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**Impact of Agricultural Research: A Study of On-Farm
Development Effects of Agricultural Research in Southern
Highlands and Eastern Zones of Tanzania**

Doctoral Thesis
Development Studies

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Abstract

This study focuses on the role of agricultural research in development. In particular, the study draws on the experiences based on agricultural research conducted during the period 1980-1990 in the Southern Highlands and Eastern Zones of Tanzania. The two zones are part of a total of seven agricultural research zones of the National Agricultural Research System (NARS), managed by the Department of Research and Development in the Ministry of Agriculture and Food Security. The findings reported in this study are based on a review of earlier impact studies and fieldwork focusing on the impact of rice research programmes in the two zones. The latter, in particular, paid attention to the adoption of selected rice research-based innovations, impact of rice research on food security, and the economic costs and benefits of rice research. The review of the impact studies shows that, unlike at the international level where, since the 1990s, attention has largely focused on the poverty reducing effects of agricultural research, no similar attention has been given to the role of agricultural research in poverty reduction in Tanzania. This fits in within a broad context in which agricultural research and extension have hardly been sufficiently able to address the needs of the poor farmers. Moreover, the limited use of selected rice research-based innovations is further evidence of the inability of agricultural research to generate innovations that cater for the different categories of farmers including the poor. This study also shows a weak impact of rice research on food security. Although this could be attributed to the limited impact of rice research on crop productivity, the multiple livelihoods that farmers seek to achieve through rice production imply that food security should be understood in the context of livelihood strategies pursued by the farmer. In reference to the economic impact of rice research, besides the rates of return, which vary widely depending on assumptions informing the analysis, the study also found great fluctuation of the benefits of research reflecting the unstable nature of rice farming carried out under rainfed conditions and limited inputs.

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General introduction

1. Science, technology and agriculture

Science is considered to be a foundation of development because it is a basic source of technologies or innovations used in human endeavours. The practical application of science in the form of technologies to bring about development is of particular interest¹. In agriculture, the use of technologies generated by agricultural research is seen essential to improve productivity. Writing on the role of science in agriculture about four decades ago, Schultz (1964) maintained that what matters are man-made differences in the way the land is used rather than its natural condition. According to Schultz such difference is defined by the knowledge that the farmers possess. This thinking has informed the promotion of agriculture based on the application of scientific knowledge.

Although there are mixed views about the Green Revolution (see for example Shiva 1991; Holmen 2003), it is still seen as an illustration of a success story of an agriculture that is built on the strong foundations of agricultural research. The International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT) based in the Philippines and Mexico respectively, pioneered this revolution in the 1960s following their generation of high yielding dwarf varieties of rice and wheat. Later on these varieties were rapidly adopted in many areas of the Third World and are credited for the tremendous increase in wheat and maize yield in both Latin America and Asia (Statz and Eicher 1990). Normally the discussion on the green revolution and agricultural change tends to focus on its technological aspects. This is in keeping with the transfer of technology model in which agricultural research is considered the source of change². Based on this model agricultural research generates innovations, which are transferred by the extension service to farmers. However, experiences with the green revolution or agricultural change in general reveal that extra-technological aspects such as credit and markets (Holmen 2003) are also crucial in facilitating the use of technologies. Moreover, policy intervention is important to ensure that these extra-technological aspects are not only made available but also accessible to the farmers.

2. Assessing the impact of agricultural research

It is evident that most attempts to launch a Green Revolution in sub Saharan Africa have not been successful (Holden and Shanmugaratnam 1995; Larsson et al. 2002; InterAcademy Council 2004; UN Millennium Project 2005), as has been the case in Latin America and Asia. But the poor performance of this revolution has drawn attention to issues connected with the use of innovations generated by agricultural research in agricultural production, especially their use among smallholder farmers. In turn, this has increased the interest in gaining a better understanding of the role of agricultural research in development in developing countries. Whether resources invested in agricultural research have had impact on development merits investigation. This is particularly important in a country such as Tanzania where impact studies that measure the long-term on-farm impacts several years after the end/closure of research projects hardly exist. Seeking to bridge part of the knowledge gap concerning long-term effects in the field, this study aims to assess the impact of agricultural research done in two different agricultural research zones, the Southern Highlands Zone (SHZ) and Eastern Zone (EZ) of Tanzania, during the period 1980-1990³. The specific objectives are to (1) review impact studies with reference to their focus and methods used; (2) explore the adoption of selected rice research-based innovations in rice farming; (3) assess the impact of rice research on food security; and (4) assess the economic costs and benefits of rice research.

Impact assessment is understood as “a special form of evaluation that deals with the intended and unintended effects of a project’s output on the target beneficiaries (also called people level impact)” (Anandajayasekeram et al. 1996: 47). Bellamy (2000:5) more specifically views impact studies as aiming to “measure not only the reactions of the beneficiaries and the outputs generated by them, but also the proportion of any discernible change attributable to the project”. As Morris et al. (2003) put it; these outputs are not the ultimate aim of investment of resources in agricultural research. Rather they are the means towards achieving some ultimate goals, which may include bringing about improvements in broad measures of human welfare, such as poverty and hunger, food security, health and nutrition.

In this study impact assessment of agricultural research is understood as seeking to determine the effects of research on the farmers following the application of its outputs (e.g. crop variety, fertilizer recommendation). Understanding impact assessment of agricultural research

in Tanzania requires an understanding of the context in which it has been carried out. In the following sections an outline of the Tanzanian context in terms of economic policies as they relate to the agriculture sector and the institutional set up of agricultural research and extension is presented. In this context, the dominant approaches to agricultural research and extension are also presented.

3. Economic policies and agriculture

Located in sub Saharan Africa, Tanzania has a total area of 94,520,000 ha and a population of 34, 443, 603⁴. Tanzania is a low-income country with a gross national income per capita at 270 USD in year 2001 (World Bank 2003: 16), meaning that the average population is well below the commonly used absolute poverty line of 1 dollar per day. Agriculture employs about 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). Except for the experiment on collective agriculture between late 1960s and early 1970s, which was abandoned around mid 1970s (Lofchie 1978; Mapolu 1990; Havnevik 1993); agriculture has been largely a private undertaking. 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 her people but also, in some years, to export some food (Lofchie 1978; Tapio-Biström 2001).

Tanzania faced an agricultural crisis in late 1970s and early 1980s. During this period the 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. This crisis was, according to Tapio-Biström (2001), Lofchie (1978), and Lofchie (1989), explained by, among others, the oil crisis, war with Uganda as well as the government marketing and pricing policy.

According to Havnevik and Skarstein (1985), there is a tendency among Tanzanian officials to attribute poor agricultural performance to external factors while disregarding 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. By the mid-1990s, as a result of implementing economic reforms, ‘Tanzania had become a much more market-oriented country with a friendly attitude to business ...’(Ponte 1998:331). The agricultural adjustment programme implemented in the late 1980s and early 1990s involved, among others, abolishment of most domestic market controls on food crops and liberalization of producer prices for the main agricultural products (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). A number of factors contributed to the good performance of both export and food crops in the late 1980s and early 1990s. These include good weather and policy changes under the structural adjustment programme. The latter contributed to markedly improved availability and distribution of inputs, and availability of consumer goods, which provided the incentive to increase production among the rural dwellers (Havnevik 1993; Ministry of Agriculture 1993; Kaduma 1994). However, the noted improvement in agricultural production was largely achieved through expansion of land under production rather than increased crop productivity. Hence, agricultural productivity on small farms has remained generally low (Msambichaka 1994). Low use of research-based technologies is one of the reasons for low agricultural productivity, which raises concerns regarding the conduct of both agricultural research and extension in the country.

4. Agricultural research and extension in Tanzania: past and present

4.1 Policy and institutional set up

In Tanzania agricultural research and extension have largely been a public undertaking. 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 the mid 1960s that the promotion of food crops became the major preoccupation of agricultural research. Most recently, the main objectives of agricultural research in Tanzania have been the promotion of food self-sufficiency, diversification, income generation, employment growth, and export enhancement (Shao 1994). These objectives are to be achieved through:

- Characterization, evaluation and conservation of natural resources;
- Generation, adaptation, and the promotion of adoption of technologies which can increase productivity, employment opportunities, income, and equity;
- Developing sustainable production systems;
- Providing efficient methods of processing, marketing and utilization of both food and non-food products;
- Dissemination of research findings to end users including extension workers, farmers, policy makers, scientists and teachers

To reach smallholders who produce most of the food crops in the country, the farming systems research (FSR) approach was introduced during the 1970s instead of the commodity approach advocated earlier (Liwenga 1988). From the 1980s, and especially after reorganisation of the research system in the 1990s, the research policy emphasises the use of a farming systems approach (FSA) to address the constraints faced by smallholder farmers.

Tanzania's agricultural research during the period from 1970 to early 1990s was characterized by frequent organizational changes (Liwenga 1988; Tanzania. Department of Agricultural Research and Training 1991). The last major change in organizational set up of research was executed in the early 1990s. Following this change the Directorate of Research and Development (DRD) of the Ministry of Agriculture and Food Security has been the lead institution of the National Agricultural Research System (NARS) for both crops and livestock, even though currently 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 such as the Tea Research Institute of Tanzania (TRIT) and

Tanzania Coffee Research Institute (TACRI) are also constituent part of the National Agricultural Research System (NARS).

Following the provision for private sector based research, the current NARS “is a loose conglomeration of multiple, public and private sector institutions” (Sempeho 2004:2). Thus the involvement of the private sector can be seen as an attempt to diversify sources of funding for agricultural research and reduce over dependence on donor funding (Shao 1994; Ravnborg 1996; Pardey et al. 1997). In particular, the private sector is expected to play a significant role in supporting research on traditional cash crops such as coffee and tea. Mainstream public-financed research under NARS is conducted in seven agro-ecological zones - Eastern, Western, Northern, Central, Lake, Southern and Southern Highlands with each zone having a mandate for certain priority research programmes (Table 1)⁵.

Table 1: Agricultural research centres and programmes in Tanzania

Zone	Institute/Centre	Programs
Lake	Ukiriguru	Cotton, Roots and Tubers
	Maruku	Banana and Coffee
Southern Highlands	Uyole Centre	Ruminant Milk and Meat (Animal Nutrition) Pyrethrum, Potatoes, Agricultural Engineering
	Kifyulilo	Tea
Northern	Selian	Wheat and Barley, Phaseolus Beans
	Lyamungu	Coffee
	Tengeru	Horticulture

Table 1 continued

Zone	Institute/Centre	Programs
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	Cashew nut, Oil seeds, Roots and Tubers
National	National Coconut Development Programme	Coconut
	DRD Headquarters	Farming Systems Research/Agricultural Economics
	Animal Disease Research Institute (ADRI), Temeke	Animal Health and Diseases
Others	SUA and TPRI	Post Harvest Technology Non Ruminant, Meat Production (Poultry/Piggery)

Source: Shao (1994)

SUA= Sokoine University of Agriculture TPRI= Tanzania Pesticide Research Institute

The extension service has also experienced changes in approaches, as well as institutional changes (Mvena and Mattee 1988; Sicilima and Rwenyagira 2001; Sicilima 2005). Despite the pluralisation of extension provision, the national extension service managed under the local government administrative structure remains the main provider of extension services catering for about 3.5 million farm families in the whole country (Sicilima and Rwenyagira 2001). The reforms implemented by research and extension systems so far are in line with the 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 more 'pluralistic' and 'demand-driven' (Gibbon 2000).

4.2 Carrying out agricultural research and extension

In spite of these reforms in the field of research and extension little has been achieved in ensuring that agricultural research is demand-driven. This, as Ravnborg (1996) points out, is due to the fact that the effected changes were informed by the perception that the problems of agricultural research were management issues involving finance and organization. Hence little attention was paid to the relevance of research content to farmers. This remains the situation today. There is still "a tendency to provide farmers/clients with pre-determined package of research-designed technology instead of carefully adapting the technology to individual farmer/client needs" (Sempeho 2004:3). This, according to the author quoted, is partly the result of weak mechanisms for establishing research-extension-client linkages. He also partly attributes it to the low capacities of the farmers in articulating their needs. In addition, he observes that "past research has focused more on production-enhancing technologies without concurrent attention to problems that limit access to markets and profitability" (Ibid: 3). Based on the above, it appears that inability among farmers to express their needs is seen as unrelated to the approaches employed in agricultural research so far.

Interactions between extension and farmers are important especially as regards the use of research-based innovations among farmers. How farmers and extension staff interact would depend greatly on the extension approach used⁶. In Tanzania, currently extension is expected to empower farmers through participatory experiential learning approaches. This is expected to be achieved through the Training and Visit (T&V) approach. This approach is used in the country not only because "it is more effective than the systems used previously" but also because "no clear alternative is available that can be used nation wide" (Van den Ban and Mkwawa 1997:117). However, the fact that T&V has not been able to promote participatory

experiential learning approaches (MAC 2000) is not surprising given the top-down nature of the approach.

On the other hand, inability to establish participatory research and extension as well as more linkages among research, extension and farmers is not due to the absence of mechanisms that promote linkages. These, as noted by Ravnborg (1996), are provided for under the reformed research and extension system established in Tanzania. Overall, it would appear that the problem is that the existing linkages are weak. Summing up the implications of weak linkages on agricultural research, Ravnborg (1996: 71) writes: "Given the poor functioning of the linkage mechanisms between research, extension and farmers, and particularly of the mechanisms intended to provide feedback from farmers to researchers, there is little 'formal' guarantee that research is planned in response to farmers' needs and circumstances". However, according to recent reports (e.g. MAC 2000; Sempeho 2004), there is growing awareness of the need to address problems that hold back the achievement of demand-driven research and extension.

5. The study areas

As noted earlier, the present study covers two of the seven agricultural research zones in the country, namely the Southern Highlands Zone (SHZ) and the Eastern Zone (EZ). In terms of occupation, residents in these areas undertake farming as their major occupation like most of the people in other parts of the country. The four regions comprising the SHZ (Iringa, Mbeya, Rukwa and Ruvuma) are locally known as the 'big four' in apparent reference to their being the main source of maize, the main staple in the country. But over time the level of maize production has been declining. This is usually attributed to the decline in the use of inputs such as fertilizer triggered by the removal of subsidy to agricultural inputs. The farmers in the EZ comprising the regions of Tanga, Morogoro, Coast and Dar-es-Salaam are more diversified in terms of crop production. Furthermore, they have a relative advantage for having close proximity to the Dar-es-Salaam market compared with farmers in other parts of the country.

6. Choice and use of analytical frameworks

In this study the innovation diffusion theory is used as the framework of analysis of adoption of innovations. This choice was made while aware of its shortcomings as well as its influence on the conduct of agricultural research and extension (Rogers 1995; Christoplos and Nitsch 1996; Haug 1999; Douthwaite 2002; Stephenson 2003).

However, this theory is used as a point of departure thus allowing the use of another approach, namely the actor-oriented approach in the analysis of the qualitative data collected to investigate the same phenomenon. This approach is also used in the analysis of the impact of rice research on food security, whereby first the production-based framework of analysis is used followed by the sustainable livelihood (SL) framework. In the analysis of the economic costs and benefits of rice research, the economic surplus approach is used as the appropriate approach given the data collected.

7. Main findings of the study

Based on the research inventory, a total of 1203 agricultural research projects were implemented during the 1980s and 1990s in the EZ and SHZ of the Tanzania. Nevertheless, most of these projects have not been assessed for their impact. Also, it is evident from the study that the few impact studies that have been reviewed have not specifically addressed the impact of agricultural research on poverty reduction, as is the case at international level where the subject has attracted increased attention among scholars. Instead these studies have sought to assess the impact of agricultural research by focusing on production, economic, social cultural, and environment aspects.

With regard to the adoption of selected innovations in rice farming, the study reveals that the diffusion of innovations model, which views the use of innovations in static terms of “adoption-rejection” masks the dynamics that underlie rice production among smallholders. From the actors’ point of view, it is shown that contextual elements especially inadequate credit and marketing arrangements greatly influence decision making among farmers regarding the use of these innovations. Moreover, these elements help explain the adaptation and discontinuation of innovations among farmers.

The rates of return depend on the yield benefits. These benefits fluctuate substantially from one year to another. This is better reflected at regional level where rice yields tend to fluctuate from year to year, and thus affecting the flow of benefits. Besides, while the rate of return is affected by rice yields, the relationship between rice yield and household food security is weak. In fact, in the context of this study food security forms part of the broad household livelihood strategies and, therefore cannot be understood outside of these strategies.

8. Outline of the dissertation

The remainder of this dissertation is organized into the following four papers:

1. Dismas L. Mwaseba, Fred H. Johnsen, Susan Nchimbi-Msolla, and Patrick J. Makungu. A review of impact studies of agricultural research in Tanzania. Submitted to the *Journal of Peasant Studies*.
2. Dismas L. Mwaseba, Randi Kaarhus, Fred H. Johnsen, Zebedayo S.K. Mvena, and Amon Z. Mattee. Beyond adoption-rejection of agricultural innovations: empirical evidence from smallholder rice farmers in Tanzania. Submitted to *Outlook on Agriculture*.
3. Dismas L. Mwaseba, Randi Kaarhus, Fred H. Johnsen, Amon Z. Mattee, and Zebedayo S.K. Mvena. Rice for food and income: assessing the impact of rice research on food security in Kyela and Kilombero Districts of Tanzania. Submitted to the *Quarterly Journal of International Agriculture*.
4. Dismas L. Mwaseba, Fred H. Johnsen, Randi Kaarhus, Zebedayo S.K. Mvena, and Amon Z. Mattee. An *ex-post* impact study on the economic costs and benefits of rice research in Tanzania. Submitted to *World Development*.

