Institute. The new research set up provides for active involvement of private sector. This is a tactical move aimed to diversify sources of funding for agricultural research from over dependence on donor funding (Ravnborg 1996; Pardey et al 1997), which is often inadequate to meet budgeted requirements. In particular, the private sector is expected to play a big role in supporting research on traditional cash crops such as coffee and tea.

Table 1: Agricultural research centres and programmes for crops in Tanzania

Zone	Institute/Centre	Programs
Lake	Ukiriguru	Cotton, Roots and Tubers
	Maruku	Banana and Coffee
Southern Highlands	Uyole Agricultural Centre	Ruminant Milk and Meat (Animal Nutrition) Pyrethrum, Potatoes, Agricultural Engineering
	Kifyulilo	Tea
Northern	Selian	Wheat and Barley, Phaseoulus Beans
	Lyamungu	Coffee
	Tengeru	Horticulture
Eastern	Ilonga	Maize, Grain Legumes, Sunflower, Sorghum and Millet, Crop protection
	Ifakara	Rice
	Kibaha	Sugarcane
	Mlingano	Soil and Water Management, Sisal
	Tsetse and Trypanosomiasis Research Institute, Tanga	Animal Health and Diseases
	Livestock Research Centre, Tanga	Ruminant Meat and Milk (Animal Breeding)
Southern	Naliendele	Cashewnut, Oil seeds, Roots and Tubers
Central	Mpwapwa	Ruminant Meat and Milk (Animal Breeding and Genetics)
	Kongwa	Ruminant Meat and Milk (Pasture and Forage)
	Makutupora	Viticulture
	Hombolo	Sorghum and Millet
Western	Tumbi	Tobacco, Agro-forestry
National (under DRD)	National Coconut Development Programme	Coconut
	DRD Headquarters	Farming Systems Research/Agricultural Economics
	Animal Disease Research Institute (ADRI), Temeke	Animal Health and Diseases
Others (not under DRD)	Tanzania Pesticides Research Institute	Post Harvest Technology
	Sokoine University of Agriculture	Non Ruminant, Meat Production (Poultry/Piggery)

Source: Shao (1994)
DRD= Department of Research and Development SUA = Sokoine University of Agriculture
TPRI = Tropical Pesticide Research Institute

2.2 AGRICULTURAL EXTENSION

Agricultural extension like agricultural research has largely been a public undertaking. Thus the period before 1988 was characterised by government monopoly in the provision of extension services through the Ministry of Agriculture. However, following a policy shift from a public sector monopoly to pluralism, there are other providers of extension services besides the Ministry of Agriculture. Among others, these include the Local Government Authorities, Non-Governmental Organizations, donor-supported projects, private agribusiness and community based organizations (Sicilima and Rwenyagira 2001). Despite this the National extension service remains the main provider of extension services catering for about 3.5 million farm families in the whole country (Ibid).

The period before 1988 also witnessed twists and turns in extension organization. In the early 1970s the government decentralized the services to regional authorities before recentralizing them again in the 1980s. Towards the end of 1980s the government decentralized the extension service to Local Government Authorities. According to Sicilima and Rwenyagira (2001) this move was justified by, among others, poor supervision of extension staff, supply-driven nature of National extension programmes, inability by the Ministry and its staff to link and collaborate with other extension providers such as NGOs and Community Based Organizations (CBOs), and the fact that the National Training and Visit approach stifled creativity and innovativeness of the system.

Between 1962 and 2001 the government adopted a number of approaches/extension programs to achieve agricultural development (Sicilima and Rwenyagira 2001). These approaches are the Transformation Approach (1962-66), the Improvement Approach (1963-1966), and the Commodity Approach (1978-1983). Furthermore, various donor-funded projects were initiated including the Sasakawa Global 2000 (1989-1998), the FAO Special Programme for Food Security (1995 to-date), the National Agricultural Extension Programme (NALERP – 1989-1996), the Southern Highlands Extension and Rural Finance Project (1994-2001) and the National Agricultural Extension Project Phase II (NAEP II 1996 – 2001) (Ibid). After limited impact of various extension approaches, a modified form of Training and Visit system has now been endorsed as the extension approach all over the country (Van den Ban and Mkwawa 1997).

