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Full Length Research Paper

Assessment of technology generating institutions in biotechnology transformation system of South-Eastern Nigeria

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The study was carried out in Southeastern agro-ecological zones of Nigeria. Questionnaire was used to collect data from a sample of forty-three heads of departments from research institutes and universities involved in biotechnology research. Results of the study revealed that some of the institutions have been involved in biotechnology research for the past two decades but have only significantly invested on bio-processing (58.8%) and cell and tissue culture (88.2%). The mandates of the institutions and donor agencies constituted the major determinants of biotechnology research. The institutions sourced research funds mainly from the government and donor agencies. However, their biotechnology research activities were highly constrained by several factors namely poor funding, unavailability of research equipment, and high cost of maintenance of equipment, among others. The study recommends that government should increase investment in human resource capacity building, infrastructural development and encourage public-private partnership for development and safe application of biotechnology innovations. Awareness campaign among researchers, consumers and farmers on the potentials of biotechnology for food security is expedient.

Key words: Biotechnology, innovation system, research institutions, universities and agricultural development programme.

INTRODUCTION

Assuring food security for the increasing population and concomitantly preserving the environment have ranked as one of the top priority issues of concern in the world continents. Over the last decade, the performance of the agricultural sector has been rated poorly. In sub-Saharan Africa, the overall agricultural production fell by 0.3% in 2000, after an increase of about 1.9% in 1999; a declined by 0.5% was recorded in Eastern Africa, 1 in Central Africa, and 3.3% in Southern Africa in 2000 after a remarkable increase of 14.2% in 1999 (FAO, 2002). Reviewing food security across the globe particularly in the developing countries, Mugabe (2003) reported that approximately 1.3 million people in Eritrea, 5.2 million in Ethiopia, 1.5 million in Kenya and 2.0 million in Sudan required emergency food in 2002 and in Southern Africa emergency food assistance is required by at least 14 million people. He observed that to meet increasing demand for food and enlarge the prospects for food security, increases in agricultural productivity is required. Furthermore, Bunders et al. (1996) had earlier asserted that the global food production would have to rise by 2.6 billion tones to maintain current per capita food consumption.

In response to the above scenario, government research institutions and donor agencies came up with a variety of technical, institutional and policy interventions, ranging from refocusing agricultural research and reviewing food security policies to the provision of emergency food aid (Mugabe, 2003). Globally, the challenge to build beyond food security and improve environmental management will not be through expansion of cultivated area but rather will require improvement in crop and livestock yields. Invariably, attention should be paid to measures and strategies that will enhance the ability to harness and apply new scientific and technological advancement.

Highlights of an international conference organized by FAO, UNDP and World Bank concludes that the solution

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to the problem of securing world food supplies, while preserving the environment is virtually inconceivable without recombinant genetics and biotechnology. Biotechnology is the application of indigenous and / or scientific knowledge to the management of micro organisms, or of cells and tissues of higher organisms so that they supply goods and services of use to human beings (Bunders et al., 1996). It represents the latest front in the ongoing scientific progress of this millennium. Agricultural biotechnology provides new technological tools and aims to develop plant varieties and animal species that provide reliable high yields at the same or lower costs by bringing in qualities such as resistance to diseases, pest stress factors. In addition to evidence of increased productivity of biotechnology crops (Chassy, 2003) reduction in cost for labour energy and chemicals have been recorded.

Pann (2003) observed that agricultural biotechnology has been changing the face of agriculture since its commercial introduction in 1996. Agricultural biotechnology can enhance agricultural productivity in a way that further reduces poverty, improves food security and nutrition and promotes sustainable use of natural resources. Regrettably, data on the current global distribution of transgenic crops show that, there has been little impact in the developing societies, with the exception of China and Argentina, (James, 1999). Nevertheless, some countries have recorded great innovative strides in biotechnology research and development. For example, in South Africa's research and development, there are molecular markers application in diagnostics for pathogen detection, cultivars identification (for potatoes, ornamentals, cereals, and cassava), selection (maize, tomatoes) and disease resistant (wheat). Mugabe (2003) reported that by the end of 2000, 41 genetic molecular field trials had been conducted in South Africa, at least 160,000 ha were on GM maize, and 18,000 ha were cultivated for GM cotton. Other advancements in biotechnology generation include micro-propagation of pathogen-free banana planting materials and field trials of recombinant livestock vaccines and diagnostic kits against rinderpest and blue tongue diseases in Kenya and epidemiological studies of foot and mouth diseases using molecular diagnostic procedures in Cameroon.