Notes

¹Röling (1997:2) sees technology as being used for controlling “the environment so as to make it productive, provide protection and comfort, and remove enemies and competitors, be they other people, animals, plants or diseases”.

²cf Rhoades (1988) who chronicles four overlapping stages of awareness and perception of problems related to agricultural research and development. These are production stage (1950-1975); economic stage (1985-1995); ecological stage (1985-1995) and institutional stage (1995-). Besides each stage being characterized by different goals and disciplines, Rhoades’ scheme reflects the evolution of approaches to agricultural research in particular

as it relates to the researchers' perceived role of farmers in research in each of the four stages. Thus during the early stages the role of farmers is minimal but is perceived to be of great importance in the last stage.

³It was carried as part of the on-going TARP II-SUA project currently implemented in Tanzania whose objectives include assessment of impact of rice research in the two zones. By focusing on the impact of agricultural research, this study pays attention to the use of innovations generated by agricultural research. This implicitly means a disregard of other sources of innovations in agricultural production.

⁴Based on the 2002 national census.

⁵These agro-ecological zones are broadly defined and follow regional boundaries (Ravnborg 1996).

⁶In an extensive review Haug (1999) draws attention to the evolution of extension theory as well as issues that feature in international debates on extension. Drawing on her review and extension practice in Tanzania it is apparent that there is a huge gap between extension theory and practice on the ground. The same appears to be the case with agricultural research.

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Paper 1

A review of impact studies of agricultural research in Tanzania

A review of impact studies of agricultural research in Tanzania

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Abstract

This article reviews the state of the art in impact assessment in agricultural research in Tanzania. In particular, it highlights on the focus and methods used in impact assessment based on impact studies conducted in the Southern Highlands and Eastern Zones of Tanzania. Overall this review shows that the impact of agricultural research on poverty reduction has not been specifically addressed in these studies, as is the case at international level. Instead the review reveals that impact studies done so far in the two zones have dwelt on assessing the impact of agricultural research on production, economic, social and environmental aspects. Lack of attention to poverty reducing effects of agricultural research in impact assessment reflects a situation where both agricultural research and extension are not geared to addressing the needs of poor farmers who form the majority of the farming population in the country.

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 result in economic growth and poverty reduction simultaneously' (Borlaug and Dowsell 1995:128).

Others, however, have been more critical to the green revolution mainly based on high-yielding crop varieties, chemical fertilisers, pesticides and irrigation. The green revolution has been 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).

These 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). This paper gives an overview of the focus and methods used in impact assessment in agricultural research in Tanzania¹ as compared to developments at global level. This is done based on impact studies conducted in the Southern Highlands (SHZ) and Eastern (EZ) zones in the country². The review is done after an outline of the context of agricultural research and extension as well as research activities in the two zones.

2. Agricultural research and extension systems in Tanzania

Tanzania is a low-income country with a gross national income per capita of 270 USD in year 2001 (World Bank 2003: 16), meaning that the average population is well below the absolute poverty line at 1 dollar per day. Agriculture employs about 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). 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 her people but also, in some years, to export some food (Lofchie 1978; Tapio-Biström 2001).

Tanzania faced an agricultural crisis in late 1970s and early 1980sⁱ. During this period the growth rates of agricultural production declined to 2.3%, 1.8% and 0.6% during 1970-75, 1975-80 and 1980-85 respectively (Kaduma 1994:92). These growth rates were well below the population growth rates, causing agricultural production per capita to decline. This crisis was explained by, among others, the oil crisis, villagization, war with Uganda as well as the

government marketing and pricing policy (Tapio-Biström 2001; Lofchie 1978; Lofchie 1989). To improve the economic performance, economic reforms were adopted in the mid 1980s in line with the International Monetary Fund (IMF) and the World Bank policies.

Following these reforms 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). A number of factors contributed to the good performance of both export and food crops in the late 1980s and early 1990s. These include good weather and policy changes under the structural adjustment programme. The latter contributed to markedly improved availability and distribution of inputs, and availability of consumer goods, which provided the incentive to increase production among the rural dwellers (Havnevik 1993; Ministry of Agriculture 1993; Kaduma 1994). However, the noted improvement in agricultural production was largely achieved through expansion of land under production rather than increased crop productivity. Hence, agricultural productivity on small farms has remained generally low (Msambichaka 1994). Low use of research-based technologies is one of the reasons for low agricultural productivity that raises concerns regarding the conduct of both agricultural research and extension in the country.

In Tanzania agricultural research and extension have largely been a public undertaking. Over the past three decades Tanzania's agricultural research has been characterized by changes in approach and frequent organizational changes (Liwenga 1988; Tanzania. Department of Research and Training 1991). The last major change in organisational set up of research was executed in the early 1990s. Following this change 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 currently livestock falls under the mandate of the Ministry of Water and Livestock Development.

Mainstream public-financed research under NARS is conducted in seven agro-ecological zones - Eastern, Western, Northern, Central, Lake, Southern and Southern Highlands with each zone having a mandate for certain priority research programmes. Following the provision for private sector based research, the current NARS "is a loose conglomeration of

multiple, public and private sector institutions” (Sempeho 2004:2). Thus the involvement of the private sector can be seen as an attempt to diversify sources of funding for agricultural research and reduce over dependence on donor funding (Shao 1994; Ravnborg 1996; Pardey et al. 1997).

The extension service has also experienced changes in approaches as well as institutional ones (Mvena and Mattee 1988; Sicilima and Rwenyagira 2001; Sicilima 2005). Despite the pluralisation of extension provision, the national extension service managed under local government administrative structure remains the main provider of extension services catering for about 3.5 million farm families in the whole country (Sicilima and Rwenyagira 2001). 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 more ‘pluralistic’ and ‘demand-driven’ (Gibbon 2000).

In spite of these reforms on research and extension little has been achieved in ensuring that agricultural research is demand-driven. This, as Ravnborg (1996) points out, is due to the fact that the effected changes were informed by the perception that the problems of agricultural research were management issues involving finance and organization. Hence little attention was paid to the relevance of research content to farmers. This remains the situation today. There is still “a tendency to provide farmers/clients with pre-determined package of research-designed technology instead of carefully adapting the technology to individual farmer/client needs” (Sempeho 2004:3). This, according to the author quoted, is partly the result of weak mechanisms for establishing research-extension-client linkages. He also partly attributes it to the low capacities of the farmers in articulating their needs. In addition, he observes that “past research has focused more on production-enhancing technologies without concurrent attention to problems that limit access to markets and profitability” (Ibid: 3). Based on the

above, it appears that inability among farmers to express their needs is seen as unrelated to the approaches employed in agricultural research so far.

Interactions between extension and farmers are important especially as regards the use of research-based innovations among farmers. How farmers and extension staff interact would depend greatly on the extension approach used⁴. In Tanzania, currently extension is expected to empower farmers through participatory experiential learning approaches. This is expected to be achieved through the Training and Visit (T&V) approach. This approach is used in the country not only because “it is more effective than the systems used previously” but also because “no clear alternative is available that can be used nation wide” (Van den Ban and Mkwawa 1997:117). However, the fact that T&V has not been able to promote participatory experiential learning approaches (MAC 2000) is not surprising given the top-down nature of the approach.

On the other hand, inability to establish participatory research and extension as well as more linkages among research, extension and farmers is not due to the absence of mechanisms that promote linkages. These, as noted by Ravnborg (1996), are provided for under the reformed research and extension system established in Tanzania. Overall, it would appear that the problem is that the existing linkages are weak. Summing up the implications of weak linkages on agricultural research, Ravnborg (1996:71) writes: “Given the poor functioning of the linkage mechanisms between research, extension and farmers, and particularly of the mechanisms intended to provide feedback from farmers to researchers, there is little ‘formal’ guarantee that research is planned in response to farmers’ needs and circumstances”. However, according to recent reports (e.g. MAC 2000; Sempeho 2004), there is growing awareness of the need to address problems that hold back the achievement of demand-driven research and extension.

3. Agricultural research in Southern Highlands and Eastern Zones

The following description of research activities in the two zones draws 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 1 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 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 – (i) crops, (ii) livestock, (iii) agricultural engineering, processing and storage, (iv) socio-economic/farming systems research and (v) others. Crops and livestock research are further categorised into sub themes as indicated in Table 1. 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.

Based on data in Table 1, the following general observations can be made: (i) For all types of research (excluding research with unknown 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, 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 1: Agricultural research activities in EZ and SHZ

Research theme	Implementation period			Total
	≤1980 No. of research projects*	1980+ No. of research projects	Not known 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 for Eastern Zone	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 for Southern Highlands Zone	172	317	25	514
Grand Total	298	634	271	1203

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

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

4. Impact assessment in agricultural research: state of the art

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: 47). There are three broad categories of impact assessment. These are the direct outcome of the research activities, the institutional impact, and the people level impact (Ibid). According to Morris et al. (2003) impact assessment can be forward looking (*ex-ante*) or backward looking (*ex-post*). The former is intended to project the impact of research that is underway or to be initiated while the latter aims to document and evaluate the impact of research that has already been conducted.

Anandajayasekeram et al. (1996) identify two types of analyses employed in impact assessment in agricultural research, namely effectiveness and efficiency analyses. In effectiveness analysis the logical framework approach 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). On the other hand, efficiency analysis assesses the people level impact by comparing the benefits to society from agricultural research and development (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. Other studies have employed the comprehensive impact assessment framework (see for example, Esterhuizen and Liebenberg 2001). In short, this approach involves the use of indicators and allows for the three categories of impact – direct, intermediate and people level- to be addressed simultaneously (Anandajayasekeram et al. 1996).

Pingali (2001) and Morris et al. (2003) have done extensive reviews of the state of the art in impact assessment in agricultural research. As Pingali (2001) observes the focus of impact assessment work at the Consultative Group on International Agricultural Research (CGIAR) centers “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 2001:12). The short review below is, therefore, limited to highlighting some developments on impact assessment in agricultural research at international level as they relate to the impact of agricultural research on poverty, which has become the centre of attention in this field.

4.1 Agricultural research and poverty reduction

Impact assessment in agricultural research has become more oriented to addressing the role of agricultural research in poverty reduction. This is as a result of growing interest in the donor community in seeking evidence that modern technology has contributed to poverty alleviation (Pingali 2001). Moreover, poverty reduction has become a policy goal at both national and international levels. As shown below the studies on impact of agricultural research on poverty reduction differ in approaches. 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. More or less using a similar approach, David et al. (2003) in their study carried out in Uganda 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.

Furthermore, using changes in poverty levels and regression techniques Gottret and Raymond (2003:224), found that “the emergence of the cassava-drying agro-industry encouraged both directly and indirectly the adoption of modern varieties, which in turn contributed to poverty alleviation”. On the other hand, Adato and Meinzen-Dick (2003) employed a sustainable livelihoods framework to study the impact of agricultural research on poverty. They claim that unlike conventional studies in impact assessment “this study goes beyond conventional economic measures of income or nutrition and looks at poverty and well being in a more complex and dynamic manner” (Ibid: 149).

In some quarters doubts have been expressed whether agricultural research can have impact on poverty. Menz et al. (1999), for example, 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. Walker (2000:518), also seems to point out the difficulties of establishing the link between agricultural research and poverty reduction when he remarked: “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”.

Furthermore, Hazell (2003) is critical of attempts done so far to establish the link between agricultural research and poverty alleviation. In part he attributes this failure to “establishing an adequate counterfactual (without technology) situation for comparative purposes, controlling for the many other variables that condition the multifaceted impacts of technological change on the poor, and assessing the indirect as well as the direct impacts” (Ibid: 54).

It is apparent from the above that efforts have been placed on assessing the impact of agricultural research on poverty reduction instead of dwelling only on such conventional aspects as production and rate of return. While this is a notable development in impact assessment in agricultural research, questions are being raised by scholars about the adequacy of methods used in assessing the impact of agricultural research on poverty reduction.

4.2 Impact assessment in agricultural research in Tanzania

4.2.1 The Programmes

This review of impact assessment in agricultural research in Tanzania is based on four studies done in the Southern Highlands Zone (SHZ) and Eastern Zone (EZ) between 1996 and 2002. This limited number of studies is explained by the fact that so far reviews or evaluations at project level have not been done for majority of the research projects done in the two zones (see Table 1). The four studies reviewed in this article are those 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), on the other hand, 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 are not covered in the present study because they were not implemented in EZ and SHZ. The assessment was for the period from 1990 to 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 (2002) 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.

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. In using the comprehensive impact assessment these studies assessed direct, intermediate and people level (economic, social and environmental) impacts. However, intermediate impacts (e.g. the number of staff or farmers trained under each programme) are not addressed in this review. 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 using the economic surplus approach and simple cost-benefit method. The following section presents and discusses data on production, economic, socio-cultural, and environmental impact of these research programmes.

4.2.1.1 Adoption of innovations and their impact on crop yield

Table 2 presents data on adoption rate and impact on crop yield. The table shows the variation of adoption rates by 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, 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 outputs, 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.

Msambichaka (1994:435) gives figures on national average and potential yields of the main food crops and exports. Comparison between yield due to research intervention and these figures (national average and potential yields) of relevant crops shows differential impact of the programmes. Research in bean, and root and tuber contributed to yields that are higher than the estimated potential. Despite recorded increase in productivity due to fertilizer 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. 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). In addition, the use of fertilizer contributed to increase in yield of 0.8 ton/ha of beans. This yield is above the national average (0.2-0.7 ton/ha) but below the potential yield of 1.5-3.0 ton/ha. 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 these yields were about the same as the potential yield range (40-60 nuts/per palm). In general, these results confirm the existence of a gap between yields at farm level and yields under optimum management conditions.

Table 2: Released technologies, adoption rate and yield impact of selected R&D programmes

Research and development programmes	Produced or released technologies	Adoption rate/use of recommended technologies	Crop yield
Bean	Five 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	Two sweet potato varieties for the whole of the country*	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	<ul style="list-style-type: none"> - Cultivators for opening straight parallel planting furrows using animals - Mineral fertilizer recommendations for food and cash crops 	<ul style="list-style-type: none"> - 50 farmers in five villages in Mbozi District have adopted cultivators using animals for opening straight parallel planting furrows - 40%, 40%, 20% and 25% of farmers apply fertilizer in maize, beans, rice and wheat respectively 	Yield gains (tons/ha) due to application of fertilizers 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**
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	-

* Grown by farmers though not formally released

** Data presented for the maize programme were aggregated at national level

Table 2 continued

Pasture	11 cultivars for EZ	90% of dairy farmers using pasture species	- Grass yield increased from 3.8 to 11.5 ton/ha - Milk yield increased by 49.6%.
Potato	7 varieties of round potatoes and agronomic packages	- 10 – 100% farmers using improved varieties - Majority of farmers using fungicide and row planting	Potato yield increased from 85 to 90 bag/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	Rice yield increased by 2 ton/ha

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

4.2.1.2 Economic, socio-cultural and environmental impacts

Table 3 presents data on economic, socio-cultural and environmental impacts of the R&D programmes. 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. While some studies quantify the increase in income others don't. As indicated earlier, only a study on maize programme estimated the rate of return. This study showed returns to research at 19% to 23% depending on the calculation method.

Moreover, these studies report on the socio-cultural impacts of the programmes mainly in the form of gender and food security. In respect of impact on gender, the tillage programme empowered women by making them less dependent on men. On the other hand, as a result of the bean programme intervention husband and wife jointly made decisions in bean production and disposal of income obtained from bean sales. Further impact on gender was attributed to the technology promoted by the cassava programme. The technology is reported to have 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.

Almost all programmes contributed to improvement in household food security (Table 3). This was mainly the result of increased crop production. Anandajayasekeram et al. (2001), and TARP II-SUA (2002) seem to use this argument in attributing improved food security to agricultural research. In similar vein, Moshi et al. (1997) argue that since maize is grown for home consumption an increase in maize sales implied increased surplus maize production in the area. In other words, Moshi et al. (1997) assume that farmers only sell the crop after meeting household consumption needs.

Table 3 also shows data on environmental impact of the programmes. As the data show, overall environmental impact assessment of 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, it is shown that practices used by farmers and those promoted by programmes were environmentally friendly.

Table 3: Economic, socio-cultural and environmental impacts of R&D programmes

Research and development programme	Type of impact		
	Economic	Socio-cultural impact	Environmental
Coconut	<ul style="list-style-type: none"> - Income from sale of coconut by-products increased - Income increased between 1993 and 1996 	-	-
Maize	IRR was 19% - 23% depending on the calculation method	Contribution to household and national food security	<ul style="list-style-type: none"> - 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 - Environmental pollution due to continuous use of inorganic fertilizers and residual effects of insecticides (e.g. DDT)
Bean	Household income increased from 140,000 – 370,000 Tshs/ha	<ul style="list-style-type: none"> - Husband and wife jointly share in decision making in bean crop production and disposal of income from the crop - Beans contribute to food security and nutritional status of farm families 	<ul style="list-style-type: none"> - Beans improve soil fertility - Positive environmental consequences due to breeding resistant varieties and use of IPM to control pests and diseases
Soil and water, and tillage systems	-	<ul style="list-style-type: none"> - Women less dependent on husbands - Change in division of labour 	Cultivator technology in maize reduces run-off and improves moisture retention in soils

Table 3 continued

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
Cassava	Improvement in household income	- Reduction of 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 for animal fodder rather than mulching in SHZ harmful to environment
Potato	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	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 activities 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: Adapted from Ashimogo et al. (1996), Moshi et al. (1997), Anandajayasekeram et al. (2001), and TARP II-SUA (2002).