The reforms implemented by research and extension systems so far are in line with research and extension reforms, which had been advocated for implementation in the 1990s as part of structural adjustment programmes in sub-Saharan Africa. As observed by Friis-Hansen (2000), these reforms involved taking up measures that aimed to (i) reduce the scope of state involvement by transferring financial obligations and actual delivery of services to the private sector or farming communities, and (ii) to improve cost-effectiveness of the research and extension activities which remain in public sector. In addition to these measures efforts have been made to promote a new model of research and extension, which is 'plurastic' and 'demand-driven'(Gibbon 2000).

In Tanzania, while research and extension have been pluralized, attempts to ensure research is demand-driven remain elusive. Ravnborg (1996) seem to blame this on the fact that changes implemented earlier were based on the perception that the problems of agricultural research were management issues (finance and organisation) with little attention paid to the relevance of research content to farmers. Also lack of relevance faces the extension service. Although Van den Ban and Mkwawa (1997) make a number of suggestions to ensure that agricultural extension is participatory and demand-driven it is doubtful that this would have the desired impact without having demand-driven research (Haug 1999: 268). In short, to achieve demand-driven research, researchers will have to espouse active involvement of extension workers and farmers in technology development.

3. AGRICULTURAL RESEARCH IN SOUTHERN HIGHLANDS AND EASTERN ZONES

This section describes agricultural research in SHZ and EZ[2] based on research inventories carried out in SHZ and EZ respectively by Kamasho and Mussei (2001) and Nyaki et al. (2001). The inventories sought to provide information on, among others, research topics, sites, project implementation period, budget and evaluation status of the projects. Table 2 presents a summary of the inventory. In the absence of information on funding (budgets) for most projects, the analysis carried out is descriptive and is limited to providing general observations

[2]The Southern Highlands Zone is comprised of Iringa, Mbeya, Rukwa and Ruvuma regions. On the other hand the Eastern Zone consists of Coast (Pwani), Dar es Salaam, Morogoro and Tanga regions.

on the type and number of research projects conducted during the pre- and post-1980s periods.

For purposes of this study research projects are classified into five main thematic areas - crops, livestock, agricultural engineering, processing and storage, socio-economic / farming systems research and others. Crops and livestock research are further categorised into sub themes as indicated in the table. To establish the number of projects implemented during 1980-2000 period, it was decided to divide the projects into three categories according to implementation dates. Consequently, in the first category are research projects done during or before 1980 and some of which extended beyond 1980. The second category consists of research projects done after 1980. In the third category are research projects for which implementation dates were not shown.

On the basis of data in Table 2, the following general observations can be made: (i) For all types of research (excluding research without known implementation dates), almost twice the number of research projects was done in the post-1980s compared to the pre-1980s. (ii) The EZ carried out more research projects than the SHZ (iii) Crops research is dominant over livestock research in the two zones. Within crops research, consistent with the research policy, a greater number of research projects focused on food rather than traditional cash crops. In EZ the leading crops were grain legumes, maize, sorghum and millet while horticulture (tomato and onion), legumes and wheat, and barley topped the list in that order in SHZ. Livestock research in both zones focused on pasture and forages (iv) Implementation dates for a large number of projects, especially in EZ, are not shown indicating poor record keeping of information on research projects.

Table 2: Research activities in SHZ and EZ

Research theme	Implementation period			
	≤1980	1980+	Not known	Total
	No. of research projects	No. of research projects	No. of research projects	
	Eastern zone			
1. Crops research				
1.1 Food crops*	107	146	153	406
1.2 Cash crops*	15	38	56	109
1.3 Plant protection	0	21	12	33
1.4 Soil and water management	0	70	14	84
2. Livestock research				
2.1 Breeding	0	0	2	2
2.2 Nutrition	0	6	0	6
2.3 Management	0	0	0	0
2.4 Health	0	7	2	9
2.5 Pasture and forages	3	6	3	12
3. Agricultural engineering, processing and storage	0	7	2	9
4. Socio-economic/Farming Systems Research	1	14	2	17
5. Others (agro forestry and forestry)	0	2	0	2
Total	126	317	246	689
	Southern Highlands			
1. Crops research				
1.1 Food crops*	71	174	7	252
1.2 Cash crops	17	21	4	42
1.3 Plant protection*	17	25	0	42
1.4 Soil and water management*	23	29	1	53
2. Livestock research				
2.1 Breeding	0	4	0	4
2.2 Nutrition	6	5	0	11
2.3 Management	1	10	0	11
2.4 Health	0	4	0	4
2.5 Pasture and forages*	18	19	3	40
3. Agricultural engineering, processing and storage	11	11	2	24
4. Socio-economic/Farming Systems Research	8	15	7	30
5. Others (crop-livestock linkage)	0	0	1	1
Total	172	317	25	514
Grand Total (	298	634	271	1203

