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Analysis of the Agricultural Science, Technology and Innovation System: Banana (*Musa spp.*) Case Study in Tanzania

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Abstract

This study was conducted to collect information on the agricultural science, technology and innovation (ASTI) system in the banana (*Musa spp.*) subsector in Tanzania. Major policies were reviewed with respect to their impact on the subsector. Linkages among key actors were identified and analyzed. Surveys were conducted in four agro-ecological zones that are major banana producers. The information was collected using two structured questionnaires: one for farmers and another for organizations. Generally, Tanzania was found to have well established agricultural and science and technology policies. However, implementation was hampered by low investment that did not match with government commitments. Main key actors, identified in the subsector, included smallholder farmers, private enterprises and various organizations that played major roles in creation, diffusion and utilization of knowledge. Research and training were found to be mainly under the control of the Ministry of Agriculture, Food and Cooperatives and the Sokoine University of Agriculture. Results indicate that 60% of smallholder banana farmers had received primary education. Land is under family ownership, with an average 1.5 ha of which 25–53% was devoted to banana production. Most banana producers were found to operate on an individual basis, with collaboration mainly amongst themselves rather than with other actors. They lacked specialized training and operated at traditional level with very low use of innovations. It is recommended that all major areas of action require strengthening of existing information diffusion system, incentives for innovations, infrastructure, credit schemes, and recognition of banana as an important food and cash crop.

INTRODUCTION

Tanzania is a largely agro-based developing country. Agriculture contributes 50% to the country's gross domestic product (GDP), 66% to export earning, 75% to employment and 70% to rural household income. Food crop production accounts for about 65% of agricultural GDP, while traditional export cash crops account for only about 10% (URT, 2005). Major staple crops are maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), millet (*Eleusine coracana*) and cassava (*Manihot esculenta*). Others are Irish potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomoea batatas*) and banana and plantain (*Musa spp.*). Export cash crops are coffee (*Coffea spp.*), cotton (*Gossypium hirsutum*), cashew nut (*Anacardium occidentale*), tobacco (*Nicotiana tabacum*), tea (*Camellia Sinensis*), sisal (*Agave sisalana*), pyrethrum (*Pyrethrum cenerariaefolium*) and cut flowers.

Banana is grown in all regions, from the coast to highland areas and Tanzania ranks third in banana production in East and Central Africa (FAO, 2007). It is a staple food for about 15% of Tanzanian's population (Ngeze, 1994) and also contributes to household income generation through sales on the domestic market. Despite this importance, banana and plantains, although mentioned in reports and plans, are never reported in national crops production statistics.

The main objective of this case study was to better understand the strengths and weaknesses of the science, technology and innovation system in the banana subsector of Tanzania, for the purpose of identifying policy options and interventions that could contribute to improved performance.

METHODOLOGY

Based on the agricultural science, technology and innovation (ASTI) systems framework (CTA, 2005), desk studies were conducted to review Tanzania's policy environment to determine the impact on the agriculture sector and the banana subsector in particular. The Ministry of Agriculture, Food and Cooperatives (MAFC) classifies the country in seven agro-climatic zones, based on climate, soil types and crops grown (Mowo et al., 1993). The study was conducted in four of the agro-ecological zones: (a) the lake zone; (b) the southern highlands; (c) northern zone; and (d) eastern zone. In each agro-ecological zone, the most important banana production regions, districts and eventually villages were chosen. Two villages were selected in each zone for conducting farmer interviews, with the exception of the lake zone, where four villages (two in Bukoba district, Kagera region; and two in Tarime district, Mara region) were chosen.

Two structured questionnaires, one for farmers and one for organizations, were used. Data were collected for analysis as follows. Firstly, key actors were identified and their functions, resource allocation and their practices, competencies and habits with respect to how they acquire knowledge, interact, innovate and react to changes within and outside their local environment. Secondly, linkages were identified between the identified actors, in terms of how they link up locally and internationally, and their perceptions on the intensity of the linkage. The aim was finally to assess to what extent linkages were viable in facilitating innovation. Thirdly, in each participating village, 15 farmers were randomly picked from existing lists of banana growers. A total of 213 participating banana growers were interviewed. Twenty organizations were also interviewed. Finally, the collected information was coded and analyzed, using the Statistical Package for Social Sciences software to generate descriptive statistics.