5. Conclusive remarks

Over time various research programmes have been carried out in EZ and SHZ. As this review shows, during the period 1980-1990 a total of 1203 research projects were conducted in the two zones. However, most of these projects have not been evaluated hence the reliance of this study on only four studies. In addition, it is worthy noting that these studies covered programmes implemented at different times making any attempt at comparison unfeasible. Despite this it is clear from this review that the impact of agricultural research on poverty reduction, currently a topical issue in impact assessment at international level, has not been specifically addressed in the reviewed studies. Instead impact studies reviewed in this article are broad in scope covering economic, socio-cultural cultural (e.g. gender relations, food security) and environmental aspects employing more or less similar assessment methods used elsewhere. The lack of attention to poverty reduction in impact assessment is also reflected in the way agricultural research and extension are conducted. As currently implemented both agricultural research and extension are not geared to addressing the needs of poor farmers in the country because they perform in a top-down rather than being participatory and demand-driven.

Notes

¹In 1964 Tanzania Mainland (formerly Tanganyika) merged with Zanzibar to form the United Republic of Tanzania. This article, however, is confined to the mainland part of the union

²The two zones Southern Highlands and Eastern zones are part of a total of seven research zones in the country. The zonation is based on broadly defined agro-ecological zones that follow regional boundaries (Ravnborg 1996). Thus the Southern Highlands Zone is comprised of Iringa, Mbeya, Rukwa and Ruvuma Regions while the Eastern Zone consists of Coast, Dar-es-Salaam, Morogoro, and Tanga Regions.

³Kauzeni (1988) also reports about economic decline during this period, which he attributes to deep-rooted structural imbalances.

⁴In an extensive review Haug (1999) draws attention to the evolution of extension theory as well as issues that feature in international debates on extension. Based on her review and extension practice in Tanzania it is apparent that there is a huge gap between extension theory and practice on the ground. The same appears to be the case with agricultural research as well.

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Paper 2

Beyond adoption-rejection of agricultural innovations: empirical evidence from smallholder rice farmers in Tanzania

Beyond adoption-rejection of agricultural innovations: empirical evidence from smallholder rice farmers in Tanzania

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Abstract

This study seeks to explore the adoption of rice research-based innovations in rural Tanzania. Specifically the diffusion of innovation model and the actor-oriented approaches are used in the analysis of the adoption of selected innovations. Of the two, the actor-oriented approach seems more appropriate for understanding the use of innovations among smallholder rice farmers. This is because, based on this perspective, the use of innovations is shown to be a dynamic process that best reflects the existing context of rice farming.

1. Introduction

The use of agricultural innovations among farmers and the resulting social change can be understood from two main perspectives, namely the diffusion of innovation perspective and the actor-oriented perspective respectively. The diffusion of innovations perspective or model¹ sees change as a linear process in which innovations generated by agricultural research are passed down to farmers through extension agencies. Thus in this process agricultural research is the source of innovation or change and farmers are its recipients. Moreover, farmers' rationality is conceived as being influenced by a stimulus-response model of communication. The criterion used in judging farmers' rationality is either adoption or rejection of innovations, which are seen as the outcome of an innovation-decision process. According to Rogers (1995:21)², “the innovation-decision process can lead to either *adoption*, a decision to make full use of an innovation as the best course of action available, or *rejection*, a decision not to adopt an innovation” (italics in original). Moreover, a farmer who adopts an innovation is considered rational, while the opposite is true for one who rejects it. The reduction of the innovation-decision process to a dichotomy simply involving adoption and rejection is based on the idea that research-generated innovations are finished products (Douthwaite 2002). For this reason farmers are not expected to modify them.

The second perspective is actor-oriented. Based on this perspective farmers' decisions are viewed as concrete manifestations of having agency, i.e. their knowledge and ability to act. This happens, as Long (1992) points out, within the limits of information and constraints existing in society. Hence with respect to use of innovation, farmers are not seen as simply accepting or rejecting it as a fixed idea as it is assumed in the diffusion model. Rather, this perspective focuses on how they modify or change the innovation – a process, which is referred to as re-invention or adaptation of innovations (Rhoades 1991; Rogers 1995; Christoplos and Nitsch 1996). The modification or changes made to the innovation by farmers, according to Christoplos and Nitsch (1996) is the result of a myriad of different and rapidly changing agro-ecological and socio-economic conditions. Hence, the decision to use an innovation would be based on the farmer's evaluation of how the technology fits in with farmers' own strategies (Kaarhus 1994).

This study employs both perspectives one at a time in the analysis and interpretation of the data on the adoption of innovations in rice farming. First, the diffusion of innovation perspective is used followed by the actor-oriented perspective.

2. Background

According to FAO (2004), per capita rice consumption in Asia increased rapidly during the 1960s and 1970s. However, since then the consumption of other foods has increased, and as a result the relative contribution of rice in the diets has fallen. In contrast, the consumption of rice has increased significantly both in volume and as a proportion of calorie intake in parts of Africa, the Near East, Latin America and the Caribbean. In addition, according to FAO (2004:30), in Africa rice is now the most rapidly growing source of food. In Tanzania rice is now second only to maize as a cereal crop. Rice consumption in the country is reported to have been increasing, both due to the increasing population and changes in traditional food habits of consumers (Kanyeka Undated). At present rice is grown almost all over the country both as a cash and food crop. Nevertheless, FAOSTAT data (2004) indicate great fluctuation in area harvested, production and yield of during a 25-year period (1980-2004). Based on these data, the annual average area harvested, production, and yield of rice in Tanzania during the 25-year period is estimated at 362,126 ha, 546,893 metric tones and 1.6 ton/ha respectively. Given the low rice yields in the country (Msambichaka 1994; FAO 2004)

increase in rice production is mainly due to expansion in cultivated area. Thus over time agricultural research efforts have been directed towards generation of innovations in order to contribute to improved crop yield.

3. Methodology

3.1 Study areas

Selection of the study areas was done at district and village levels. First, Kyela and Kilombero Districts located in Mbeya and Morogoro Regions respectively were selected for the study (Fig.1). This is because they are among the districts in Tanzania where rice production is an important source of livelihood. Most of the Kilombero district lies along the Kilombero Valley - a part of Rufiji Basin, which extends below the Udzungwa Mountains from its east towards the southwest. Kyela district, on the other hand, lies in the converging area of eastern and western Rift Valleys of East Africa. A great part of the district lies on the floor of the Great Rift Valley at the northern tip of Lake Nyasa. Second, after choosing the two districts it was decided to select one village per district. The criterion for choosing villages was that they should represent areas where 'modern rice farming', especially production of modern varieties produced by agricultural research institutes, is practised. In Kilombero district Mang'ula A was selected based on this criterion. The above criterion could not be applied in Kyela where farmers were reported to have uniformly rejected modern varieties released by Agricultural Research Institute at Uyole in Mbeya (Mussei and Mbogollo 2001). Instead, it was decided to select a village, which was involved in on-farm research intended to promote the rejected varieties and where crop management innovations were being practised. Thus Kikusya village was selected for the study.

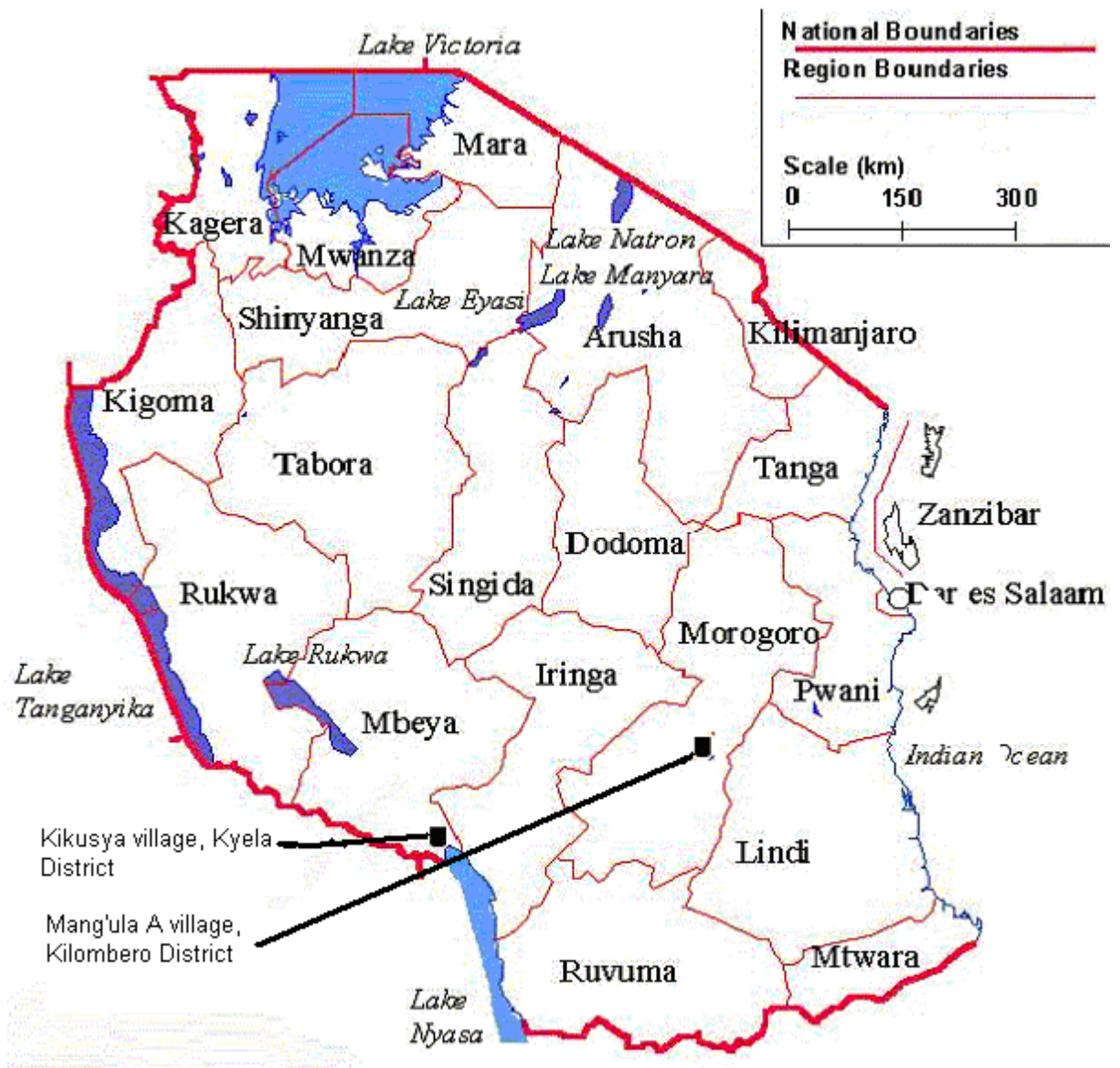


Fig1: Map of Tanzania showing the study areas

Although rice production is an important source of livelihood in the two villages, they represent a range of variation on some variables described herein. In Mang'ula A the area planted with rice is estimated at 4,214.5 ha with an average of 1.2 ha per household (Liguguda and Kisunjuru 1996). Other crops produced include maize, cassava, banana, pigeon peas and sweet potato. In Kikusya rice is the major crop accounting for 75 percent of the total cultivated land (Kayeke 1998). Apart from rice, farmers grow cocoa, banana, cassava, oranges, cashew and oil palm. As in most parts of the country where rice is cultivated, in these villages rice is grown under rainfed conditions. This means that rainfall has a great influence on rice yields. In Kilombero district where Mang'ula A is located rainfall ranges from 1,200-1,400 mm and in the highlands reaches 1,600 mm. The district seldom receives less than 1,100 mm rainfall. Kyela district where Kikusya is situated receives rainfall ranging between 2,000 mm and 3,000 mm. In addition to the total amount of rainfall received, its distribution is of critical importance to distinguish a good year from a bad one.

The two villages are served with reliable means of communication. Kikusya is well connected with other parts of Tanzania as well as Malawi through a good road network as well as by ferry on Lake Nyasa. Similarly, Mang'ula A is served by both road and railway. In addition, unlike Kikusya, Mang'ula A' is relatively closer to Dar-es-Salaam, the largest market of agricultural produce in the country. In both villages people access land for farming through inheritance. In addition to inheritance, allocation by the village government was an important source of cultivated land in Mang'ula A. In Kikusya, the other important means of accessing land is through borrowing, usually from relatives.

Mang'ula A village is multi-ethnic with Wabena, Wapogoro and Wahehe comprising the three largest ethnic groups. A large number of these settled in the village on retirement from the Kilombero Sugar Factory located nearby. Other inhabitants came to the area during the construction of the Tanzania Zambia Railway in the late 1960s up to mid 1970s. On the other hand, Kikusya village is almost entirely inhabited by one ethnic group - the Wanyakyusa. Also, there have been differences with respect to intervention in agricultural development in the study villages. In Kikusya the promotion of 'modern rice farming' has largely relied on an extension officer whose area of jurisdiction extends to eight (8) other villages. In Mang'ula A promotion of modern rice production began in the village in 1996 when an FAO-sponsored National Special Programme on Food Production (NSPFP) started working with a group of

farmers (for details on this programme see Laizer, 1999). They supplied them with rice seeds of TXD88 – a new variety. Later on working with farmers groups became the programme's *modus operandi*. Each group had a demonstration farmer, on whose plot improved farming involving modern varieties and crop management innovations was demonstrated. Additionally, the project supplied the demonstration farmer with some inputs such as fertilizer for rice production. Group members worked closely with the Village Extension Officer (VEO) and were expected to transfer the skills and knowledge learnt from the demonstration plot to their own plots. Besides demonstrations, field days were held to persuade farmers to adopt modern rice farming (pers. comm. Kisunjuru 2003)³.

3.2 Data sources

Data for the study were obtained from various sources by using a number of data collection methods. First, village leaders were interviewed for background information on their respective villages. Moreover, exploratory investigations were done to get an understanding of rice production, in particular the modern farming involving use of modern varieties⁴ and crop management innovations. These investigations in Mang'ula A involved group interviews with men and women farmers. In Kikusya group interviews could only be done with men⁵. Farmers who participated in the interviews were selected with the help of the Village Extension Officer (VEO) and village chairman at Mang'ula A and Kikusya respectively. The selection of these farmers was based on their experience in growing modern rice varieties (only Mang'ula A) and use of crop management innovations (both Mang'ula A and Kikusya). In addition, key informant interviews were held with selected farmers and the VEO and Community Development Officers (CDOs).

Exploratory investigations were followed by in-depth interviews with individual farmers, most of whom had taken part in the group interviews conducted earlier. Individual interviews dwelt on individual experiences as opposed to general community level experiences addressed during group interviews. On several occasions the interviews were tape-recorded for later review. As was the case with group interviews, an interview guide was used to conduct interviews with individual farmers. The guide was modified from time to time depending on the informant because the interviews involved a cumulative process of interviewing implying a “back-and-forth movement between data collection, interpretation, and reinterpretation” (Kaarhus 1999: 173). Direct observation and informal interviews were

also done during field walks to obtain more insight into rice farming. Following literature review and consultations with rice researchers⁶, as well as interviews with farmers, and extension staff, a list of innovations constituting “modern rice farming” in the two villages was drawn and formed the basis of developing the interview schedule for the formal survey for this study. In Mang’ula A these innovations include modern rice varieties (TXD88 and TXD85) and crop management innovations, namely planting methods (dibbling and transplanting) and use of fertilizer, herbicide, and pesticide. In contrast, in Kikusya the list comprised of only crop management innovations, namely dibbling, transplanting, use of herbicide and fertilizer.

Also, drawing on exploratory and in-depth interviews, an interview schedule was designed and used in the formal survey. A total of 50 heads of household in Kikusya and 50 heads of household in Mang’ula A village were randomly selected from a list of 335 and 524 heads of household respectively using a table of random digits. The interview schedule comprised open- and close-ended items on adoption of modern varieties and crop management innovations. To ensure validity the schedule was pre-tested on 10 non-sample farmers at Mang’ula A after which it was administered to the sampled farmers. The interviews were done at the homes of individual farmers. In the case of male-headed households both the husband and wife were mostly interviewed together. The data presented in this study are thus largely drawn from in-depth interviews and the interview schedule.

3.3 Data analysis

Various techniques of data analysis were used for this study⁷. Chi-square and t-tests were used to compare the two study areas. Frequency counts; means and percentages were used to describe the sample households. Adoption of innovation was measured in terms of rate and incidence of adoption. Both were analysed using frequency counts and percentages. Following Kaliba et al. (1998: 28), the rate of adoption was here defined as the proportion of farmers who have adopted an innovation over time. The incidence of adoption, on the other hand, was defined as the percentage of farmers using an innovation at a specific point in time, which in this study is the 2002/03 cropping season. Furthermore, the chi-square test was used to compare the adoption of selected innovations in the two villages. Plot level data were used to estimate the binary logistic regression model on factors affecting adoption. Based on the

innovation diffusion perspective of adoption, the response on the use of innovations was binary, i.e., 1 if farmer used an innovation, 0 otherwise.

4. Results and discussion

4.1 Description of sample households

Table 1 presents data on the selected characteristics of sample households. The majority of household heads in both Mang'ula A and Kikusya were males. Heads of the remaining households were either widows or divorcees. As the table shows, there is no statistically significant difference between the villages regarding the type of household headship.

Furthermore, the table shows the average age of household heads. In Mang'ula A the average age is about 43 years whereas in Kikusya it is about 50 years. The difference is, however, not statistically significant. Also, the study shows that heads of household in Mang'ula A have an average of about 5 years of formal education while their counterparts in Kikusya have about 4 years. The difference, as the table shows, is not statistically significant. Similarly, there is no statistical difference between the two villages with regard to household size and household farm labour. Regarding household income derived from rice sales, the average income for Mang'ula A and Kikusya is TAS 117,830 and 19,373 respectively. This difference in income is highly statistically significant.