∗ Includes research projects that started in or before 1980 but whose implementation may have extended beyond 1980

Sources: Kamasho and Mussei (2001) and Nyaki et al. (2001)

4. IMPACT ASSESSMENT OF AGRICULTURAL RESEARCH: STATE OF THE ART

Agricultural research at global and national levels has been devoted to research efficiency in order to rejuvenate donors' and governments' support and to convince them of the importance of agricultural research and attract continued future investment (Maredia *et al* 2000; Alston and Pardey 2001). By promoting impact assessment research, research centres, universities and donor agencies react to the concern for demonstration of tangible benefits to society of public research and development investment (Esterhuizen and Liebenberg 2001; Springer-Heinze *et al.* 2001). This is particularly important in an era of economic liberalisation and rising demands on agricultural development policies to pursue the objectives of poverty alleviation and sustainable development (Springer-Heinze *et al*. 2001).

Pingali (2001) presents a comprehensive literature review of impact assessment studies conducted over the past three decades (1970-1999) by CGIAR economists and other scientists. Most of the studies covered in this review address the impact of crop improvement (breeding) research rather than improved crop management. This apparent bias is methodological because as observed by Maredia *et al.* (2000) and Morris and Heisey (2003) tracing the link between improved crop management and agricultural research interventions is difficult.

4.1 EMPIRICAL EVIDENCE FROM CONVENTIONAL IMPACT STUDIES

Despite difficulties in quantifying the benefits of agricultural research (Arnon 1989), its impact has been widespread (Lynam and Blackie 1994). In a study by Echeverria (1990), for example, most of the rates of return (ROR) reported for different crops in different countries in the period between 1958 and 1990 were high compared to normal profit rates in public investments. In another study, Alston and Pardey (2001) disaggregated rates of return by nature of research, commodity orientation and geographic location. The estimated annual rates of return averaged 99.6% for research only, 47.6% for research and extension combined, and 84.6% for extension only. They further point out that the distributions are generally positively skewed, with a significant number of exceptionally high rates of return. Arnon (1989) also points out that most studies show consistently, both on commodity and on a national basis, that the returns are two to three times higher than likely returns from most alternative investment opportunities. In addition, many studies of individual commodities show good return to research investments. From Mexico, an analysis of agricultural productivity from 1940 to 1964 found generally favourable rates of return for research on maize, wheat, sorghum and potatoes and higher returns for wheat than maize (McIntire 1994).

In sub-Saharan Africa a growing number of rates of return studies have been done (Oehmke and Crawford 1996; Anandajayasekeram *et al* 1996; Anandajayasekeram *et al.* 1997; Masters *et al.* 1998; Maredia *et al.* 2000; Karanja 1993; Isinika 1995; Moshi *et al.* 1997). As elsewhere, these studies show favourable returns to research for almost all the crops. Reasons behind the reported success of some of the programs have been suggested. For instance, Ahmed *et al*. (1995) report that a key factor driving the very high return to a research on hybrid sorghum in the Sudan is the relatively low cost and rapid success of the research. The program took advantage of cross-border spillovers thus underscoring the importance of international cooperation in raising the cost-effectiveness of research.

Even though agricultural research has been overwhelmingly successful in terms of rates of return, performance tends to differ between programs. Thus some programs have registered negative rates of returns to research investments (Oehmke and Crawford 1996; Maredia *et al.* 2000). These are attributed to such factors as supply and prices of agricultural inputs and the market for and price of agricultural outputs (Oehmke and Crawford 1996). In the Sudan, the slow evolution of the seed industry and over-reliance on one cultivar alone in the harsh environments where sorghum and millet are produced worked to limit the aggregate gains for a research on the two crops (Ahmed *et al.* 2000:58). Commenting on the limited impact of some research programs, Masters *et al.* (1998:84), write that, "the most compelling general explanation for some programs' failure is simply that local institutions had not (yet) found the right mix of activities to produce cost-effective technologies in those locations". Furthermore, high rates of return to agricultural research are difficult to sustain in environments where inputs are not accessible or affordable to farmers (Maredia *et al.* 2000). Hence the suggestion that "technical, economic, and public policy support need to be combined for increasing productivity and incomes in semiarid areas" (Ahmed *et al.* 2000:63). These studies highlight some policy implications for addressing factors that are external to agricultural research but that have influence on the impact of research based interventions.