RESULTS AND DISCUSSION

From the mid 1990s, Tanzania implemented second generation policies and legal and institutional reforms to enhance growth and investment in the agricultural sector, redefine the roles and increase the efficiency of public institutions, engage in capacity building and empower the private sector to play a leading role in agricultural production, marketing, processing and other services. The 1997 agricultural and livestock policy places banana in two categories: as a horticultural crop (fruit) and as a food crop. Despite the importance of agriculture, funding for key public services in the sector declined in real terms. Only 2.7% of agricultural GDP is reinvested in providing agricultural services. This is far below the average spending by other countries in the region, which reinvest an average of 11.6% of their agricultural GDP (URT, 1997). From 2000, the government introduced tax incentives to stimulate investment, but implementation for smallholders was difficult.

The dominance by small-holders, with low levels of productivity, education, experience and insufficient access to credit and input, does not make agriculture a viable option for foreign investors. However, a small percentage of sufficiently organized farmers and large commercial enterprises, e.g. sugar, barley and sisal, attracted foreign investment.

In 1996, the government revised the national science and technology policy with the stated objective to promote science and technology for economic development as well as improve the human, physical and social well being and protect national sovereignty. Priority research areas included biotechnology and information technology. Only 0.01% of GDP is invested in research and development, although the government had set a target of 1% of GDP by the year 2000. Banana is assigned low priority in the National Agricultural Policy, and as a consequence, there is not a clear research and development

program that is comparable to other major export cash and food crops such as cereals. Most trade regulations are commodity specific and each 'export cash crop' is governed by a separate law, mainly providing for crop husbandry, primary processing, marketing and export. There are also requirements for payment of 'cess' (tax) by crop traders. Such legal and institutional frameworks do not exist for non-traditional cash crops, such as banana.

The coordination of the agricultural sector at national level is under MAFC. The ministry has at least one agricultural research institute (ARI) in each agro-ecological zone. In addition, there are commodity research institutes specific to cash crops (coffee, tea and tobacco). These operate with funding from the specific crop cess and support from the government and other sources. The ministry also operates agriculture training institutes (MATIs). These offer training at Certificate and Diploma levels. Graduates of these institutions become extension agents or support staff in research. The Sokoine University of Agriculture (SUA), established in 1984, is the only university of agriculture in the country. It is administered under the Ministry of Education and Vocational Training and has the mandate to conduct training, research and outreach activities in the various fields of agriculture.

There are a number of organizations, associations and non-governmental organizations (NGOs), which act as advocacy platforms. At various levels, they promote and coordinate agriculture sector or subsector interests. These include Tanzania Chamber of Commerce, Industry and Agriculture, the Agricultural Council of Tanzania, cooperative societies, the Tanzania Horticultural Association and the National Network for Smallholder Farmers of Tanzania (MVIWATA), and very recently (2007) the Horticultural Development Council of Tanzania.

Banana production is mostly undertaken on fields of 1.5 ha or less, and the proportion of farm land allocated to banana varies from 25 to 53% among zones. The highest allocation is seen in the northern zone and the lake zone (Kagera region) as opposed to the southern highlands and the eastern zone (Table 1). Observations in the lake agro-ecological zone are similar to those reported by Nkuba et al. (2006). Farmers are engaged in a multitude of businesses, including the production of crops, livestock and poultry. In all zones, except in the eastern zone, more non-land farm resources (e.g., time, money and labor) appear to be directed to banana production than to marketing, sales and distribution activities. This gives an indication of the relative importance of the crop in the different areas. In the northern and lake zone and the southern highlands, banana is firstly an important staple and secondly a cash crop. In the Kagera region (lake zone), banana is synonymous to food (Mgenzi et al., 2003). On the contrary, in the eastern zone banana is most importantly a cash crop, sold to the local market, particularly to urban centers. Market demand in urban centers, such as Dar es Salaam and Dodoma, is growing.