In Nigeria, the national biotechnology policy and strategic framework was adopted in 2001. Essentially, the policy established a national agency to provide overall leadership for all public biotechnology activities. The liaison centres of the national agency were established in some public institutions; probably as an incentive to increase research activities in biotechnology. Subsequently, many public research institutes and universities have extended their research tentacles through human capacity building and infrastructural development to explore the enormous potentials of biotechnology for input production, processing and quality of foods. The question therefore is; what is the level of involvement of these institutions in biotechnology research? Although, the national biotechnology policy articulated specific priority areas of agricultural biotechnology research and development, and provided an institutional arrangement for its research, the nature and extent of involvement of institutions in agricultural biotechnology are not certain. The study therefore aims to assess:

i.) Socio-economic characteristics of institutions engaged in agricultural biotechnology.
ii.) Identify the thematic areas of biotechnology research carried out.
iii.) Determine impediments/constraints to biotechnology activities in the institutions.

METHODOLOGY

The study was carried out in Southeastern agro-ecological zone of Nigeria. The zone is made up of nine states, namely Abia, Akwa-Ibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo and Rivers. Three States (Abia, Enugu and Rivers) were purposively selected based on the existence of agencies involved in biotechnology. All the public research institutes and universities in the states constituted the population. The research agencies include National Root Crops Research Institute (NRCRI) Umudike, Forestry Research Institute of Nigeria (FRIN) Umuahia, International Institute of Tropical Agriculture (IITA) Onne, and World Agroforestry Centre Onne. The universities included Michael Okpara University of Agriculture, Umudike (MOUA), Abia State University, Umuahia (ABSU), River State University of Science and Technology (RSUST), Enugu State University of Technology (ESUT) and University of Nigeria, Nsukka (UNN). All the departments involved in agriculture biotechnology were purposively used. A total of 43 departments consisting of 17 departments from research institutes and 26 departments from the universities were sampled. The heads of the departments were purposively selected giving a total of 43 respondents for the study. The questionnaire used for data collection was divided into 3 sections based on the objectives.

The first section sought information on socio-economic characteristics of the institutions. Respondents were asked to indicate years of experience in biotechnology research, sources of funding, type of collaborations, and thematic areas of biotechnology generated. Section two addressed issues on determinants of biotechnology developed. Respondents were asked to indicate among three actors, namely farmers, donor agencies and institutions, the ones that influenced the technologies generated. The third section considered the constraints to biotechnology generation in the institutions. The respondents reacted to nine possible constraint variables using a four-point Likert - type scale of "to a great extent (3)", "to some extent (2)", "to a little extent (1)" and "to no extent (0)". The mean value of 1.5 was used to determine the constraints. The data generated were presented using percentage, pie charts and mean scores.

RESULTS AND DISCUSSION

Socio-economic characteristics of biotechnology generating institutions

Years of experience in biotechnology research: Majority

(59.0%) of the research institutes have been involved in biotechnology research for over 20 years, while majority (69.0%) of the universities have been into biotechnology research activities for the past 1 to 5 years (Figures 1 and 2). Only about 29% of the research institutes and 8.0% of universities had 11 - 15 years of experience, respectively. Also, 8% of the universities have conducted biotechnology research for more than 20 years. The results show that biotechnology researches have been taking place in the research institutes for more than two decades. Its development at the universities is still at the embryonic stage, probably because of poor funding, in-adequate facilities and the skepticism of the public over the safety and health consequence of genetically modified products and technologies. Mugabe (2002) reported that concern has been raised about the potential ecological impact of releasing genetically modified organisms (GMO) into the environment. He noted that this is as a result of the fear that these organisms would erode genetic diversity and thus undermine socio-economic and cultural security of many households in the developing world. However, the increasing awareness of the importance of biotechnology to achieving food security and sustainable agriculture demands that the institutions particularly the universities should step up their research efforts in biotechnology.