4.2 METHODOLOGICAL ASPECTS OF CONVENTIONAL IMPACT STUDIES

Impact assessment is understood as a special form of evaluation that deals with the intended and unintended effects of the project output on the target beneficiaries (Anandajayasekeram *et al*. 1996). Its focus goes beyond the output of research (e.g. seed variety, fertilizer etc.) to determine the effects of research following the application of its product(s). Research-generated knowledge is of limited use unless the intended beneficiaries utilize it (Alston *et al*. 1998). Adoption of the innovations is therefore a prerequisite for obtaining the benefits of investment in agricultural research. This, in the words of Hazell (1999:3) "requires that technologies produced by agricultural research are not only appropriate and profitable for the farmers but that they have access to the necessary knowledge and inputs to adopt technology". Since adoption is an adaptation and experimentation process, and not a one-off event as was generally assumed (Kristjanson and Thornton 2001), benefits that accrue to farmers depend on the intensity of their adoption.

The effects or impacts of agricultural research and development (R&D) are generally categorised into direct product of research, intermediate or institutional and people level impact. Impact assessment is either done before (*ex-ante*) project intervention or after (*ex-post*) project intervention. Assessment of such impacts is mainly done using effectiveness and efficiency analyses (Anandajayasekeram *et al.* 1996). In effectiveness analysis the logical framework is used as a reference to determine the extent to which the project goals have been achieved. Thus a simple comparison is made between research targets and actual or observed performance (achievement). Efficiency analysis assesses the people level impact by comparing the benefits to society from an agricultural R&D and costs incurred in technology development and transfer. These benefits and costs are normally collapsed into a single number, the rate of return (Ibid).

Ex-post methods for estimating rate of return can be divided into two broad groups. The first group falls under surplus approaches. Using these approaches economic surplus calculations are done in terms of index number method and the simple benefit cost approach. In the index number method the price elasticities of demand and supply determine the relative benefits gained by the producers and consumers. The simple benefit-cost approach is a simplified version of the surplus approach or index number method. It assumes inelastic supply and perfectly elastic demand functions. One characteristic feature of these methods is that they calculate the average or internal rate of return, which takes the research expenditure as given and then calculates the rate of return for the project or program in its entirety. With respect to econometric methods, they use the production function in which research and transfer activities are considered inputs and gives the marginal rate of return (MRR) to agricultural R&D. This approach enables the quantification of the returns to the last dollar expended in the research project. Although it is the only method that allows for the separation of the effects of research from those of extension and other support services, its use and usefulness is limited by data requirements (Anandajayasekeram *et al.* 1996).

Even though the rate of return is the most commonly used measure of the economic profitability of agricultural research investments (Oehmke and Crawford 1996), it does not capture other impacts of agricultural research such as improvements in the status of women within the household, improvements in the environment and the sustainability of agricultural production, and improvements in income distribution. Furthermore, Anandajayasekeram and Rukuni (1999) maintain that in several impact studies, it was difficult to separate the effects of research from the impacts of extension and support services because of data problems. Consequently, the ROR was estimated for both research and complimentary services making it impossible to account for the contribution of the different institutions to the realized benefits.

Concern also has been raised that the estimated rates of return to research investments may be biased upward (Arnon 1989; Anandajayasekeram *et al.* 1996). While the belief that public sector agricultural R&D has paid handsome dividends for society as a whole is not questioned, even those who believe that agricultural R&D is a good investment for society may be sceptical about some of the very high reported estimates of rates of return to research (Alston and Pardey 2001). The rather high rates of return are attributed to various reasons. Pingali, for example, observes that, "We ought to recognize, however, that these high rates of return are partly biased by the fact that in general only success stories are incorporated in rate of return studies" (Pingali 2001: 4). However, the basic problem behind such high returns is that of attribution (Alston and Pardey 2001), that is, yield increases that are attributed to research alone may in fact be attributable to several other factors. Failure to take account of effect of research spillins (Traxler and Byerlee 2001) could also explain biased rates of return.

4.3 POVERTY REDUCTION AND IMPACT ASSESSMENT RESEARCH AGENDA

The agenda of impact assessment has recently expanded. This is reflected by the scope of impacts work done at the CGIAR centres, which has expanded from a narrow effort to measure the adoption of modern varieties to research quantifying a wide array of impacts on production, productivity, equity, human health, and environment (Pingali 2001). CGIAR economists have also begun measuring the impacts of policy research and advocacy, training and human capacity strengthening, and networks for technology generation and exchange.