Table 1: Characteristics of the sample households

Characteristic	Mang'ula A	Kikusya	Significance test	P-value
Gender of household head				
Number of female heads	8	14	$\chi^2=$	0.148
Number of male heads	42	36	2.098	
Average age of household head	42.88	49.68	t= 1.89	0.062
Average education of household head	4.96	4.30	t= 1.09	0.279
Average household size	4.70	4.38	t= 0.51	0.609
Average household farm labour	2.34	2.32	t= 0.07	0.947
Average household income (TAS)*	117,830	19,373	t= 2.70	0.008**

Source: Survey data, 2003

*Cash income received from rice sales during 2001/02 cropping season. 1USD=1,000 TAS (Tanzanian Shilling)

** Significant at 1 percent level of probability

Numbers in brackets are percentages

4.2 Rice varieties

Table 2 shows that a large number of rice varieties are grown in the two villages. The most preferred varieties in Kikusya are Kilombero, Zambia and Rangimbili in that order. Kilombero is the most popular of the varieties cultivated. Indeed, during the 2001/02 cropping season it was grown by 86.36 percent of households while in the following season 58 percent of households grew it. Also, the variety accounted for 58 percent and 61 percent of the total rice area during 2001/02 and 2002/03 cropping season respectively. In Mang'ula A, as the table shows, both traditional and modern varieties are grown. Based on varieties grown, three categories of farmers can be identified: there are farmers who only grow modern varieties (13 percent); farmers who grow both traditional and modern varieties (27 percent); and farmers who grow only traditional varieties (60 percent). Among farmers who only grow modern varieties, some of them produce rice for the market and buy the rice they consume from other farmers in the village.

Table 2: Cultivation of rice varieties by households

Varieties	2001/02	2002/03
Kikusya	N=44	N=48
Kilombero	38 (86)	28 (58)
Zambia	11 (25)	14 (29)
Rangimbili	12 (27)	4 (8)
Faya	1 (2)	0 (0)
Supa	5 (11)	5 (10)
Faya mpata	1 (2)	1 (2)
Mwasungu	2 (5)	1 (2)
Gwindima	1 (2)	0 (0)
Mixed	1 (2)	3 (6)
Mang'ula A	N=50	N=48
<i>Traditional varieties</i>		
Supa India	38 (76)	40 (83)
Mwanza	4 (8)	6 (13)
Kaling'anaula	5 (10)	4 (8)
Rufiji	2 (4)	0 (0)
Kangaga	1 (2)	3 (6)
Rangi	1 (2)	0 (0)
Kingomo	1 (2)	1 (2)
Kalilambula	1 (2)	0 (0)
Mixed	1 (2)	0 (0)
<i>Modern varieties</i>		
TXD88	12 (24)	13 (27)
TXD85	2 (4)	6 (13)

Source: Survey data, 2003

Numbers in brackets are percentages

Despite efforts to encourage farmers to produce modern varieties in Mang'ula A, Supa India⁸, rather than modern varieties, is the most popular rice variety considering that over three-quarters of the households grew the variety during the two seasons. This finding confirms an earlier study by Ashimogo et al. (2003) conducted in Kilombero District, where they found that most (88 percent) of the households planted traditional varieties while only 12 percent cultivated modern varieties. During the cropping seasons 2001/02 and 2002/03 Supa India accounted for about 72 percent and 76 percent of the total land planted with rice respectively. In contrast, during the same period only 12 percent and 22 percent of the land was planted with modern varieties while the remaining 16 percent and 2 percent was grown with traditional varieties other than Supa India. This limited production of modern varieties could be related to problems associated with growing these varieties, which based on interviews

with groups of farmers, include poor quality, susceptibility to pest infestation, high production costs, and difficulty in marketing them.

4.3 Adoption of innovations

Table 3 presents data on adoption of innovations. Farmers in Kikusya grow only traditional varieties. According to Mussei and Mbogollo (2001), varieties released for farmers adoption in Kyela district – Afaa Mwanza, Katrin, and Salama- were widely rejected because they were of poor quality⁹. In Mang’ula A, the study shows that the rate of adoption of modern varieties was as follows: 54 percent adopted TXD88 while TXD85 was adopted by only 28 percent indicating that TXD88 spread more among farmers than TXD85. This, in part, is explained by the fact that TXD85 is more susceptible to white flies infestation than TXD88.

Table 3: Adoption of innovations

Innovation	Mang’ula A	Kikusya	Chi-square value	P value
Rate of adoption	N=50	N=50		
TXD88	27 (54.00)	-	-	-
TXD85	14 (28.00)	-	-	-
Fertilizer	13 (26.00)	24 (48.00)	5.191	0.023*
Herbicide	39 (78.00)	17 (34.00)	19.643	0.000**
Transplanting	40 (80.00)	23 (46.00)	12.398	0.000**
Dibbling	7 (14.00)	9 (18.00)	0.298	0.585
Pesticide	5 (10.00)	-	-	-
Incidence of adoption	N=48	N=48		
TXD88	13 (27.08)	-	-	-
TXD85	6 (12.50)	-	-	-
Fertilizer	3 (6.25)	12 (25.00)	6.400	0.011*
Herbicide	25 (52.08)	14 (29.17)	5.225	0.022*
Transplanting	15 (31.25)	3 (6.25)	9.846	0.002**
Dibbling	1 (2.08)	0 (0.00)	1.011	-.***
Pesticide	0 (0.00)	-	-	-

Source: Survey 2003

*X² significant at .05 level of probability

**X² significant at .01 and 0.05 levels of probability

*** X²-test not valid due to few adopters

Regarding crop management innovations, the table shows that the leading innovations in terms of adoption were transplanting, herbicide and fertilizer. However, there is a difference between the two villages regarding the rate at which each of these innovations was adopted. For example, in Mang’ula A the highest percentage of farmers adopted transplanting compared with other innovations. On the other hand, in Kikusya the highest percentage of

farmers adopted fertilizer. Table 3 also presents data on the incidence of adoption of innovations for the cropping season 2002/03. As in the case of the rate of adoption, there existed differences between the villages on the extent of the adoption of these innovations. In Kikusya the highest percentage of farmers adopted herbicide and fertilizer whereas in Mang'ula A herbicide and transplanting topped the list of adopted innovations.

Comparison was also made between the two villages regarding the adoption of innovations that formed part of 'modern rice' farming. These are fertilizer, herbicide, transplanting, and dibbling. Results in Table 3 show that location, represented by villages had influence on the rate and incidence of adoption of herbicide, transplanting, and fertilizer. The table indicates that more farmers in Mang'ula A adopted transplanting and herbicide than in Kikusya. The fact that farmers in Mang'ula A adopted more herbicide than their counterparts in Kikusya suggests that they were able to afford the cost. On the other hand, the fact that transplanting was adopted more in Mang'ula A than Kikusya could be associated with the growing of modern varieties in the former. In growing these varieties farmers are advised to do so either through transplanting or dibbling. Also there is significant relationship between location and adoption (both rate and incidence) of fertilizer. The table shows that more farmers in Kikusya adopted fertilizer than in Mang'ula A. It could be that farmers in Kikusya put priority in improving the fertility of the soil, which was reported to have declined over the years. Furthermore, the data show no significant relationship between location and adoption of dibbling. This was to be expected considering that, unlike other innovations, it is hardly practised.

With respect to the level of adoption of selected innovations during 2002/03 cropping season, the study reveals that in Mang'ula A 31.3 percent of the farmers did not use any of the innovations, 27.1 percent used one innovation, 22.9 percent used two, 16.7 percent used three and 2.1 percent used four innovations during the cropping season 2002/03. During the same season in Kikusya, where the study focused on the adoption of only crop management innovations, 47.9 percent did not use any of the innovations, 43.8 percent used one of the innovations while 8.3 percent used two. This shows that although farmers are advised to use innovations in the form of packages for maximum output, they only use the innovations that suit them. This result is consistent with the observation that whereas components of a package may complement each other, some of them can be adopted independently indicating

that, farmers have the option to adopt whole or part of the package (Feder et al. 1984; Ravnborg 1996).

4.4 Factors affecting adoption of innovations in rice farming

The variables used in the prediction of the logistic model, which were selected based on the literature review, are described in Table 4. The data used are for the cropping season 2002/03.

Table 4: Definition of variables used in the logistic model

Variable name	Description
ADOPT	1 if farmer grew modern variety, 0 otherwise
ADOPTFET	1 if farmer used fertilizer, 0 otherwise
ADOPTHEB	1 if farmer used herbicide, 0 otherwise
ADOPTRAS	1 if farmer transplanted rice, 0 otherwise
HHAGE	Age of household head in years
HHEDUC	Level of education of household head in years
LABOUR	Number of household members working on farm
HHGENDER	Sex of household head, 1 if male and 2 if female
INCOME	Amount of cash obtained from rice sales in 2002, TAS

Results of the binary logistic regression model on factors affecting the adoption of the innovations are as presented in Table 5. The table shows that none of the selected factors had significant influence on the adoption of modern varieties in Mang'ula A. This is probably because, as Douthwaite et al. (2001) writes, generally modern varieties are grown in similar ways to traditional varieties and as a result they need to learn little about them. In both villages the adoption of herbicide was influenced by age, and education. Specifically, the study shows that the use of herbicide is more likely with increasing age. This is probably because as farmers get old they cannot provide labour for weeding hence their reliance on herbicide. The influence of education of household head on adoption of herbicides implies that its use requires managerial skills, which educated farmers are most likely to master.

Table 5: Estimates for the logistic analysis of adoption of innovations

Factor	Estimated coefficients			
	Modern varieties Φ	Herbicide	Fertilizer	Transplanting
Mang'ula A village				
HHAGE	-0.028	0.079**	-0.183	-0.043
HHEDUC	-0.203	0.569**	8.000	-0.046
LABOUR	-0.007	0.577*	1.799*	-0.017
HHGENDER	-0.479	1.584	-16.000	-1.270
INCOME	-0.000	0.000	0.000 Φ^*	-0.000
Kikusya village				
HHAGE	-	0.066*	-0.041	0.111
HHEDUC	-	0.753**	-0.162	-0.398
LABOUR	-	-0.072	-0.022	0.375
HHGENDER	-	2.201*	1.959*	-11.979
INCOME	-	0.000	-0.000	-0.000

Source: Survey data, 2003

* Significant at 0.05 probability level

** Significant at 0.01 probability level

Φ Only grown in Mang'ula A village

Φ^* The coefficients on income are so small that they come out rounded to 0.000. In the case of influence of income on adoption of fertilizer in Mang'ula A, which came out as a significant variable, the precise coefficient is 5.774×10^{-6} .

On gender, the table shows that in Kikusya village households headed by females were more likely to adopt herbicide than those headed by males. This can be explained by the fact that female-headed households are faced with labour shortage with the head of household being the main and sometimes the only provider of labour. Indeed, the study showed that male-headed households had more labour than those headed by females and the difference was statistically significant (t-value=3.72; p-value=0.001). Thus the use of herbicide is a logical response to this problem. In addition, adoption of herbicide in Mang'ula A was more likely with households with more labour.

In Kikusya gender had significant effect on fertilizer adoption. In particular, female heads of household were likely to adopt fertilizer. It could be that since female-headed households face more labour shortage than those headed by males they seek to maximize output per unit of labour available rather than through expansion of land area. In this regard, the use of fertilizer is a logical response to this problem. Moreover, in Kikusya none of the selected

factors had influence on adoption of transplanting. In Mang'ula A, households with more labour were more likely to adopt fertilizer.

Results presented in Table 5 also indicate that income had influence on adoption of fertilizer only in Mang'ula A. Generally, adoption studies in Tanzania have paid little attention to the influence of demographic/farmer characteristics including income on adoption of innovations (Mattee 1994). However, while studies done elsewhere (see Obinne 1996; Lapar and Ehui 2004) point to the influence of income on adoption of innovations, other studies indicate that it is the type of income rather than income per se that influences adoption. For example, Ransom et al. (2003) and Wünscher et al. (2004) reported on the influence of off-farm income on adoption. On the other hand, experience from Tanzania and Kenya does not confirm these findings. In a study conducted in Tanzania, Semgalawe (1998) found that households with cash crops (coffee and tea) were more likely to adopt conservation measures than those who did not grow at least one cash crop and thus relied on off-farm income. She attributed this to competition for labour between off-farm and farm activities. Similarly, Mullah (1992) who did his study in Kenya reported a negative correlation between adoption of alley cropping and non-farm income indicating that the more the farmer depended on trade the less the likelihood of adoption of alley cropping. Overall, the contradictory findings on factors affecting adoption confirm earlier studies (see Ravnborg 1996; Christoplos and Nitsch 1996), which have reported on the influence of the context in which farmers operate on the use of innovations.

4.5 Use of innovations: transcending adoption-rejection dichotomy

Thus far adoption of the selected innovations in rice farming has been dealt with using the innovation diffusion model or perspective. In employing this perspective the focus of attention has been the innovations. This is because adoption, as observed earlier in this article, is seen as a reaction to external stimuli. Moreover, the rate of adoption, which is measured cumulatively, gives an impression that the use of an innovation is spreading among members of the society. However, when the rate of adoption is compared with the incidence of adoption, it becomes apparent that some farmers have stopped using respective innovations. Additionally, the adoption-rejection mode is restrictive. For to which category do, for example, farmers who would like to use fertilizer but do not have money belong? What about farmers who discontinue an innovation for a season for lack of money but intend

to use it when they get it? As observed by Rhoades (1991:5) “Farmers do not think in terms of adoption or non-adoption ... but select elements from the technological complexes to suit their constantly changing circumstances. The dichotomous terms of adoption, non-adoption ... are irrelevant and misleading from the farmers’ point of view”.

Thus the use of innovation is contingent upon consideration of many factors both at the micro (household) level as well as macro level factors over which the farmer has little control (e.g. market)¹⁰. Thus understanding the rationality behind use or non-use of innovations requires comprehension of the context in which they make decisions. This requires that the use of innovations be viewed beyond the ‘adoption-rejection’ framework. Only then can discontinuation and adaptation of innovations revealed during interviews with farmers be understood. This last part of the article addresses these issues by employing the actor-oriented perspective. Drawing on this perspective, the study shows that farmers produce rice in order to meet food needs or income needs or both. For most farmers these needs are met by growing either Kilombero (Kikusya) or Supa India (Mang’ula A) (Table 2). The widespread production of these varieties is based on the fact that they have superior food qualities, which farmers themselves and the market demand. In contrast, modern varieties are relatively poor in quality, hence cannot meet the dual goals of the farmers. Thus yield would not seem to be as important as quality to these farmers.

Nevertheless, the yield advantage of modern varieties seems to make sense to some farmers in Mang’ula who only grow modern varieties for the market¹¹. These farmers find the venture profitable because the varieties mature early and can be sold at times when there is high demand for rice; i.e. during the period just before traditional varieties are harvested. This shows the fact that, as observed by Andersson (1996), technical considerations are important but that they have to make sense in social contexts where these varieties are used. In short, the market as shown above offers different opportunities to different categories of farmers. Most farmers seek to balance consumption and income needs through production of traditional varieties. In addition to quality, the choice of variety can also be understood in terms of the costs required to produce it. Thus following the emergence of a new pest, that is white flies, continued cultivation of modern varieties has meant additional expenses on the part of farmers. Besides herbicides and fertilizers, the farmer must purchase pesticides for controlling white flies. This partly explains why some farmers have discontinued the

production of modern varieties. Therefore continued production of traditional varieties makes sense because, unlike modern varieties, they are less affected by pests. Besides, they perform well under low risk and poor management conditions (Msomba et al. 2002).

Interviews with farmers indicated that lack of cash limited the use of fertilizer and herbicide. For instance, one farmer said: *“We like fertilizer but we cannot afford it”*. Emphasizing that lack of cash is the main constraint on fertilizer usage a farmer remarked that, *“When there is cash we use fertilizer”*. This shows that discontinuation of innovation such as fertilizer is not necessarily a permanent decision. Rather it is a response influenced by lack of cash, which may be exacerbated by external factors such as lower producer price and increase in prices of inputs. Farmers are aware that without fertilizer application yields are usually low, about 45 kg per acre or even less. The usual recommendation of fertilizer is a bag (50kg N) per acre. Farmers hardly buy this amount as the amount of cash available, rather than recommendation, dictates the amount of fertilizer used. As a result, a farmer would adapt the innovation by buying a few kilograms and spread it thinly over a big land area as this statement attests: *“I cannot buy a bag of fertilizer. When I see some spots with poor plant growth I buy two kimbos of fertilizer and apply it there”*¹². This happens because most farmers sell rice as their main source of income during or immediately after harvesting (May-July). This money is normally used to meet large cash expenditure needs such as payment of school fees and building of houses. Consequently, some months later in February-March most households are left with little or no money to buy inputs such as fertilizer and herbicide. Faced with lack of cash some farmers said that they borrowed money from local moneylenders and used it to buy inputs such as herbicide. In Mang’ula A, for instance, the borrower is required to pay back a bag (90kg) of rice at the time of harvesting for each 5000 TAS borrowed. It is evident that this arrangement is in favour of the moneylender. Others would brew local beer and use the money obtained to buy fertilizer or pay for other farming expenses.

Availability of labour or lack of it helps explain the use of labour intensive innovations, namely transplanting and dibbling. When asked to comment on his experience with dibbling one male farmer said: *I tried to plant by dibbling and applied fertilizer. I observed the difference in yield. Now I am not doing it any more because the children have left and are living on their own*. This view is further emphasized in the following statements: *“I tried dibbling but it is hard labour”*; *“Transplanting and dibbling are laborious and to simplify*

matters we broadcast"; "I cannot practice dibbling because I am sick". "You use a lot of time to cultivate a small area"; "You waste a lot of time and you need many people". Nevertheless, labour considerations are ignored when the fields are inundated by water: "If it rains early I transplant otherwise I broadcast" and another farmer said: "I transplanted because the plot was inundated by water". In this situation broadcasting is not a feasible planting method.