The key actors in the banana subsector in the four study zones have been clustered, based on their main activities (enterprise, research, diffusion, infrastructure and market/demand) (CTA, 2005) (Table 2). In terms of numbers, farmers are the most important and the majority can be classified as peasant farmers. Producer organizations are few. Agro-food processors/value addition agents and farmers' cooperatives fall into the category market/demand, as they buy fresh fruit, but they also often undertake production. Market/demand components are generally underdeveloped.

Various organizations, mainly NGOs and district councils, are involved in diffusion or agricultural extension. Agricultural extension is the mandate of the district councils. The ARIs in each agro-ecological zone and SUA are involved in research and training. Occasionally, NGOs undertake farmer training as is the case of the Mogabiri Farm Extension Centre in Tarime district (lake zone). In general, financing agents are largely missing from the infrastructure category. Policy making lies with the district councils. The local governments are also regulatory bodies and infrastructure service providers. ARIs are mandated to work on the major crops in the zones. The major limitation they face is poor funding. Since banana is considered a subsistence crop, it is not a research and training priority, except for addressing agronomic practices related to low yields, low soil fertility and pest and disease problems, such as banana weevils

(*Cosmospolites sordidus*), nematodes (*Meloidogyne* spp), black sigatoka (caused by *Mycosphaerella fijiensis*) and banana bacterial wilt (caused by *Xanthomonas campestris* pv. *musacearum*). Since the ARIs, SUA and extension services are under the auspices of different ministries, there is little coordination in the development and diffusion of technologies.

Most of the actors had received formal education. More than 60% of the farmers had attained the level of primary education (Table 3). Many of them (38%) have been producing bananas for over 20 years. However, only a quarter of them (26.8%), across agro-ecological zones, had received specialized training on banana (Table 4). Training was mainly focused on general banana production practices (38.0%), planting and spacing techniques (28%), use of improved banana cultivars, general crop marketing aspects (10%) and banana pest control methods (8.0%). With respect to performance, most actors perceived that the banana subsector was still functioning very traditionally, as there was very low use of technologies such as improved cultivars, improved cultural practices, improved postharvest handling and value addition, and the prevalence of inefficient marketing systems. Yields average as low as 10 kg per bunch, although under research conditions yields can be as high as 20–25 kg per bunch (Nkuba et al., 2002). Use of tissue culture planting material was unpopular among farmers, averaging an uptake of 2%. In the study areas, proper postharvest practices, such as careful packing, cool storage and immediate transport to markets, are not practiced. In the eastern zone, dessert bananas are ripened in special ripening pits, using smoke application. Only two private organizations had invested in banana processing. Nyire-Farmi is processing banana into wine and powder, while Kyimo Investment is making chips (Table 2). Farmer groups under MVIWATA are undertaking small scale solar drying of ripe banana.

Most farmers rated the government extension services as not good (39.5%) or average (26.3%). Most farmers identified that working capital was derived mainly from self-generated funds, followed by remittances. They considered their ability to adapt to change with respect to climate change as average (33.7%) or good to excellent (55%), but average or not good with respect to market availability (56.7%). They were more challenged ('average' or 'not good' responses) with respect to responding to changes in extension services (65.8%), input supply (78.4%) and infrastructure (62.7%). With respect to international trade, 73.7% considered their ability to respond to change in this environment as not good.

Collaboration between farmers and other actors (national/local agricultural research organizations, extension agents, farmer organizations, input suppliers and policymakers) was considered as non-existent or weak. However, farmers rated collaboration with international research organizations as average and collaboration among farmers themselves as strong. Many agricultural research and development projects are externally funded by international organizations. This would explain why farmers rank higher the linkage between them and international organizations than with local organizations. Networking between local and international organizations in the banana industry was not strong. Although most of the local actors were government agencies that include the ARIs, weak linkages existed between them. A similar situation was observed with the district councils, with whom the linkage was shown to be very poor, despite the fact that these organizations are responsible for extension services. All government institutions were mainly working on national projects in which the banana industry does not feature.