There is growing interest in the donor community in seeking evidence that modern technology has contributed to poverty alleviation (Pingali 2001). Unfortunately, there are also conceptual problems associated with the concept of poverty. There has been a tendency, according to Menz *et al.* (1999), to broaden out the definition of poverty alleviation – from 'simple' measures of income or consumption, to basic needs perspectives. Walker (2000) supports this view when he says: "… The emphasis on poverty alleviation is increasing and is qualitatively changing. Poverty is increasingly defined in an absolute context and in a multi-dimensional sense. In particular, some donors and stakeholders are interested in broadening and deepening the poverty agenda in agricultural research to include enhancement of capabilities and freedoms, empowerment and health, and educational outcomes" (Walker 2000:517).

The linkage of agricultural research to poverty alleviation is difficult to establish. Menz *et al.* (1999) claim that agricultural research cannot be expected to have any direct impact on some of the parameters associated with the broader-based definitions of poverty alleviation, such as access to health and education services. Similar sentiments have been expressed by Walker (2000:518) who observed that, "Generally, trying to encounter impacts on health, educational and political dimensions of poverty in the ex-post evaluation of a particular agricultural technology is akin to looking for a needle in a haystack and is beyond the competency of practitioners who work in interdisciplinary agricultural research".

Examining studies that have been done so far, Alston *et al.* (1998) reported that the vast majority of several hundred case studies on returns to agricultural research are mute about poverty-specific consequences because poverty alleviation did not figure explicitly as an objective in agricultural research. Similarly, Anandajayasekeram and Rukuni (1999) observed that, almost all studies, which they reviewed, estimated the ROR for society's investment but did not explicitly look at the impact of technologies on poverty alleviation. Some studies, however, have attempted to assess the role of agricultural research in poverty alleviation. For example, Altshul (1999) assessed the impacts of post-harvest crop research on poverty alleviation in Northern Ghana. In this study poverty alleviation is not defined but food security and income appear to be the main indicators used in assessing the impact of the project on poverty alleviation. According to the author "Both case studies illustrate the substantial impacts on poverty alleviation that crop post-harvest research can achieve". In another study carried out in Uganda, David *et al*. (1999) assessed the impact of bush bean varieties on poverty reduction at three levels, namely, household income, food security and consumption patterns and gender relations. They also explored factors that enhance or reduce the contribution of varietal improvement to poverty reduction.

Clearly, the few examples presented above point to the difficulties of linking poverty alleviation to agricultural research. In general, Hazell (1999) is very critical of attempts done so far to establish the link between poverty alleviation and agricultural research. His criticisms and the weaknesses he identified in these studies also apply to impact studies in general. To overcome methodological inadequacies of conventional impact studies, Horton (1986:454) advocates the adoption of "broader, interdisciplinary approaches, that while perhaps less elegant or methodologically rigorous, are likely to produce results which are more useful for policy makers, research managers, and donor organizations". Kristjanson and Thornton (2002), based on their experience, are also of the opinion that the multidisciplinary team approach is by far the most beneficial one. They further recommend that the results of informal or participatory approaches and formal surveys need to be linked.

5. IMPACT OF SELECTED RESEARCH PROGRAMMES

5.1 THE PROGRAMMES

Since this study sought to discuss the impact of agricultural research in SHZ and EZ, only four studies that were carried out in these two zones were relevant for this study. The limited number of studies selected for this study is explained by the fact that so far reviews or evaluations at project level have not been done for majority of the 1203 research projects done in the two zones (see Section 3). The four studies covered in this study are by Ashimogo *et al*. (1996); Moshi *et al*. (1997); Anandajayasekeram *et al*. (2001); and TARP II-SUA (2002). Ashimogo *et al.* (1996) assessed the impact of the national coconut development program, which started in 1979 for the period 1993-1996. Moshi *et al.* (1997) carried out an assessment of the maize program over the period 1974-1996. A study by Anandajayasekeram *et al.* (2001) covered six programmes but only four programmes are addressed in this study, namely the bean, roots and tubers, soil and water management, and tillage systems. The other two programmes not covered in the present study were not implemented in EZ and SHZ. The assessment was for the period from 1990-2000. The fourth and final study by TARP II-SUA (2002) assessed four programmes – cassava, rice, pasture and potato for the period between 1980 and 2000. Whereas the programmes covered in the TARP II-SUA (2000) study were all implemented in SHZ and/or EZ, some of the programmes in the other three studies were executed outside of SHZ and EZ. Such programmes are, however, not included in this study. In some cases aggregate data covering areas other than those in the two zones are used.