5. Conclusion

This study employed two perspectives in the analysis of adoption of selected innovations in rice farming. These are the diffusion of innovation perspective and the actor-oriented perspective. Of the two perspectives, the actor-oriented approach seems more appropriate for understanding the use of innovations among smallholder rice farmers. This is because it gives a better understanding of the context, which informs the farmers' decision making regarding the use of innovations. In this regard, inadequate credit and market arrangement for rice and for the agricultural inputs required in rice production are contextual elements that affected the use of both modern varieties and crop management innovations covered in this study.

Notes

¹The model has its roots in diffusionism, which in early 20th century anthropology explained social change in a given society as a result of the introduction of innovations from another society. Consequently, diffusionists made a strong claim to the effect that innovations tended to spread from one original source. This, in essence, disputed the existence of parallel invention, which is now widely acknowledged (Rogers 1995:41). Diffusionism has continued to have a following, in somewhat modified form in a number of scientific disciplines (Eriksen and Nielsen 2001). Research on the diffusion process by rural sociologists is often dated as starting with the Iowa State hybrid corn studies of the 1940s (Fliegel 1993). It is, however, to the work of Bryce Ryan and Neal Gross on the diffusion of hybrid corn in two Iowa communities in 1943 that the development of the diffusion research paradigm in rural sociology is credited. In this respect Rogers (1995:53) writes, "Although a couple of pre-paradigmatic diffusion studies had been completed during the 1920s and 1930s ... investigation of the diffusion of hybrid corn, more than any other study, influenced the methodology, theoretical framework, and interpretations of later studies in the rural sociology tradition, and in other research tradition as well". This perspective has had great influence on the conduct of diffusion studies over many years. Acknowledging this Rogers observes: "... the typical research design for studying diffusion was established in 1941. It has lived on, with only certain modifications, to the present day (Rogers 1995:55).

²This is done under reciprocal arrangement such that the borrower of land is expected to return favours as appropriate.

³Village Extension Officer for Mang'ula A village

⁴For the purpose of this study, we adopt the definition of modern variety by Morris and Heisey (2003: 242) to refer to a variety that can be traced to a particular scientific breeding programme.

⁵Arrangements to conduct group interviews with women farmers failed because those selected were busy with farm work. Instead, they were interviewed individually.

⁶Consultations were done with rice researchers in the summer of 2002 in order to familiarize with the research programmes. The main fieldwork part of the study was done throughout 2003.

⁷Data analysis was done using the MINITAB Programme.

⁸After over thirty years of its cultivation in the country Supa or Supa India is taken as a local variety. However, it is an introduced variety probably from Surinam in South America. It was introduced in the late 1960s when the Rice Improvement program of 1965 was redesigned at Ilonga. During the variety testing series in Kilosa and other areas through 1968 to the early 1970s, farmers adopted the variety probably because of its extra long and strongly scented (aromatic) kernels (pers. comm. Kanyeka 2004). From a technical point of view, according to Dr. Kanyeka, a rice breeder, after 15-20 years of cultivation a variety deteriorates very fast due to mechanical mixing probably because of crossing and rare mutations. For this reason, irrespective of its origin, Supa India is considered a traditional variety.

⁹Breeding work was designed following a diagnostic study by Kirway (1982), which identified the main problems in rice as local low yielding varieties, weed infestation, poor soil fertility and untimely planting. Drawing on researchers' perspective, it is thus not surprising that rice breeding focused entirely on technical aspects and less on qualitative ones, which appear to be given top priority by farmers. Similarly, although farmers in Mang'ula A rated TXD88 and TXD85 highly in terms of yield (especially TXD88 because of its tillering ability), they indicated that both did not taste as well as local varieties and that TXD88 had a 'white belly'. The latter affects its market value. In addition, they said TXD85 was more susceptible to pest. Indeed, interviews with farmers revealed that some of them lost the entire crop to white flies. As a result one must use pesticide to control them.

¹⁰Also, traditional culture is often cited as one of the factors limiting the use of technological innovations in African agriculture. According to Øyhus (2000:265) 'modern technology constitutes a particular challenge to traditional cultural patterns since its inherent dynamics quite often is contradictory to the limitations that cultural identity and a common system of values and norms imply'. Further, in his study of Didinga tribe in Southern Sudan, Øyhus (1992:250) argues that while the modern, industrial farmer draws the information guiding his decisions from the market in the form of prices, the Didinga farmer draws the information guiding his decisions 'from particular socio cultural sources related to kinship, age-organisation and the spiritual world.' In the present paper the cultural explanation for low adoption rates seems relevant in the case of adoption of modern varieties where taste, aroma, and cookability are some of the most important qualities that influence the farmers' choice of rice varieties.

¹¹ In particular some of these farmers have been targeting the Dar-es-Salaam market.

¹²Kimbo is a cooking fat and its containers particularly the 1kg container is one of the local units of measurements widely used in local markets in Tanzania.

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Paper 3

Rice for food and income: assessing the impact of rice research on food security in Kyela and Kilombero Districts of Tanzania

Rice for food and income: assessing the impact of rice research on food security in Kyela and Kilombero Districts of Tanzania

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Abstract

The main objective of this paper is to assess the impact of rice research on household food security in Tanzania. The adoption of research-based innovations in rice farming, on which the impact of rice research is assumed to depend, is outlined. Rice production and consumption levels are presented. The paper shows that farmers produce rice for purposes of meeting a range of livelihood outcomes, which include food security. Meeting household needs such as education, health, and building good houses are as important as food security. In this context, it is argued that food security should be understood within the framework of household livelihood strategies rather than being seen as dependent on household rice production.

1. Introduction

Large numbers of people in developing countries have not been able to escape from hunger and constant threat of famine (Timmer 2000). This is happening at a time when there has been a phenomenal increase in food production at the global level (Plucknett 1991; McCalla 1999; Cohen 2001; Pinstруп-Andersen 2001; Kotze 2003). Cohen (2001), drawing on FAO statistics, claims that the centre of gravity of hunger in 2015 will remain squarely in South Asia and Sub-Saharan Africa. Moreover, Pinstруп-Andersen (2001) notes that though per capita availability of food is projected to increase between 1993 and 2020 in all major regions, a large part of the population in Sub-Saharan Africa is likely to have access to less food than needed. However, according to FAO (2004:4) most countries in sub-Saharan Africa between 1990-1992 and 2000-2002 “have brought the prevalence of hunger down by 25 percent or more, although often from very high levels at the outset”. This gives hope for the struggle against food insecurity in the region. Nevertheless, it remains to be seen whether this development can be sustained for a longer period of time.

The role of agricultural research in food security in developing countries is considered vital. This view no doubt informs, among others, the argument by Cohen (2001) that public

investment in agricultural research aiming to improve small farmers' productivity is crucial for food security in developing countries. In assigning public research the responsibility to develop agricultural technologies, Cohen is conscious of the fact that it is by treating agricultural research products as a public good¹ that its products can be made accessible to the majority of poor smallholders in developing countries. To what extent public-funded agricultural research in developing countries has actually had impact on food security is thus a relevant research topic. In light of this, there have been some attempts to document the impact of agricultural research on food security (see Maredia et al. 2000; Manyong et al. 2000a and 2000b). In these studies what constitutes food security is, however, taken for granted. Based on the reported findings it seems to be equated with increased production following research intervention. For example, in attributing increased food security to the cassava programme implemented in a number of sub-Saharan African countries, Manyong et al. (2000a: 10) reported that, "The increased production ... resulting from improved varieties was about 10 million tons of fresh storage roots, which could feed about 14 million people". Similar findings have been reported for Tanzania (see Anandajayasekeram et al. 2001; TARP II-SUA 2002). This study assesses the impact of rice research² on household food security drawing on the experience from two communities in rural Tanzania where rice is both a staple and preferred food.

2. Analytical framework

The concept of food security has over the years been evolving (Maxwell and Smith 1992; Nyborg and Haug 1995; Maxwell 1996; Mechlem 2004). As observed by Nyborg and Haug (1995:1), academically, "the concept has made a quantum leap from being a simple measure of national food production, food grain storage, national food self sufficiency ... towards an integrated concept requiring an understanding of the interaction of several disciplines, spanning from micro to macro levels of analysis". Launched in the 1970s, when concern was mostly directed at national and international food availability, it is no surprise that food insecurity was seen as a problem of food supply. Indeed, the early definition of food security, at least in Africa, reflected this view as it was equated with national aggregate food production measured by national food production statistics (Amalu 2002; Gladwin et al. 2001). Following Amartya Sen's work *Poverty and Famines* published in 1981, starvation and hunger is attributed to food entitlement decline (FED) rather than food availability

decline (FAD) as earlier argued. Sen (1981:154) is critical of the food availability decline approach because “it gives little clue to the causal mechanism of starvation, since it does not go into the relationship of people to food”. In Sen’s view, people establish their relationship to food through legal entitlements. Furthermore, it is through these entitlements that people acquire food. These include production, trade, own labour, and transfers (e.g. gift exchanges).

Moreover, the entitlement approach to famines concentrates on the ability of an individual to command enough food through legal entitlements. Consequently, an individual starves because of his or her failure to command enough food. As Sen (1981:4) writes: “A general decline in food supply may indeed cause him to be exposed to hunger through a rise in food prices with an unfavourable impact on his exchange entitlement. Even when his starvation is caused by food shortage in this way, his immediate reason for starvation will be the decline in his exchange entitlement”. This approach³ to food security marked a paradigm shift as attention shifted from food supply to food demand. A growing number of definitions of food security reflected changes following Sen’s work⁴. These include the widely cited World Bank (1986) definition around which most proposed definitions of food security vary (Maxwell, S. 1996)⁵.

Devereux (2000) points out economic, demographic and political perspectives as the three broad perspectives used in explaining famine. Generally, the political perspective is a critique of the other two perspectives. Arguing for the political explanation of famine Devereux writes that it is “a very different perspective on famine than that offered by demographers and economists... both of whom neglect to assign culpability for famine to anyone other than the victims themselves and the banal mechanics of market forces” and goes on to make the controversial conclusion that “famines are *always* political” (Ibid: 21, 23). Staatz and Eicher (1990) are also critical of approaches that address only part of the “food security equation” (i.e. the supply side or the access side) arguing that such approaches have failed to alleviate food insecurity.

Overall, attention to food security has dwelt on the potential quantity of food consumed rather than its quality expressed in terms of food preferences⁶. People’s preferences for certain foods over others are based on taste, which in part is culturally constructed. It follows that it is through food taste that culture plays an important role in determining what is

classified as food (Caplan 1997). Considering the subjective nature of taste and hence preferences for certain types of foods, what constitutes food would vary from one society to another. Consequently, food is one of “the primary ways in which notions of ‘otherness’ are articulated” (James 1997:72) or “one of the strongest of ethnic and class markers” (Weismantel 1988:9). In addition, Weismantel (1988:7) writes: “It is not only a physiological truism that we are what we eat; what we eat and how we eat it also defines us as social beings ... When foods become symbols, their meanings are not arbitrarily defined but derive from the role they play in economic life. An expensive food stands for wealth, a cheap one for poverty ...”. This implies that food provides a good identity marker in any given society. More importantly it also implies that food preferences may be limited by one’s ability to acquire the food of one’s choice. However, food preferences may also have significant implications for food security in Sub-Saharan countries where access to food and food production are very closely linked (Kotze 2003)⁷. This is because farmers tend to concentrate their efforts and resources in food crops that meet their taste. Therefore, in order to test claims on the impact of agricultural research innovations on food security – through ‘adoption’- two perspectives will be employed.

The first perspective involves a reductionist definition of food security based on household rice production. In the other perspective, the sustainable livelihoods (SL) framework, food security is seen as embedded in the household’s livelihood system (Negash and Niehof 2004). On the basis of the sustainable livelihood framework household food security is but one of a number of livelihood outcomes, which households seek to achieve using available household resources. Achieving such outcomes, however, is subject to the influence of factors both at household level and external to the household (Ellis 1998; Farington et al. 1999; Ellis 2000; Adato and Meinzen-Dick 2003).

3. Rice research programmes in Tanzania

Rice research in Tanzania started in 1935 at Mwabagole, near Ukiriguru on the shores of Lake Victoria (Tanzania. Department of Research and Training 1991). The two rice research programmes, which are assessed here for their impact on food security, were conducted in the Eastern Zone (EZ) and the Southern Highlands Zone (SHZ)⁸ of Tanzania in the period from 1980-1990. In 1983 a hybridization-breeding project geared to developing improved rice

cultivars with desirable grain quality was initiated at Dakawa (Cholima), Morogoro Region in EZ. In 2001 the programme released two high yielding varieties – TXD88 and TXD85 (Kanyeka et al. 2004)⁹. Another variety – TXD306 was released in 2002 (Msomba et al. 2004). According to TARP II-SUA (2002) agronomic research led to recommendations that focused mostly on spacing, sowing dates, and fertilizer application rates.

In SHZ rice research started in the early 1980s at the Uyole Agricultural Research Institute, Mbeya Region. By 1992 several improved high yielding varieties were released including Afaa Mwanza 1/159, Katrin, Selemwa, Afaa Mwanza 0/746 and Salama (Mghogho 1992). Besides crop breeding, the programme involved carrying out agronomic research whose recommendations with respect to crop management included time of planting, seed rate, fertilizer application and weed control involving hand weeding and use of herbicide (see Mussei and Mbogholo 2001).

4. Study areas and context

Fieldwork providing data on which the present article is based was carried out in the villages Kikusya and Mang’ula A, located in Kyela and Kilombero District respectively¹⁰, where rice is an important economic activity (Liguguda and Kisunjuru 1996; Kayeke 1998). The villages have both some similarities and certain differences on key variables. In Kilombero district, where Mang’ula A is located, rainfall ranges from 1,200-1,400 mm and in the highlands reaches 1,600 mm. The District rarely receives less than 1,100 mm rainfall. Kyela district, where Kikusya is situated, receives more rainfall, ranging between 2,000mm and 3,000mm. Land tenure arrangements are more or less similar with access to land being mainly through inheritance. Allocation by the village government and renting of land in Mang’ula A, and borrowing of land usually from relatives in Kikusya, are important means of accessing land.

The two villages are served with reliable means of communication. Kikusya is well connected with other parts of Tanzania as well as Malawi. Similarly, Mang’ula A is well linked to various parts of the country. Mang’ula A is relatively closer to Dar-es-Salaam, which serves as the largest market of agricultural produce in the country. Also, deliberate externally initiated interventions were implemented in Mang’ula A to promote ‘modern rice

farming' involving the use of modern varieties and complementary crop management innovations. Kikusya, on the other hand, did not benefit from similar efforts.

5. Data sources

Data collection involved mainly group and in-depth interviews with farmers, and administration of a pre-tested interview schedule. Group interviews were conducted with men and women groups of farmers in Mang'ula A to assess the impact of growing modern varieties. An interview checklist was used to facilitate the interviews. An interview guide was used in individual in-depth interviews with selected farmers. These farmers were purposely selected and had earlier participated in the group interviews. Similarly, in Kikusya both group interviews and individual in-depth interviews were also carried out.

The interview schedule drawing on some key issues raised in group and individual interviews conducted earlier was prepared and administered to a random sample of 50 household heads in Kikusya and 50 household heads in Mang'ula A. The sampling frame in Kikusya and Mang'ula A comprised a total of 335 and 524 household heads respectively. The schedule, among others, comprised items on the use of selected innovations (dibbling, transplanting, pesticide, fertilizer, herbicide and modern varieties – TXD85 and TXD88), rice production and marketing, types of food eaten, and their sources.

6. Results and discussion

6.1 Perceptions of food security

Rice production is an important economic activity in the two villages. It serves both as a source of staple food and cash income. Most farmers are able to grow rice because, unlike tree crops such as cocoa whose production is conditional on land ownership, it can be grown on borrowed or rented land. Rice is considered the main staple and most preferred food when compared to such foods as *ugali* (mostly maize-based stiff porridge), cassava, and banana. Festivities, whether religious or traditional, are usually held during or immediately after rice harvesting. Moreover, as Aberra et al. (1994) found in Kyela, rice is synonymous with food and its availability is equated with food security¹¹. This is not only because rice is the

preferred food but also because other foods are produced on small scale. Also, in using the term 'food', reference is usually made to the main component of the meal such as rice, which can be substituted by other foodstuffs such as *ugali* and bananas. Therefore, in this usage, attention is not paid to the remaining part of the meal, that is complements or *mboga* (relish) in Kiswahili language, which is usually composed of, among others, fish, meat, milk, and beans.

Despite the fact that food can be obtained from the market, food security as locally perceived seems to be associated with availability of foods (especially rice) grown at home rather than food from the market¹². This is because even though people could obtain food from the market, in most cases they are not able to do so because of lack of cash. Normally the money obtained from rice sales is not intended for buying food. Rather it is used to meet cash obligation, which require large sums of money, such as health and education costs, building a house, or buying clothing.

6.2 Adoption of innovations in rice farming

In principle farmers are expected to benefit from agricultural research by adopting innovations generated by research. These innovations are mainly of two types, namely crop varieties and the complementary crop management innovations (e.g. use of fertilizers, herbicides and planting methods). In Mang'ula A the adoption of the following innovations was observed: modern rice varieties (TXD88 and TXD85), fertilizer, herbicides, dibbling, transplanting and pesticides. In the other village, Kikusya, the study focused on the adoption of fertilizer, herbicide, dibbling and transplanting. In this subsection we focus on the four cases (presented below), two farmers each of the villages Kikusya and Mang'ula A¹³. The aim is to highlight some key issues on the rationale behind farmers' adoption or non-adoption of innovations in rice farming.