CONCLUSIONS

Although Tanzania has well established agricultural, science and technology policies, investment in research and development remains very low. On the other hand, banana, which is an important staple food crop, is not adequately addressed in the agricultural policy and therefore receives little consideration in research and development programs. Banana remains a subsistence crop, with little innovation taking place among the smallholder farming community. This study, employing the ASTI system analytical

framework, provides information that can contribute to enhancing innovation in the banana subsector in Tanzania in case this commodity would be considered as a priority for improving food security, household income or export growth. The development and implementation of options can be based on the information generated on the policies, socio-demographic and functional aspects of the sub-sector, and the actors and their competencies, habits, practices and linkages. The study recommends major areas of action that require improvement to enhance the innovation capacity of the sub-sector as: (a) the government needs to fulfill its commitment to invest in science and technology; (b) strengthen the diffusion system; (c) provide incentives for innovation, including research, training, credit schemes, market development and other service infrastructure; and (d) recognition by the government of the importance of banana as a major staple crop.

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Tables

Table 1. Total farm and banana farm size in four agro-ecological zones in Tanzania¹.

Parameter	n	min	max	mean	SD
Northern					
Total farm size (ha)	61	0.1	3.6	0.7	1.6
Banana farm size (ha)	61	0.1	2.2	0.4	0.7
Farmers' resources to banana (%)	60	8.1	40.5	24.0	21.0
Southern highlands					
Total farm size (ha)	31	0.2	53.4	3.4	23.2
Banana farm size (ha)	31	0.1	8.9	0.9	3.9
Farmers' resource to banana (%)	26	4.1	32.4	17.2	20.8
Eastern					
Total farm size (ha)	59	0.2	6.5	2.1	3.9
Banana farm size (ha)	59	0.1	3.2	0.5	1.2
Farmers' resource to banana (%)	55	2.0	40.5	15.9	23.9
Lake					
Total farm size (ha)	62	0.2	5.3	1.3	2.8
Banana farm size (ha)	61	0.1	2.8	0.7	1.5
Farmers' resource to banana (%)	60	2.0	39.7	20.7	23.0

¹On average, 53, 29, 25 and 52% of the farm land was allocated to banana farming in the northern, southern highland, eastern and lake zone, respectively.

Table 2. Actors and their area of activity that were identified in the banana sub-sector in Tanzania.

Component/actor	Area of activity (organization)
Enterprise	
Farmers	Smallscale banana Production
Kyimo Investment Banana Investment LTD	Medium-size banana production
Research and training	
ARIs Maruku, Selian Tengeru Horticulture Research and Training Institute	Research and diffusion (Ministry of Agriculture, Food and Cooperatives)
Uyole Agricultural Centre Sokoine University of Agriculture	Research (Ministry of Education and Vocational Training)
Bujera Secondary School	Secondary school (Ministry of Education and Vocational Training)
Diffusion	
MVIWATA	Extension, advocacy, marketing and training (NGO)
Mogabiri Farm Extension Centre	Extension services (Anglican church)
District Councils	Extension services and policy making (Local governments)
Market/demand	
Equatorial Foods	Value addition
NYIRE-FARMI LTD	Production and food processing
Kivulini Natural Products Group	Value addition and marketing
Jua Tamu Products	Production, marketing and value addition
CLAPHIJO	Value addition and marketing
Kireka Agricultural Producers Marketing Cooperative Society	Production and marketing (Farmers Cooperative)

Table 3. Level of education of interviewed farmers, across the four project zones in Tanzania.

Education level	n	%	SD	CV (%)
No formal education	32	15.0	25	0.0
Adult education	1	0.5	0.1	0.0
Primary school (Class 1–4)	134	62.9	9.6	65.3
Primary school (Class 5–7 or 8)	7	3.3	1.2	26.2
Secondary school	30	14.1	2.3	34.7
Certificate course	3	1.4	0.8	15.2
Diploma	4	1.9	0.5	80.1
University ¹	2	0.9	0.4	0.0
Total	213	100.0		

¹Retired officers that had returned to their home villages to engage in farming.

Table 4. Number and percentage of interviewed farmers that had received specialized training in banana in the four project zones in Tanzania.

Type of specialized training courses	n	%	SD	CV (%)
New pests and disease control	4	8.0	1.4	56.4
Planting of new /improvement of banana variety	7	14.0	2.5	62.9
Planting/Spacing of banana	14	28.0	4.9	76.4
Banana cultivation/production	19	38.0	7.9	45.9
General crop marketing aspects	5	10.0	1.5	59.9
Tissue culture	1	2.0	0.0	0.0
Total	50	100.0		