The four studies used two main approaches to impact assessment. While Ashimogo *et al*. (1996) essentially used effectiveness analysis approach the other studies by Moshi *et al.* (1997); Anandajayasekeram *et al.* (2001) and TARP II-SUA (2002) used the comprehensive impact assessment approach[1]. In using the latter these studies assessed direct, intermediate and people level (economic, social and environmental) impacts. However, in addition to addressing such economic aspects as production and income, Moshi *et al.* (1997) assessed the economic impact of the programme by computing the rate of return (ROR) using the economic surplus approach and simple cost-benefit method. Anandajayasekeram *et al.* (2001), and TARP II-SUA (2002) could not estimate the rate of return to investments in the programmes for technical and logistical reasons.

5.2. ADOPTION AND IMPACT ON CROP YIELD

Understanding farmers' adoption behaviour of agricultural technologies is essential for comprehending impact assessment. Table 3 shows that adoption rates vary between programmes. There is also wide variation of adoption rate within some programmes (e.g. potato programme). Constraints to adoption of the technologies released by the programmes,

[1]Details on this approach are given by Anandjayasekeram *et al.* (1996).

which ultimately impact on their success are also listed. In SHZ, for example, high costs of technologies, namely seed, fertilizer and chemicals constrained the adoption of maize R&D programme technologies. In the case of EZ the constraints were low levels of fertilizer use, poor marketing for inputs and output, pests and diseases (Moshi *et al.* 1997). Regarding pasture technologies, farmers have abandoned the use of fertilizer in pasture production because of low prices of milk. Furthermore, none of the farmers in the Coast region are using the low cost fresh cassava storage technology. The main reason for this is that households do not store cassava for food as they eat freshly harvested cassava. They also don't have to store cassava for the market because traders prefer fresh cassava rather than stored cassava.

Comparison between yield due to research intervention against national average and potential yields of the main food and export crops shows different impact of the programmes (Table 3). Research in bean, and root and tuber contributed to yields that are relatively higher than the estimated potential. Despite recorded increase in productivity due to fertiliser use in maize (3.5 ton/ha) and rice (2 ton/ha), these yields compare poorly with figures from the national average or potential yields for the same crops (Msambichaka 1994). Maize yield of 3.5 ton/ha is well above the national average (0.6-1.5 ton/ha) but below potential yield estimated at 4.0-8.0 ton/ha. Similarly, rice yield (0.2 ton/ha) is both below the national average (1.5-2.0 ton/ha) and existing potential (8.0 ton/ha (Ibid). In addition, the use of fertiliser resulted in the production of 0.8 ton/ha of beans, which is above the national average (0.2-0.7 ton/ha) but below the potential yield of 1.5-3.0 ton/ha (Ibid). Furthermore, wheat yields were at the same level as the national average but below potential yield. Regarding coconut production, the yields were within the target range of the project and above the national average. Also they were about the same as the potential yield range (40-60 nuts/per palm). Generally, these results confirm the existence of a gap between yields at farm level and research station results. The results also point to the existing potential for improving agricultural productivity in the country.

5.3 ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS

Data on economic, socio-cultural and environmental impacts are presented in Table 4. Remarkable economic impact in terms of income is reported for research programmes on bean (Anandajayasekeram *et al*. 2001) and coconut (Ashimogo *et al.* 1996). TARP II-SUA (2002) also gives a similar picture for potato, pasture and rice programmes. An increase in farmers' income from coconut was also reported between 1993 and 1996. While some studies quantify the increase in income others don't. Such increases in income are expected to translate into improved farmers' welfare. On the rate of return, as indicated earlier, only a study on the maize programme estimated it. The study showed that the returns were favourable based on both the economic surplus approach and the simple benefit-cost method.

The studies also report on the socio-cultural impacts of the programmes in the form of gender and food security. In the case of gender impact, the tillage programme empowered women by making them less dependent on men as a result of change in gender division of labour. Sharing of opinion and allocation of income obtained from bean sales between wife and husband was attributed to the bean programme intervention. The technology promoted by the cassava programme helped reduce women's workload and time spent in processing cassava flour. Furthermore, increased involvement of women in potato petty trading was reported for the potato programme. While these are laudable achievement less is known, for example, whether these impacts translated into improved welfare of women farmers.