Case 1: Jennifer Lazaro, Mang'ula A village

Jennifer is married to a schoolteacher. The husband teaches in a primary school far away from Mang'ula A village. She is thus responsible for organizing all farming activities. According to her she started growing TXD88, a modern variety, in 1996 and obtained 30 bags (each bag weighs 75 kg) per acre (5.6 ton/ha)¹⁴. She further says that modern farming is beneficial as she has been able to build a good family house, buy a sewing machine and one-acre plot of land. She sells and receives about 0.3 USD per kilogram of the rice seed sold. Nevertheless, she admits that it was difficult to sell the produce for lack of immediate market.

She had to wait till February and March to sell the produce that was harvested earlier in May to July. In 2001 she started to grow TXD85, another improved variety, and has been growing it ever since. Currently she plants three acres with the variety by transplanting and using fertilizers, herbicides and pesticides. She is no longer facing the problem of marketing as she did when she began growing TXD88. This is because farmers from within and outside the village buy the variety for planting. She also grows local varieties of rice for food as well as maize for household consumption. However, growing TXD85 has not been without problems as in 2002 she suffered a severe loss by harvesting only 5 bags from one acre (0.93 ton/ha). She blamed this on pest infestation. Commenting on her experience with modern varieties she had this to say: “These pests are affecting us. You use a lot of money but get low yield. Those who grow traditional varieties harvest more than us who grow modern varieties”. She also adds: “This variety can make you rich or poor. From three acres you get 90 bags a good fortune and you can cultivate the same acres and get five bags”. Despite this she plans to expand the area under improved variety based on proceeds from her venture.

Case 2: Upendo John, Mang’ula A village

Upendo is 31 years old and has one child. She is also living together with her mother. She doesn’t own her own land. Instead she cultivates fields rented from other farmers. Consequently, she ends up farming anywhere land is available. Sometimes she ends up getting land not well suited to rice farming. According to her, a good land for rice farming is one that is well inundated with water during the rainy season. Such land is, however, more costly. She says you need about 10 USD to rent a one-acre plot and 50 USD to buy a similar plot. In 2003 she cultivated two plots with traditional varieties, namely *Supa India* and *Usiniguse*. The latter, she says, matures early and thus it provides food before other varieties that take longer to mature. In addition to the two rice varieties, she planted 0.5 acre of maize for food. Although she has been growing traditional varieties most of the time in her farming career, in 1999 Upendo cultivated two acres of TXD88 – a modern variety. She cultivated the land by hiring a tractor and then planted the seed by broadcasting. She neither used fertilizer nor herbicide and harvested 26 bags of rice i.e. 13 bags per acre. She is of the opinion that she did not get a much better yield because she did not follow the advice by the resident Village Extension Officer (VEO). She normally plants by broadcasting even though she knows that yields are better when transplanting is done. Both dibbling and transplanting are labour demanding, whose cost she cannot afford. Furthermore, she says, you need money to buy inputs. Compared with other rice farmers in the village, she says that farmers who have cash do broadcast like she does but are able to buy and use fertilizer and herbicide. Most of these farmers are either civil servants such as teachers or farmers who trade in rice or owners of shops and make shift food stalls or ‘*magenge*’. She is not planning to grow the variety (TXD 88) again because when she grew it she had difficulties in selling it in the local market. She had to wait until December to sell it. In contrast, she says that a variety such as *Supa India* is easy to sell and enables one to meet cash obligations.

Case 3: Lugano Asumwisye, Kikusya village

Born in 1965 and a primary school leaver, Lugano is married and has five children. He is living in a house (burnt bricks and with corrugated iron sheet roof) he has built recently. He started farming in 1988. Through farming he has been able to build a house and to buy two more oxen. He is thus having four oxen and two ploughs. The oxen are used to cultivate his fields and those belonging to his father. Normally two days are enough to cultivate his

two acres and two weeks are set aside to cultivate his fathers' fields. Once he is through with this task he hires out the oxen for a fee, which ranges from 5-7 USD per acre depending on how close the customer is related to him. In 2003 he cultivated 2 acres (0.81 ha) of rice and planted it with the Kilombero variety. He, like other farmers in the village, planted the variety by broadcasting. He also used fertilizer and harvested about 17 bags (about 9 bags/acre or 1.7 ton/ha) from the two acres. He is very much aware that rice yields are usually low without fertilizer application. He observed that one must use fertilizer at least once in every three years. He used fertilizer for the first time in 1998 after seeing some fellow farmers using it. Previously he did all the weeding with his wife. But now he often uses hired labour for weeding. Sometimes he does not harvest much because of lack of cash to buy fertilizer or hire labour for weeding. He cites unpredictable weather as a problem in rice farming. He also said that inability to weed the rice fields on time is another problem. For example, he said that in 2003 he obtained only 17 bags instead of 26 bags. He normally sells rice in December and February in order to get money to pay for hired labour. Otherwise he would only sell rice if and when there is need for cash. The income he receives from selling rice is used to pay school fees for his children as well as medical expenses. These, he says, affect his ability to invest in farming especially the ability to buy fertilizer and pay for hired labour. His household depends on rice as the main staple. According to him food supply has increased as a result of expanding the acreage under rice. He plans to increase his rice farm from two acres to three now that he has two pairs of oxen and ploughs. Apart from rice he also cultivates small plots of maize and cassava for food.

Case 4: Subilaga Seba, Kikusya village

Subilaga is a widow and in her early 50s. Her husband died about 20 years ago and as a result she has been responsible for raising her three children. She also managed to build a good house (cement floor, burnt bricks and corrugated iron sheet roof). Like the rest of the villagers she mainly grows rice. In addition, she cultivates other crops such as maize, cassava, sweet potato and groundnuts on small scale. All along she has been growing only the *Kilombero* rice variety. She likes the variety because of its good milling qualities. Rice farming is a source of income and food for her household. The income she gets from rice is used to pay school fees for her children. She has also started planting cocoa on her homestead plot. She has three acres where she uses to grow rice. She has been using fertilizer since the 1980s. When she uses fertilizer she gets about 10 bags per acre and when she doesn't she gets about 7 bags. She normally processes and sells palm oil and use the cash to buy fertilizer. For her rice farming involves two basic things: weeding and fertilization. She knows that one 50kg/bag of fertilizer is required for an acre of rice. However, when she is not able to buy the bag she would spread half a bag (25kg) of fertilizer on a one-acre plot. She could easily tell by the colour of the crop in her fields whether the required amount of fertilizer had been applied. Thus when the rice crop is dark green she knows that the required amount of fertilizer has been used. In 2003, however, she did not get a good harvest because she was sick and hence could not weed her rice fields. Weeding is a big problem and she attributes it to poor land preparation. According to her, oxen owners do not face this problem because they prepare their land well and therefore reduce weeds in the field.

Generally, these indicate conditions that promote/support the adoption of modern rice varieties and complementary crop management practices (Case 1). Conversely, they point out

conditions, which make it difficult for some farmers to use these practices and as a result improve crop productivity (Cases 2, 3, 4). Generally, the adoption of modern varieties and complementary crop management practices require commitment of cash resources on the part of farmers. The cash is required for the purchase of inputs (e.g. fertilizer) and payment for hired labour. Certainly, knowledge of these practices per se does not guarantee their adoption (Cases 2, 3 and 4). Indeed, lack of cash necessitates some modification of the practices such as application of fertilizer (Case 4). Where rice sales provide the main source of cash for buying fertilizer, its use depends on the ability to meet other cash needs (Case 3). It would seem, as observed by Upendo (Case 2), that farmers who have sources of cash other than farming are well placed to use some of the innovative practices in rice farming.

Even though the cultivation of modern varieties in Mang'ula A appears beneficial, it is also a risky and uncertain venture (Case 1). This is more so with incidence of pest infestation. The farmer engaged in production of modern varieties has not only to deal with uncertainty with respect to crop yield but also the market for the produce. Hence, in order to continue the production of modern varieties the farmer must be able to deal with uncertainties and risks associated with these varieties. Such ability it seems is based among others on sources of cash other than farming such as Jennifer's husband's salary. Moreover, the cases indicate that besides rice, other crops are produced, especially for food.

6.3 Rice production and consumption

Table 1 presents data on area planted with rice, production, sales and consumption¹⁵ for the two cropping seasons 2001/02 and 2002/03. In both villages there was a change over time in area grown to rice. In Mang'ula A a larger area was cultivated in the season 2001/02 than in the cropping season 2002/03. The reverse was the case in Kikusya. In both villages the change in area planted with rice between the two seasons is not statistically significant ($t=0.77$, $p=0.442$, $df=90$ for Kikusya, and $t=1.22$, $p=0.224$, $df=96$ for Mang'ula A). But the difference between the two villages during the reference period is highly statistically significant ($t=3.78$, $p=0.000$, $df=92$ for 2001/02 and $t=4.01$, $p=0.000$, $df=94$ for 2002/03) in favour of Mang'ula A. As with area planted with rice, the difference in mean rice production is not statistically significant between years ($t=1.28$, $p=0.203$, $df=90$ for Kikusya, and $t=1.22$, $p=0.225$, $df=96$ for Mang'ula A) but statistically highly significant between villages ($t=4.28$, $p=0.000$, $df=92$ for 2001/02, and $t=3.39$, $p=0.001$, $df=94$ for 2002/03). Again the difference

was in favour of Mang’ula A confirming that the farmers in this village produced more rice than their counterparts in Kikusya. It is also evident that there is greater variation in crop yield between the two cropping seasons in Mang’ula A than in Kikusya (Table 1). Interviews with farmers indicated that this variation in yield is due to less rainfall in 2002/03 than in the previous season.

Analysis of survey data indicates that the proportion of households who sold rice in Mang’ula A in 2001/02 and 2002/03 season is about 88 and 98 percent respectively. In Kikusya households that sold rice account for about 46 percent and 80 percent during the same periods. Moreover, based on Table 1, the proportion of rice sold in Kikusya remained more or less the same 22 percent in both years. On the other hand, in Mang’ula A the proportion of rice sold varied from 54 percent in 2001/02 to 37 percent in 2002/03 indicating that rice marketing decreased with decreased amount of rice harvested. The proportion of rice consumed depended on the proportion sold. In this regard, while in Kikusya the proportion of rice consumed remained more or less the same (78 percent in both years), in Mang’ula A the amount varied between 46 percent in 2001/02 and 63 percent in 2002/03. This finding suggests that the proportion of rice sold and consumed in Mang’ula A depends on the rice harvest in a particular season.

Table 1: Rice harvest, consumption and sales in 2001/02 and 2002/03 cropping seasons¹⁶

Response category	Mang’ula A		Kikusya	
	2001/02	2002/03	2001/02	2002/03
Cropping season	2001/02	2002/03	2001/02	2002/03
Sample size (n)	50	48	44	48
Mean area cultivated to rice (acres)	2.03	2.49	1.06	1.18
Mean amount of rice consumed (kg)	802	838	367	462
Mean amount of rice sold (kg)	945	487	103	127
Mean amount of rice produced (kg)	1747	1325	470	589
Yield (kg/acre)	861	532	443	499
Yield (ton/ha)	2.13	1.31	1.09	1.24

Source: Survey data, 2003

Nevertheless, the data in Table 1 masks the differences between households at the village level regarding the amount of rice consumed. Thus it was decided to categorize households by the proportion (percentage) of sales out of the total amount of rice produced as follows: The first category comprises market-oriented farmers who sold two-thirds and more of their produce. The second category consists of farmers who are both market and subsistence-

oriented. These sold less than two-thirds but more than one-third. The third and last category comprises subsistence-oriented farmers who sold a third or less of their produce. Although Table 1 presents the data for the two seasons, the focus is now on the crop harvested in 2002 (cropping season 2001/02) and whose consumption was expected to last up to the next harvest in 2003 (cropping season 2002/03). The results are as summarized in Table 2. The table indicates that the majority (about 77 percent) of households in Kikusya sold less than a third of their rice while in Mang’ula A 44 percent of household did so. Generally, the analysis shows statistically significant difference regarding market orientation between the two villages ($X^2= 11.029$, $p= 0.004$, $df=2$) with Kikusya being more subsistence-oriented while Mang’ula A more market-oriented. It could be that higher rice production and closeness to the large market in Dar-es-Salaam provide incentives for market-orientation in rice farming in Mang’ula A.

Table 2: Household categories by share of rice sales

Response category	Mang’ula A	Kikusya
Households that sold two-thirds or more	11 (22)	5 (11)
Households that sold more than one-third but less than two-third	17 (34)	5 (11)
Households that sold one-third or less	22 (44)	34 (77)
Total	50 (100)	44 (99)

Source: Survey data, 2003

Figures in brackets are percentages

6.4 Rice research and food security

Since local perception of food security is associated with rice produced at household level, the number of months a household took to exhaust own rice produce was used as a proxy indicator for food security. Specifically, households that took 12 months (from 2001/02 to 2002/03 season) to exhaust household rice stock were categorized food secure. On the other hand, households who took less than 12 months were classified food insecure. Using this indicator, about nine percent and 30 percent of the households in Kikusya and Mang’ula A respectively were food secure. The mean number of months of rice consumption in Kikusya and Mang’ula A respectively is 6.16 and 8.75. This difference is statistically significant ($t=3.63$, $p=0.001$, $df=70$) implying that households in Mang’ula A were more food secure than those in Kikusya.

Although both crop varieties and crop management practices contribute to crop yield, the impact of rice research was measured on the basis of the adoption of modern varieties¹⁷. As a result the analysis is confined to Mang'ula A and excludes Kikusya because none of its farmers cultivated modern varieties. The analysis involved comparing the food security status between households that only grew modern varieties and those that only cultivated traditional varieties representing a 'with and without' research scenario. The mean number of months of consumption of rice among households who grew modern varieties and traditional varieties is 11 and 8.70 respectively. Even though this finding suggests a difference in household food security between the two categories of households, this difference is statistically insignificant ($t=1.13$, $p=0.265$, $df=33$). From this analysis, the impact of new varieties on food security is not convincing.

Two plausible explanations regarding this weak impact of rice research on food security are given. First, the weak impact could be attributed to the fact that yields obtained by households that cultivated modern varieties (with research) and those that grew traditional varieties (without research) were more or less similar. This is to be expected given that, as found in Mang'ula A, farmers use crop management innovations such as fertilizer irrespective of the type of variety grown. As observed earlier attaining high yields demands more cash investment on the part of the farmers. Certainly, Jennifer's (Case 1) experience in Mang'ula A demonstrates that high yield is the result of a combination of both modern varieties and improved crop management practices. Hence, modern varieties by themselves are not likely to give the farmers the yield advantage on which the impact of rice research depends. The other three farmers (Cases 2, 3 and 4) represent the majority of farmers who are not able to adopt these practices¹⁸. As a result, they are not able to obtain the benefits that research intervention promise.

A second explanation relates to the approach itself. This approach is reductionist in the sense that: (1) food security is seen as dependent on the availability of rice produced at the household level, and (2) food security is examined in isolation from other livelihood outcomes pursued by the farmers. However, an examination of the empirical evidence presented earlier based on the sustainable livelihoods (SL) framework, clearly shows that rice production is not only meant for food security. Rather people cultivate it to attain multiple livelihood outcomes as has been reported elsewhere (e.g. Maxwell and Smith 1992; Maxwell,

S. 1996). In this study, it was found that most farmers cultivate rice in order to achieve both household food security and income. The income obtained from rice sales is used to meet basic welfare needs such as health and education. Thus addressing the impact of rice research on food security per se, as attempted in this article, ignores the link of food security to the broader livelihood system. Moreover, as shown below, for practical purposes food security is not solely dependent on rice, however much people prefer it to other foods. For this reason neither depletion of household rice stock nor changes in eating habits¹⁹ from rice to other types of food necessarily mean that households are food insecure in the sense, which the previous approach would seem to imply.

Household food security strategies embarked upon are based on the available rice produce. Indeed, the decline in rice stock at household level leads to two notable changes. First people start eating other foods besides rice. These include mainly maize-based stiff porridge, cassava, banana and sweet potato. Initially the source of these types of food is from own household production. Second, with the next harvest still months away, the market becomes an important source of food for most households. Reliance on cash income to access food becomes inevitable. In other words, households are forced to engage in various livelihood activities in order to be able to access food. The main source of cash income used to obtain food from the market differed between the two villages. In Kikusya farmers buy food by using cash obtained from cocoa and oil palm sales. In Mang'ula A, sale of labour was frequently mentioned as the main source of cash used in buying food.

Petty trading (e.g. selling kerosene, fried cassava, fish, beans) and brewing of local beer are sources of cash for purchasing food. Among women *producing rice, brewing and selling and buying food/inputs for rice farming* is a common cycle. This entails investment of cash from rice sales in beer. In turn the money obtained from the sale of beer is used either to buy food or reinvested in rice farming or both. In this way it helps in providing for household food security. Even though some farmers indicated buying rice, the most widely eaten food during time of shortage is maize-based *ugali*. The change regarding the main source of food from the household to the market is indicative of the inadequacy of household production and especially rice production to provide for household food security. Hence households adopt various livelihood strategies to ensure household food security. According to Gladwin et al.

(2001) this employment of multiple livelihood strategies is necessary because none of the strategies on their own are capable of sustaining the farmers' livelihoods.