Table 3: Released technologies, adoption rate and yield impact of selected R&D programmes

Research and development programmes	Produced or released technologies[1]	Adoption rate/use of recommended technologies	Crop yield
Bean	5 varieties	70% farmers in SHZ using seed sorting method to control seed borne diseases	Over 200% increase in farm yield level (from 400 – 700 Kg/ha to 1000-1500 Kg/ha)
Root and tuber	2 sweet potato varieties for the whole of the country[2]	80% farmers growing Simama variety	Improved sweet potato and cassava varieties have out yielded local varieties at farm level by about 150%
Soil and water and, tillage systems	- Cultivators for opening straight parallel planting furrows using animals	- 50 farmers in five villages in Mbozi district have adopted cultivators using animals for opening straight parallel planting furrows	
	- Mineral fertilizer recommendations for food and cash crops	- 40%, 40%, 20% and 25% of farmers apply fertiliser in maize, beans, rice and wheat respectively	Yield gains (tons/ha) due to application of fertilisers for selected crops are: maize (3.5 ton/ha), beans (3.5 ton/ha), rice (2 ton/ha), wheat (1.5 ton/ha)
Maize	15 varieties (10 adapted to SHZ) and 12 agronomic recommendations (10 appropriate for SHZ)	-	38% increase in yield from 1.03 ton/ha in 1970-1975 period to 1.42 ton/ha in the 1985-1992 period[3]
Coconut	-	-	38 and 40 nuts/palm/year for Mainland priority and Mainland non-priority zones against the project target of 30-40 nuts/palm/year
Cassava	Agronomic packages	98% of farmers using row planting	-
Pasture	11 cultivars for EZ	90% of dairy farmers using pasture species	- 3.8-11.5 ton/ha - milk yield increased by 49.6%.

[1] Excludes technologies that have been recommended for release, but not yet released
[2] Grown by farmers though not formally released
[3] Data presented for the maize program were aggregated at national level

Table 3 continued

Potato	7 varieties of round potatoes and agronomic packages	- 10 – 100% farmers using improved varieties - Majority of farmers using fungicide and row planting	85-90 bg/acre
Rice	More than 10 varieties and agronomic packages	- Only 5% of 57 surveyed farmers in Kyela (EZ) adopted Afaa Mwanza - Majority of farmers using agronomic recommendations e.g. ploughing and two harrowing; weeding and herbicide	2 ton/ha

Source: Ashimogo *et al.* (1996); Moshi *et al.* (1997); Anandajayasekeram *et al*. (2001); TARP II-SUA Project (2002)

According to Table 4, almost all programmes contributed to improvement in household food security. This was mainly as a result of increased crop production. For example, Moshi *et al.* (1997) observed that since maize is grown for home consumption an increase in maize sales implied increased surplus maize production in the area. In other words, farmers only sell the crop after meeting household consumption needs. Anandajayasekeram *et al.* (2001) and TARP II-SUA (2002) use a similar argument. However, experience shows that the argument advanced in these studies is based on a flawed assumption. This is because in most cases cash obligations such as payment of school fees and health services force farmers to sell their food produce even when their consumption needs are not met. This argument is supported by a finding by TARP II-SUA (2002). The study reported that, although women in EZ appreciated that rice yields had increased, they complained that their husbands disposed paddy without consulting them and thus affected the food security of their households. In such circumstances increased production does not necessarily guarantee ones household food security. Linking food security to household production, according to Gladwin *et al*. (2001), characterized the initial thinking about food security in Africa. Currently, however, food security is understood as not simply a function of household food production, but is linked, often to the overall livelihood strategies of households (Sutherland *et al*. 1999: 365). Besides inadequate aggregate food production, food security is viewed as an issue of household income and poverty (Gladwin *et al*. 2001) and as a question of equity, distribution, power and politics (Haug 1999; Haug and Teurlings 2001). In short, there is more to food security than mere production.

Table 4 also presents data on environmental impact of the programmes. As the data show impact assessment for all the programmes was qualitative in nature. At the centre of this assessment are the types of farmers' practices, which contribute to environmental conservation or degradation. Generally, farmers' practices and those promoted by some programmes were environmentally friendly. However, it would appear that the limited environmental impacts of some technologies occurred because farmers were not able to purchase the technologies. In other words, lack of cash meant that farmers could not buy fertilizer or insecticides, which in the long run, without careful management, would contribute to environmental degradation. In this and similar cases it would be inappropriate to attribute the state of the environment to research intervention. In general, the qualitative approach to impact assessment is limited in terms of providing an understanding of the magnitude of the impact of these practices on the environment. Combined use of both qualitative and quantitative approaches could have provided a much better environmental assessment of the impacts of the programmes.

Table 4: Economic, social and environmental impacts of selected R&D programmes

Research and development programme	Type of impact		
	Economic	Socio-cultural impact	Environmental
Bean	Household income increased from 140,000 – 370,000 Tshs/ha	- Husband and wife share in Joint decision making in bean crop production and disposal of income from the crop - Beans contribute to food security and nutritional status of farm families	- Beans improve soil fertility - Positive environmental consequences due to breeding resistant varieties and use of IPM to control pests and diseases
Root and tuber	-	Improvement in food security	-Use of biological control agent and varieties resistant to cassava mosaic disease and other diseases have made use of chemical control unnecessary and hence less environmental contamination
Soil and water, and tillage systems	-	- Women who have adopted weeding technology are less dependent on husbands - Following the adoption of weeding technology women have taken over activities which used to be done by men	Cultivator technology in maize reduces run-off and improves moisture retention in soils
Maize	IRR was 23% for the Akino-Hayami method and 19% for the simple benefit-cost method	Contribution to household and national food security	- Control of soil erosion through row planting by 90% of the farmers - Breeding for pest and disease resistance reduce need for chemical treatment in field and storage - Crop rotation and intercropping with legumes and ploughing under the crop residues improves the soil texture, structure and quality - Limited environmental pollution due to continuous use of inorganic fertilizers and residual effects of insecticides (e.g. DDT) - Slash and burn cultivation opens up land for soil erosion

Table 4: continued

Coconut	- Income from sale of coconut by-products increased - Income increased between 1993 and 1996	-	-
Cassava (EZ)	Improvement in household income	- Introduced technologies have reduced women workload and time spent in processing cassava flour - Improvement in food security	- Use of biological control against cassava mealy bug - Use of cassava processing technologies friendly to environment.
Pasture	Increase in household income by 50%	Improvement in nutrition status through milk consumption	- In EZ farmers used grass as mulch to conserve soil moisture; soil erosion control through bench terraces planted with elephant grass in EZ; - Use of crop residues in SHZ harmful to environment.
Potato (SHZ)	Incomes increased from 50,000-475,000 T.shs	- Improvement in household food security - Improved housing - More women involved in potato petty trading	- Incorporation of heavy plant biomass followed by rotation with maize improves soil fertility - Lifting up soil to form ridge during weeding reduces soil erosion - Reduction in vegetation cover - Absence of fallowing and crop rotation
Rice (EZ)	Positive impact on household income in EZ	- Positive impact on food security - Empowerment of women through membership in groups. Enabled women to earn income from sideline farms hence allowing husbands to invest their income in durable assets such as improved houses.	Increased rice yields reduce the need for expanding farms into marginal and environmentally fragile areas.

Source: Ashimogo *et al.* (1996); Moshi *et al.* (1997); Anandajayasekeram *et al.* (2001); TARP II-SUA Project (2002)

6. CONCLUDING REMARKS

In this study the role of agricultural research carried out during the period 1980 – 2000 in SHZ and EZ of Tanzania in poverty reduction is discussed. The capacity of existing impact studies to give adequate information on the poverty reducing effect of agricultural research is examined. During the reference period a total of 1203 research projects were conducted in SHZ and EZ during the period. Most of these projects have not been evaluated hence the reliance of this study on only four studies. Despite this some general observations can be made from these studies. The rate of adoption of technologies varied between the selected programmes. Equally important is the fact that the rate of adoption of the technologies was limited by various constraints some of which were external to the programmes. Other technologies were not adopted because they did not address the felt needs of the farmers. Except for the coconut programme, the impact of the other programmes on crop yield was limited. Although farmers realized increased yield for the other crops (beans, maize, wheat and rice), the increase was found to be well below existing potential.

Turning to the question on our title, does agricultural research reduce poverty among smallholder farmers? While existing impact studies give good information on technology generation, adoption and yield increases, other aspects like food security, gender and environmental impacts are not adequately examined. On the basis of this information it is difficult to tell the contribution of agricultural research to poverty reduction. However, these studies point to the potential of agricultural research to contribute to poverty reduction through increased income and improvement in food security.

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