7. Conclusion

The relationship between rice research and food security formed the focus of this paper. The study shows a weak relationship between food security and rice research. This could be attributed to the limited impact of rice research on rice yields. But this only holds true if the assumption is accepted that food security can be analyzed as dependent on household rice production. Furthermore, it is based on the idea that farmers give priority to food (rice) over other needs that constitute a household's livelihood system. This, however, seems to be far from being the case in practice. Instead, farmers produce rice for purposes of meeting a range of livelihood outcomes, which include food security. But as far as these farmers are concerned, household needs such as education, health, and building good houses are as important as food security. Hence, the challenge that farmers face is how to balance food security on the one hand and other household needs on the other. Since it is not possible to meet all their needs from rice production, farmers prioritize their household needs. Thus, the market orientation regarding rice production in Mang'ula A suggests that priority is given to income, which is used to meet cash obligation needs. In this context, food security should be understood within the framework of household livelihood strategies rather than being seen as dependent on household rice production.

Notes

¹Friis-Hansen (2000a: 21) defines public goods as goods "whose use by one person does not exclude others, and where the costs of excluding individuals would be high". Kaul et al. (1999) and Mansfield and Yohe (2000) view public goods as being both nonrival and nonexcludable in consumption. According to Kaul et al (1999) if no individual can be barred from consuming the good, then it is nonexcludable. On the other hand, it is nonrival in consumption if many individuals can consume without it becoming depleted. But Kaul et al. (1999) also point out that few goods are purely public or purely private, hence the difficulty in distinguishing between public and private goods. Such is the case when dealing with, for example, research and extension (R&E) services because both have a private and a public component. In the opinion of Friis-Hansen (2000b), whether a given R&E service is classified as public or private depends on whether a private sector exists or conditions promoting their existence are in place, and most importantly whether the users are able and willing to pay the full cost of the services in question.

²Impact 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: 47). To Bellamy (2000:5) impact studies are viewed as aiming "to measure not only the reactions of the beneficiaries and the outputs generated by them, but also the proportion of any discernible change attributable to the project". In this study impact assessment of rice (agricultural) research goes beyond the output of research (e.g. seed variety,

fertilizer recommendation) to determine the effects of research following the application of these outputs. Particular emphasis is put on varieties generated by rice research because these can easily be traced to the relevant research projects.

³For details on the limitations of the FED approach see Bowbrick (1986) and Sen (1981; 1997). Also see Sen's (1986) rejoinder following Bowbrick's (1986) criticisms of his approach. Moreover, for comments on both FAD and FED see Devereux (1988).

⁴See, for example, Negash and Niehof (2004). For more definitions of food security see Maxwell and Frankenburg (1992), and Maxwell, S. (1996).

⁵The World Bank (1986:1) defines food security as "access by all people at all times to enough food for an active, healthy life". It also distinguishes between two types of food insecurity, namely chronic and transitory. By chronic food insecurity is meant a continuously inadequate diet caused by the inability to acquire food. On the other hand, transitory food insecurity refers to a temporary decline in a household's access to enough food.

⁶Definitions of food security are largely silent on food preferences. An exception is that of Maxwell (1991). According to him "A country and people are food secure when their food system operates in such a way as to remove the fear that there will not be enough to eat. In particular, food security will be achieved when the poor and vulnerable, particularly women, children and those living in marginal areas, have secure access to the food they want" (Ibid: 12). Though not given adequate attention, food preferences have, however, featured in the discussions of food security. But as Pottier (1999:14-15) found out, because of their context specificity, they are difficult to integrate in food security policies. This is understandable because in situations where people are faced with food insecurity attention is paid to quantity rather than quality, which food preferences entail.

⁷Pretty et al. (1996) and Sen (1997) acknowledge the implications of dependence on food production for food security. In particular, Sen (1997:64) remarks that, "food production is not merely a source of food supply in Africa, but also the main source of livelihood for the large sections of the African population. It is for this reason that food output decline tends to go hand in hand with a collapse of entitlements of the masses in Africa."

⁸See also Shao (1994) for information on research organization in Tanzania.

⁹Interviews with farmers and the Village Extension Officer (VEO) in Mang'ula A indicated that some farmers started growing TXD88 in 1996, five years before its official release.

¹⁰The programme at Uyole targeted rice farmers in Southern Highlands including those in Kyela District located in Mbeya Region. On the other hand, the programme at Dakawa catered for the interests of rice farmers in the Eastern Zone including those in Kilombero District in Morogoro Region.

¹¹This observation is informed by two main reasons: (1) lean and abundant months are closely related to the rice farming calendar, i.e. food is perceived to be abundant during and immediately after harvesting season and (2) there is a positive relationship between what farmers perceive as food availability and rice availability.

¹²This perception of food security is widely shared in Tanzania, as an editorial in one of the newspapers in the country testifies: "Unfortunately, food production is not increasing at a rate necessary to meet population growth. Hence we have been experiencing food shortage over the years. It is therefore important that we step up food production so as to address the problem of food insecurity" (The Guardian 2004).

¹³Their real names have been kept confidential.

¹⁴This is quite a phenomenal achievement given that rice yields obtained by the smallholders in the country are usually low (see Msambichaka 1994:435).

¹⁵The amount of rice consumed was computed as the difference between the amount produced and the amount sold. This assumes that all the estimated amount of rice was consumed and as a result ignores, for example, post harvest losses and the amount of rice exchanged as gift between households/families, which is a common practice. This practise of food sharing helps cement social relationships between families (see Meigs 1997 for implications of food sharing).

¹⁶A sample size less than 50 excludes households who did not cultivate rice during the respective season for various reasons including illness or death of a spouse.

¹⁷This was done because unlike crop improvement (breeding) whose output (varieties) is readily observable and easier to trace to a research programme, the principal output of crop management research - information (e.g. fertilizer rate recommendation) cannot unambiguously be traced to a research initiative/programme (see Morris et al. 2003; Morris and Heisey 2003).

¹⁸In their study Byerlee and Heisey (1996) found that the impact of maize research in Africa was less than expected because of patchy adoption of fertilizer in the production of hybrid maize. They attribute this, in part, to deficiencies in local research, institutional support and inappropriate macroeconomic policies. As shown in many studies implementation of these measures calls for active involvement of state in agricultural development (See for example, Rasmussen 1986; Eicher 1995; Smale 1995). In fact, what Rasmussen (1986) termed the green revolution in the Southern Highlands of Tanzania, was as a result of the government provision of credit to maize farmers. This credit enabled the farmers to use the full package of recommendations involving hybrid

maize, fertilizer and insecticide resulting in dramatic increase in maize yields. But the revolution collapsed as soon as credit was terminated.

¹⁹Change in eating habits and other adaptive responses with respect to food security at individual, household and community levels have been widely documented in ethnographic studies (for an extensive review see Messer 1989).

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Paper 4

***An ex-post* impact study on the economic costs and benefits of rice research in Tanzania**

An *ex-post* impact study on the economic costs and benefits of rice research in Tanzania

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Abstract

Growing concern about the efficiency of agricultural research and development (R&D) has triggered the need for impact assessment in agricultural research to determine its economic costs and benefits. This paper presents results based on the assessment of the economic costs and benefits of the rice research programme conducted in the Eastern Zone of Tanzania in the period from 1980-1990. The paper shows that the rates of return vary widely depending on the assumptions informing the analysis. Moreover, the fluctuation of rice research benefits based on cash flow reflects the unstable nature of rice production in the country.

1. Introduction

Impact assessment in agricultural research is done for various reasons. On the one hand, promotion of impact assessment research by research centres, universities and donor agencies may be seen as a reaction 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). On the other hand, impact assessment is carried out for purposes of demonstrating accountability and efficiency to society. With respect to accountability, impact studies are done to show that resources allocated for agricultural research have been well spent. Furthermore, impact studies, and especially *ex-post* rate of return (ROR) studies, are meant to demonstrate research efficiency and in turn aim to rejuvenate donors' and governments' support and convince them of the importance of agricultural research (Maredia et al. 2000; Alston and Pardey 2001). This is especially important because agricultural research must compete with other development activities for scarce resources (Alston et al. 1998).

The interest in efficiency of agricultural research is reflected by an increasing number of impact studies especially in the 1990s. Although based on ROR studies agricultural research seems to have been generally successful based on the observed rates of return, some programs have registered negative rates of return to research investments (Oehmke and

Crawford 1996; Maredia et al. 2000) or performed more poorly than expected (Ahmed et al. 1995). This is attributed to such factors as supply and prices of agricultural inputs and the market for and price of agricultural outputs (Oehmke and Crawford 1996). 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, it has been argued that high rates of return to agricultural research are difficult to sustain in environments where inputs are not accessible to or affordable by farmers (Maredia et al. 2000).

Despite the fact that the rate of return is useful in guiding decision making regarding resource allocation in agricultural research, the rates of return documented in most studies have been challenged for being biased upward (Arnon 1989; Anandajayasekeram et al. 1996). In the main, over-estimated rates of return is seen as related to an attribution problem. For example, high returns are recorded because yield increases are attributed to research alone when in reality several factors explain it (Alston and Pardey 2001). Additionally, failure to take account of spill over effects of technology is a contributory factor to high rates of return (Traxler and Byerlee 2001)¹. It is also the case that high rates of return are reported because of the researchers’ inclination to address success stories (Pingali 2001).

The objective of this paper is to assess the economic costs and benefits of rice research conducted in the Eastern Zone (EZ) of Tanzania². This is done after drawing attention to the following issues: (1) rice production and rice research in the country (2) methodological aspects and empirical issues related to the study, and (3) the data used in this assessment.

2. Rice cultivation in Tanzania

Rice is grown almost all over Tanzania with varying levels of production³. About 17 million hectares out of nearly 40 million ha of arable land in the country are potentially suitable for cultivating rice (Kanyeka et al. 1995). Based only on the source of water for rice production, the rice ecosystems can be broadly classified into upland and lowland ecosystems, which occupy 80 and 20 percent of the total rice area respectively. In the upland ecosystem, rice is grown under rainfed condition without water accumulation on the soil surface. In contrast, in

the lowland ecosystem, water accumulation occurs in the rice fields during most of the crop growing periods (Ibid).

According to Isinika et al. (2003:63), drawing on data from various sources for the period 1985-1998, rice is the fastest growing crop in Tanzania compared with maize, cassava, beans, wheat, and sorghum and millet. They attribute this growth to two main factors: (i) rice is a tradable good and therefore domestic price is induced by exchange rate and international prices (ii) rice has a high income elasticity such that rising income exerts demand-pull, and subsequent supply response. But the low yields obtained by Tanzanian smallholder farmers suggest that they have not benefited much from the existing lucrative marketing potential of the crop. This situation is blamed on various factors including the use of unimproved varieties, poor weed control, poor soil fertility, poor management of water, drought and floods, inefficient pest control, and lack of inputs and credit facilities (Tanzania. Department of Research and Training 1991; Mghogho 1992; Mbapila Undated). As a result, to contribute to increased crop productivity, rice research in Tanzania has sought to address technical problems facing the smallholder rice farmers in the country.

3. Rice research in Tanzania

Rice research in Tanzania started in 1935 at Mwabagole, near Ukiriguru, on the shores of Lake Victoria (see Tanzania. Department of Research and Training 1991). The main focus of research at the time was improvement of the local varieties through selection and increasing production per unit area through improvement of cultural practices. Before 1955 several varieties were introduced from outside the country and tested. These included *Basmati*, *Pishori*, *Kihogo red*, *Ran Captain* and *Calyaman*. Rice research stopped for 10 years from 1955-1965 before it was launched again in 1965 but this time at Ilonga Research Station near Kilosa in Morogoro region. Some 10 years later, in 1975, rice research was again relocated to the Kilombero Agricultural Training and Research Institute (KATRIN) in Ifakara. Since then KATRIN has been the lead and national coordinating centre for rice research⁴.

Although rice research is done in various zones of Tanzania, this article focuses on the impact of the research programme implemented in the Eastern Zone (EZ). It is, therefore, necessary

to give a brief outline of this programme. In 1983 the hybridization-breeding project was initiated at Dakawa (Cholima), Morogoro region in EZ, with the objective of developing improved rice cultivars with desirable grain quality. In 2001 the programme released two high-yielding varieties, namely TXD88 and TXD85 (Kanyeka et al. 2004). Another variety, TXD306, was released in 2002 (Msomba et al. 2004). According to TARP II-SUA (2002) agronomic research led to recommendations mostly on spacing, sowing dates, and fertilizer application rates.

4. Methodologies for estimating rates of return of agricultural research

Two rates of return-based traditional approaches have often been used to assess the costs and benefits of research and development (R&D). The first is the econometric approach requiring time series data, which treats research expenditures as a variable, and may be estimated with a production function, measuring the marginal returns on investment. 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).

The other approach is the economic surplus model, which estimates average returns by determining the movement or shift of the supply function⁵. Moreover, the economic surplus approach measures the increase in the value of output caused by research from a given level of conventional inputs (Echeverria 1990). The main advantage of this approach is that, unlike the econometric approach, it does not require long time series data to be calculated (Alston et al. 1998). This reason informed its use in the present assessment of rice research because in developing countries (including Tanzania) sufficiently reliable time series data on production, yields and prices rarely exist.

5. Empirical studies on rates of return (ROR) to agricultural research

While acknowledging the fact that the benefits of agricultural research are difficult to quantify (Arnon 1989), impact assessment of agricultural research based on ROR has been widely reported. For example, Echeverria (1990) compiled a number of studies reporting rates of return (ROR) for different crops in different countries for the period from 1958 to

1990. Most of the RORs reported in this study were high compared to normal profit rates for public investments. Alston and Pardey (2001), who disaggregated rates of return by nature of research, commodity orientation and geographic region reported similar findings. And so did Arnon (1989) and McIntire (1994).

In Africa, where agricultural research is still mostly conducted by the public sector (Beintema and Stads 2004), a number of rates of return studies have been reported (Karanja 1993; Isinika 1995; Oehmke and Crawford 1996; Anandajayasekeram et al. 1996; Anandajayasekeram et al. 1997; Moshi et al. 1997; Masters et al. 1998; Maredia et al. 2000). As is the case with research conducted elsewhere, overall these studies report high returns for almost all the crops. Indeed, Masters et al. (1998:84) sum up their observations on rate of return studies in Africa when they write: “Our compilation confirms that returns to research in Africa are similar those found elsewhere, showing high payoffs for a wide range of programs”. Overall, these studies help justify the argument for increased investment in agricultural research, particularly in developing countries where it “potentially offers extraordinarily high returns” (Horton 1990:45).

6. Data

The data used in this article were collected from various sources. Primary data were collected using a pre-tested interview schedule. The interview schedule was administered to a total of 50 household heads in Mang’ula A village in Kilombero district. These household heads were randomly selected from a list of 524 heads of households in the village. The interview schedule contained both open- and close-ended items, including area grown to rice, rice varieties, inputs used and their costs and marketing. Secondary data on inflation rate and consumer price index were obtained from the National Bureau of Statistics (NBS). Moreover, data on rice production; area and yield at national and regional levels were obtained from publications of the Ministry of Agriculture and Food Security. National level data on production, area and yield of rice were also obtained from FAOSTAT data (2004)⁶. Research costs for developing and disseminating rice research technologies were obtained from both KATRIN and Dakawa research institutes.

7. Trends in rice production, area and yield

Table 1 presents results on rice area, production and yield at the national level. Besides, data for the Morogoro region in which the sample village is located are presented. These data should be treated with caution, as they are not disaggregated by rice varieties. Since the use of modern varieties in the country is limited, it is assumed that a bigger proportion of the reported aggregate rice production comprises traditional rather than modern varieties of rice. The table shows that rice production at both the regional and national levels reflects an upward trend. The increase is significant at both levels. Similarly, area (ha) under rice increased with time. This change is also significant. Moreover, in Morogoro and the country as a whole yield increase is not significant.

Given the fact that rice production is explained both by time and area but is not significantly related to yield (Table 1), the significant increase in rice could be attributed to the expansion of area planted with rice including marginal land coupled with limited use of modern varieties and improved crop management practices such as fertilizers, pesticides, and herbicides. Interviews with farmers in Mang'ula A village indicated that they sought to increase rice production through expansion of the acreage rather than increasing productivity (yield). Moreover, following limited availability of land in the village, some villagers sought land in other villages where it is relatively abundant.

Table 1: Regression analysis of rice production at national and regional levels in Tanzania

	Coefficient	T values	P values	R ²
Area versus year (ha)				
National	7,962	3.50	0.002	0.348
Morogoro	2,945	4.81	0.000	0.537
Production versus year (tons)				
National	16,343	4.52	0.000	0.471
Morogoro	6,260	4.37	0.000	0.489
Yield versus year (tons/ha)				
National	0.016	1.81	0.083	0.125
Morogoro	0.021	1.31	0.206	0.079

Source: Own estimates based on data from FAOSTAT (2004) and Ministry of Agriculture and Food Security
 Note: National level data cover the year 1980-2004 while regional level data are for the period 1981-2002

8. Rice production in sample village

As noted above, the data presented in Table 1 represent rice production at aggregate regional and national levels. To understand rice production at these aggregate levels, it was deemed necessary to examine rice production at micro level, that is, the village level. Of interest were the varieties and crop management practices used by the farmers in rice production in Mang'ula A village. Drawing on the formal survey, the results on crop management practices are presented in Table 2. As the table shows, households employed various crop management practices in rice production. About 44 percent of the households produced traditional varieties only⁷ (i.e. grew traditional varieties using neither fertilizer nor herbicide) while the same percentage of households grew rice using traditional varieties and herbicide. Other crop management practices were only used by a small percentage of the households in the village.

Table 2: Crop management practices used by farmers in rice production in Mang'ula A village (N=48)

Crop management practice	No. of households	%
Traditional varieties only	21	44
Traditional varieties + fertilizer	2	4
Traditional varieties + herbicide	21	44
Traditional varieties + fertilizer + herbicide	1	2
Modern varieties only	8	17
Modern varieties + herbicide	11	23

Source: Survey data, 2003

Note: Some households grew rice using more than one practice, thus the total of percentages is more than 100.

Table 3 displays regression analysis results on the influence of selected factors on rice yields. None of the selected factors namely area (ha), varieties (modern and traditional), fertilizer and herbicide had significant influence on yield at 5 percent probability level. However, the results indicate positive but weak relationship between yield and the use of modern varieties, fertilizer and herbicide. Furthermore, the results show a negative, but not significant relationship between yield and area as well as between yield and the use of traditional varieties.

Table 3: Regression analysis of the influence of selected factors on rice yield

Variable	Coefficient	T Values	P values
Area grown to rice	-209.9	-1.30	0.201
Use of traditional variety	-666.5	-1.54	0.131
Use of modern variety	98.1	0.32	0.752
Use of fertilizer	12.93	0.90	0.373
Use of herbicide	160.6	1.45	0.154
$R^2 = 14.9\%$			

Source: Survey data, 2003

Generally, these results suggest that rice yields are influenced by factors other than the selected ones. The results also seem to imply that the mere use of inputs does not by itself guarantee increased crop yield. In fact, interviews with farmers indicated that they are not able to use the required amount of fertilizer because it is expensive. As a result, they often end up applying small amounts of fertilizer, which they can afford to purchase, but which result in minimal impact on crop yield.

9. Assessing returns to rice research

Basically, the calculation of research returns has two main components, namely the costs and benefits components. The source of benefits is the yield increases, which are obtained after the adoption of both modern varieties and improved crop management practices. Thus the yield benefits due to the programme are assumed to be the result of the farmers using both modern varieties and improved crop management practices. Costs used in calculating the rates of return are those incurred in technology development, transfer and adoption. The costs involved in the development and transfer of the technology are borne by research and extension⁸. On the other hand, the farmer meets the adoption costs of the developed technology, which in this assessment were estimated based on the survey data.

A number of assumptions inform this assessment. The underlying assumption in estimating returns to research investment is that, research costs incurred in a certain period are expected to yield benefits in the following period. In this assessment it was assumed that the

contribution of the rice programme to increased rice yields would be evident in Morogoro region, which is part of the EZ. Hence the benefits in terms of yield increases were calculated based on the data for the Morogoro region (see Table 4).

The data in the table suggest that benefits accruing to the farmers started in 1981. But since the research programme started in 1982, and considering that some farmers started adopting the modern varieties in 1996, the benefits of the programme are assumed to start flowing from 1996 onwards. The baseline yield was obtained as an average (1641.9 kg/ha) of the years 1993 to 1995. Hence rice yield increase due to research intervention was obtained by subtracting rice yield in each subsequent year (1996 - 2002) from the baseline yield.

As the table shows, the costs are still being incurred well after 1996 when some farmers started adopting the varieties. This is because on-farm research was done some years after on-station research was completed for purposes of validating the varieties before their official release. This indicates that the adoption of the modern varieties started well before the official release of the varieties. Using output prices for the year 2003, the rate of return of rice research for the period 1981 to 2002 is 48 percent. When overhead costs such as salaries are added to the research costs and assumed to account for half the total costs, the rate of return declines to 41 percent. Furthermore, the table clearly shows the fluctuation of the benefits during the assessment period, that is, from 1996 to 2002. This fluctuation in benefits is likely to be the result of fluctuation in rainfall distribution as was also observed by Moshi et al. (1997) in their assessment of the national maize programme in Tanzania.

Table 4: Analysis of costs and benefits of rice research in Eastern Zone of Tanzania based on 2003 prices

Year	Area (Ha) ^a	Production (Tons) ^b	Yield (kg/ha) (1)	Yield increase (kg/ha) (2)	Yield benefits (TAS) (3)	Input cost (TAS/ha) ^c (4)	Research cost in nominal prices (TAS) ^d	Consumer Price Index ^e	Research cost per ha in 2002 prices (TAS) (5)	Cash flow (TAS/ha) (6)
1982							755,000	3.7	369	-369
1983							612,000	4.8	231	-231
1984							673,300	6.5	187	-187
1985							740,000	8.6	156	-156
1986							849,600	11.4	135	-135
1987							895,000	14.8	109	-109
1988							985,000	19.5	91	-91
1989							1,083,000	25.4	77	-77
1990							1,202,000	34.5	63	-63
1991							1,323,500	44.4	54	-54
1992							1,455,000	54.1	49	-49
1993	59,200	118,500	2002					67.1	0	0
1994	57,500	78,100	1358					90.9	0	0
1995	78,300	122,600	1566					115.8	0	0
1996	77,600	121,400	1564	-78	-23270.1	6,334		140.1	0	-29,576
1997	48,600	126,300	2599	957	287077.2	6,334		162.6	0	280,723
1998	65,700	129,500	1971	329	98751.9	6,334		183.5	0	92,418
1999	67,100	103,200	1538	-104	-31193.7	6,334	620,715	197.9	7	-37,511
2000	37,800	37800	1000	-642	-192,572.4	6,334	1,878,500	209.7	16	-198,922
2001	115,800	231,600	2000	358	107,427.6	6,334	1,513,600	220.4	12	101,081
2002	127,500	259,600	2036	394	118,235.7	6,334	7,104,200	230.5	1	111,917
Rate of return = 48% (7)										

Source: ^a United Republic of Tanzania (1993, 1998, 2000, and 2004)

^c Village sample survey, 2003

^d KATRIN, Dakawa and Ilonga Agricultural Research Institutes

^e National Bureau of Statistics

- (1) Rice production/area grown to rice
- (2) Obtained as the difference between base yield (1641.9) and yield in relevant year
- (3) Yield increase per ha x 300 TAS (Price per kg rice in 2002)
- (4) Based on sample survey
- (5) [= Research costs, nominal prices/Rice area 2002) x (CPI for 2002/Consumer price index for the actual year.
- (6) [=3-4-5]
- (7) [= IRR of cash flow 1992-2002]

10. Conclusion

Rice production in Tanzania is dominated by traditional varieties, which are produced under rainfed conditions. Crop productivity is low hence the need to expand land under cultivation in order to increase rice production. The present study indicates a rate of return at about 48 percent. However, both uncertainty of several assumptions informing the analysis and failure to show significant yield increases at regional and national levels may lead to doubts about the accuracy of these quantifications. In any case, the analysis shows that the research costs are very modest compared to the potential benefits from increased yields. Thus even a small increase in yield attributable to research can give a high rate of return. Besides, the observed fluctuation of research benefits, based on cash flow, indicates the unstable nature of rice production. Great dependence on rainfall means that farmers' rice yields and production in general, fluctuate with rainfall distribution. Moreover, the majority of farmers produce rice with limited resources. This is reflected in the limited use of agricultural inputs such as fertilizer. In addition to estimating the rate of return, this paper highlights some of the constraints to rice farming that might have limited the benefits of rice research. Consequently, the challenge facing rice research in the country is to generate technologies or innovations that best reflect the obtaining production environment.

Notes

¹These are benefits generated by the adoption of an innovation outside the mandate area of the research institution making the discovery.

²Initially it was intended to address the programme in SHZ as well but this could not be done because the research costs for the programme could not be availed.

³The leading rice producing regions in the country are: Shinyanga, Morogoro, Mwanza, Mbeya, Tabora and Coast.

⁴The coordination covers research activities done at Uyole (Mbeya), Naliendele (Mtwara), Sokoine University of Agriculture (Morogoro), Ilonga (Morogoro), Tumbi (Tabora), Ukiriguru (Mwanza) and Dakawa (Morogoro). For information on research organization in Tanzania see Tanzania. Department of Research and Training (1991), and Shao (1994)

⁵Masters (1996), define economic surplus as the value of production and consumption in monetary terms.

⁶Discrepancy between national level data obtained from the Ministry of Agriculture sources and FAOSTAT data (2004) was observed. Analysis at national level was based on data from FAOSTAT data (2004). Since FAOSTAT data (2004) cover data at national level only, analysis of data at regional level was based on data obtained from sources at the Ministry of Agriculture and Food Security.

⁷This involves weeding the crop by manual labour. Interviews with farmers indicated weeding as one of the most critical farm operations in rice farming. Sometimes farmers are required to weed up to three times to control the weeds. Most farmers cannot afford this and failure to weed the fields at all was reported. Thus inability to weed a rice plot for lack of labour or cash to buy herbicide results in great reduction in crop yield.

⁸In this assessment the transfer costs used are those incurred for on-farm research.

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Appendices

Appendix 1: Interview schedule for rice research impact study in Southern Highlands and Eastern Zones of Tanzania

Starting Time: -----

Household Head Name: -----

Household Identification Number: -----

Village: ----- Sub-village: -----

Ten-Cell Leader: ----- Date of Interview: -----

SECTION A: LIVESTOCK PRODUCTION AND CROP PRODUCTION

1. Do you keep livestock? 1. Yes 2. No

2. If yes, indicate the type and number kept respectively

Type of livestock	Number
Cattle	
Sheep	
Goats	
Chicken	

3. How many plots did you farm this year/season (2002/2003) and how did you acquire them?

Plot no.	Area (acres)	Crop grown/variety	Tenure status*
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

*Tenure status: 1=Inherited 2=Bought 3=Rented 4=Borrowed 5=Allocation by village government. Please also indicate land rent as appropriate

SECTION B: ADOPTION OF IMPROVED VARIETIES AND CROP MANAGEMENT PRACTICES

4. Have you ever grown improved varieties of rice? 1. Yes 2. No [Go to question 6]

5. If yes, which varieties have you grown?

Improved rice variety	Year first adopted	Source of recommendation	Whether farmer has ever discontinued adoption of variety			
			Yes	Main reason for discontinuation	No	Main reason for continuation
Line 88						
Line 85						
Jaribu						
Saro Five						

6. With respect to improved crop management practices, please provide the following information

Practice	Received Recommendation		Source of recommendation	Adoption			
	Yes	No		Yes	Year first adopted	No	Main reason for adopting
Planting method							
Dibbling							
Transplanting							
Fertilizer use							
Herbicide use							
Pesticide use							

Source: 1=VEO/Extension 2=Fellow farmer/neighbour 3=Researchers 4=Radio 5=Field day 6=Traders 7= Other (Specify)

SECTION C: RICE PRODUCTION TREND

7. With respect to varietal use, please provide the following information:

Variety	Year			
	2003		2002	
	Area (acres)	Total production (tins/bags)	Area (acres)	Total production (tins/bags)
Local varieties				
Var.a:				
Var.b:				
Var.c:				
Var.d:				
Var.e:				
Improved varieties				
Line/TXD88				
Line/TXD85				
Jaribu				
Saro Five				

SECTION D: FARM LABOUR AND INPUTS IN RICE PRODUCTION

8. Please provide information on the workload for each of the following activities performed during this season (2002/2003) as appropriate

Practice	Plot no./acres	Hired labour		Family labour
		Labour (man-days)	Cost (TAS)	Labour (man-days)
Dibbling/dry planting				
Transplanting				
Fertilizer application				
Herbicide application				
First weeding				
Second weeding				

9. Please provide information on costs of inputs used in rice production during this season (2002/2003)

Plot no/area in acres	Variety planted	Inputs used			
		Type	Amount (bags/kg/litre)	Price	Total cost
1.		Seed			
		Fertilizer			
		Herbicide			
		Pesticide			
2.		Seed			
		Fertilizer			
		Herbicide			
		Pesticide			
3.		Seed			
		Fertilizer			
		Herbicide			
		Pesticide			
4.		Seed			
		Fertilizer			
		Herbicide			
		Pesticide			

SECTION E: RICE MARKETING

10. Please provide information on marketing during the last two years

Variety	Year					
	2003			2002		
	Production (tins/bags)	Amount sold (tins/bags)	Selling price per tin/bag (TAS)	Production (tins/bags)	Amount sold (tins/bags)	Selling price per tin/bag (TAS)
Local varieties						
Var.a:						
Var.b:						
Var.c:						
Var.d:						
Var.e:						
Improved varieties						
Line/TXD88						
Line/TXD85						
Jaribu						
Saro Five						

SECTION F: FOOD SECURITY

11. What are the different food types, which are consumed by your household and what is the main source of each?

Type of food	Crop	Main source

12. If own production is the main source of rice consumed in your household, was the production last year (2002) enough until this year's 820039 harvest? 1. Yes 2. No

13. If no, how long did it take to exhaust the stock from last year's (2002) production ----- (Enter number of months after harvest).

14. How did you cope with the situation when the stock was finished?

.....

SECTION G: FUTURE PLANS IN RICE PRODUCTION

15. What future plans do you have concerning the total area under each of the following local varieties you planted this season (2002/03)? [**Question 3**]

Variety	Future plans on area under local varieties			Main reason
Var.a:				
Var.b:				
Var.c:				
Var.d:				

16. What future plans do you have concerning the total area under improved varieties you planted this season (2002/03)? [**Question 3**]

Variety	Future plans on area under local varieties			Main reason
Line/TXD88				
Line/TXD85				
Jaribu				
Saro Five				

17. What comments do you have regarding rice production in this area? -----

SECTION H: HOUSEHOLD CHARACTERISTICS

18. Age of the head of household ----- (Number of years)

19. Gender of household head 1. Male 2. Female -----

20. Level of education (Enter years of schooling as appropriate)⁹

Primary -----

Secondary -----

Adult -----

None -----

21. Marital status

1. Single

2. Married --- monogamist

3. Married --- polygamist ----- Number of wives

4. Divorced

5. Widow/widower

22. Please provide the following information on people living with you (including yourself)

Age category	Total	How many work full time in the farm	How many work part-time in the farm	How many have full-time off farm activities
Able bodies adult male 15+				
Able bodies adult female 15+				
Elderly/disabled				
Children 14 years and below				
Total				

Ending Time: -----

THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION

Appendix 2: Checklist/guide for interviews

Topic	Source of information
Rice research programmes Background and implementation of the two rice programmes	Researchers, extension staff
Delivery of extension services	District and village-level extension staff
Background information on village (e.g. climate, land tenure, livelihood activities)	Village officials
Rice farming - Interventions in relation to rice farming - Agricultural innovations in rice farming (rice varieties and crop management) - Use of innovations - Constraints on adoption	Groups of farmers, individual farmers, Village Extension Officer (VEO), Community Development Officers (CDOs)
Benefits and problems of growing improved varieties	Groups of farmers, individual farmers, researchers, CDOs

Appendix 3: Statements of authorship

Statement regarding the article:

A review of impact studies of agricultural research in Tanzania

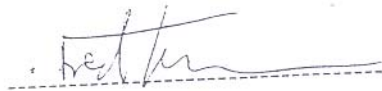
By

Dismas L. Mwaseba, Fred H. Johnsen, Susan Nchimbi-Msolla and Patrick S.J. Makungu

We, who are all co-authors of the above-mentioned article, hereby accept that the article can be used as part of Mr. Dismas L. Mwaseba's thesis to be submitted to the Norwegian University of Life Sciences. Also, we confirm that our contribution to the article is limited to a supervisory and advisory role, and that Mr. Dismas L. Mwaseba is the de facto principle researcher and main author of the article.

Ås, 23.6 2005

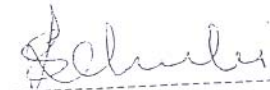
Place and date



Fred H. Johnsen

Morogoro 6th June 05

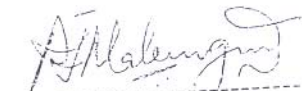
Place and date



Susan Nchimbi-Msolla

Morogoro 2nd June 05

Place and date



Patrick S.J. Makungu

Statement regarding the article:

Beyond adoption - rejection of agricultural innovations: empirical evidence from smallholder rice farmers in Tanzania

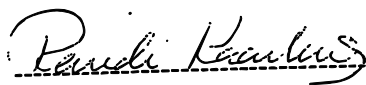
By

Dismas L. Mwaseba, Randi Kaarhus, Fred H. Johnsen, Zebedayo S.K. Mvena and Amon Z. Mattee

We, who are all co-authors of the above-mentioned article, hereby accept that the article can be used as part of Mr. Dismas L. Mwaseba's thesis to be submitted to the Norwegian University of Life Sciences. Also, we confirm that our contribution to the article is limited to a supervisory and advisory role, and that Mr. Dismas L. Mwaseba is the de facto principle researcher and main author of the article.

Oslo, 23.06.05

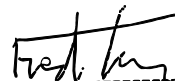
Place and date



Randi Kaarhus

Ås, 23.6.2005


Place and date



Fred H. Johnsen

Morogoro 30/5/2005


Place and date



Zebedayo S.K. Mvena

Morogoro, 30.6.05

Place and date



Amon Z. Mattee

Statement regarding the article:

Rice for food and income: assessing the impact of rice research on food security in Kyela and Kilombero districts of Tanzania

By

Dismas L. Mwaseba, Randi Kaarhus, Fred H. Johnsen, Amon Z. Mattee
and Zebedayo S.K. Mvena

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Morogoro 30/5/2005

Place and date

Zebedayo S.K. Mvena

Zebedayo S.K. Mvena

Statement regarding the article:

**An ex-post impact study on the economic costs and benefits of rice
research in Tanzania**

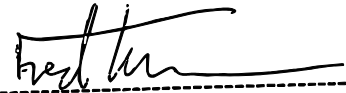
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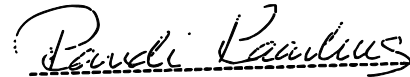
Place and date



Fred H. Johnsen

Oslo, 23.06.05

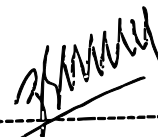
Place and date



Randi Kaarhus

Mongu 30/5/2005

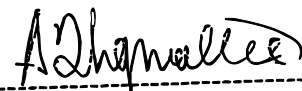
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Amon Z. Mattee