Sources of funding: The major sources of funding for biotechnology research among the research institutes (Figure 3) include government (41.2%) and donor agencies (47.1%). The universities sourced their funds mainly from the government (61.5%), donor agencies (57.7%) and self-generated (46.2%). About 29 and 38.5% of researchers from the research institutes and universities respectively asserted that they privately funded their researches. Generally, the biotechnology generating institutions were mainly funded by the government and donor agencies. The results partly confirms reports by IITA and CTA (1992) which observed that in most developing countries the public sector investment are still the main source of finance for biotechnology research and development. Research in agricultural biotechnology is expensive hence reliance of the institutions on the government may be counter productive given the reduction of government involvement in provision of services. Collaboration of the institutions with private sector should be emphasized and exploited.

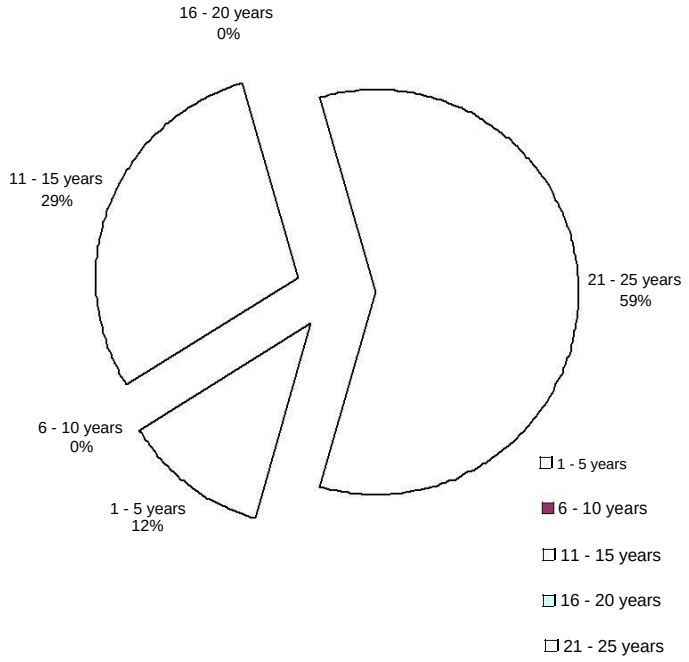

Figure 1. Percentage distribution of research institutions by number of years engaged in biotechnology research.

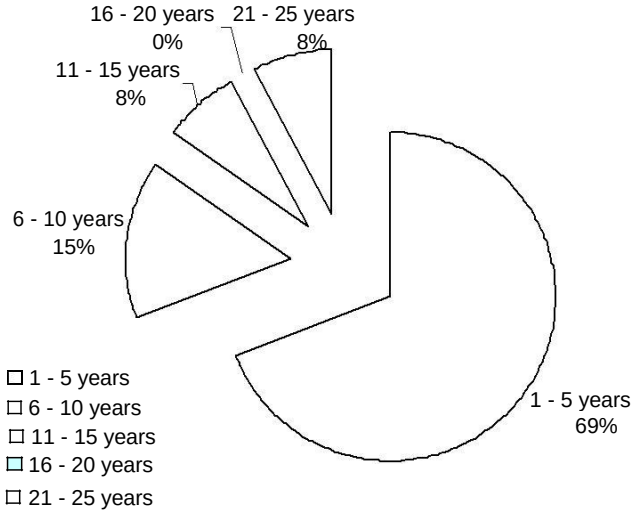

Figure 2. Percentage distribution of universities by number of years engaged in biotechnology research.

Key actors and existing linkages/collaboration among biotechnology generating institutions

The research institutes indicated the presence of local (52%) and overseas (48%) collaborations (Figure 4). Also, majority (65.0%) of the universities had overseas collaboration, while only about 35% reported of the existence of local collaborations (Figure 5). The types of collaborations identified were in the areas of funding, training of scientists and offering of research grants. The key actors in this regard were the World Bank, International Finance Corporations, NGOs and private biotechnology organizations. The results show that the institutions have both local and overseas collaborations, but the research institutes seem to be more linked to

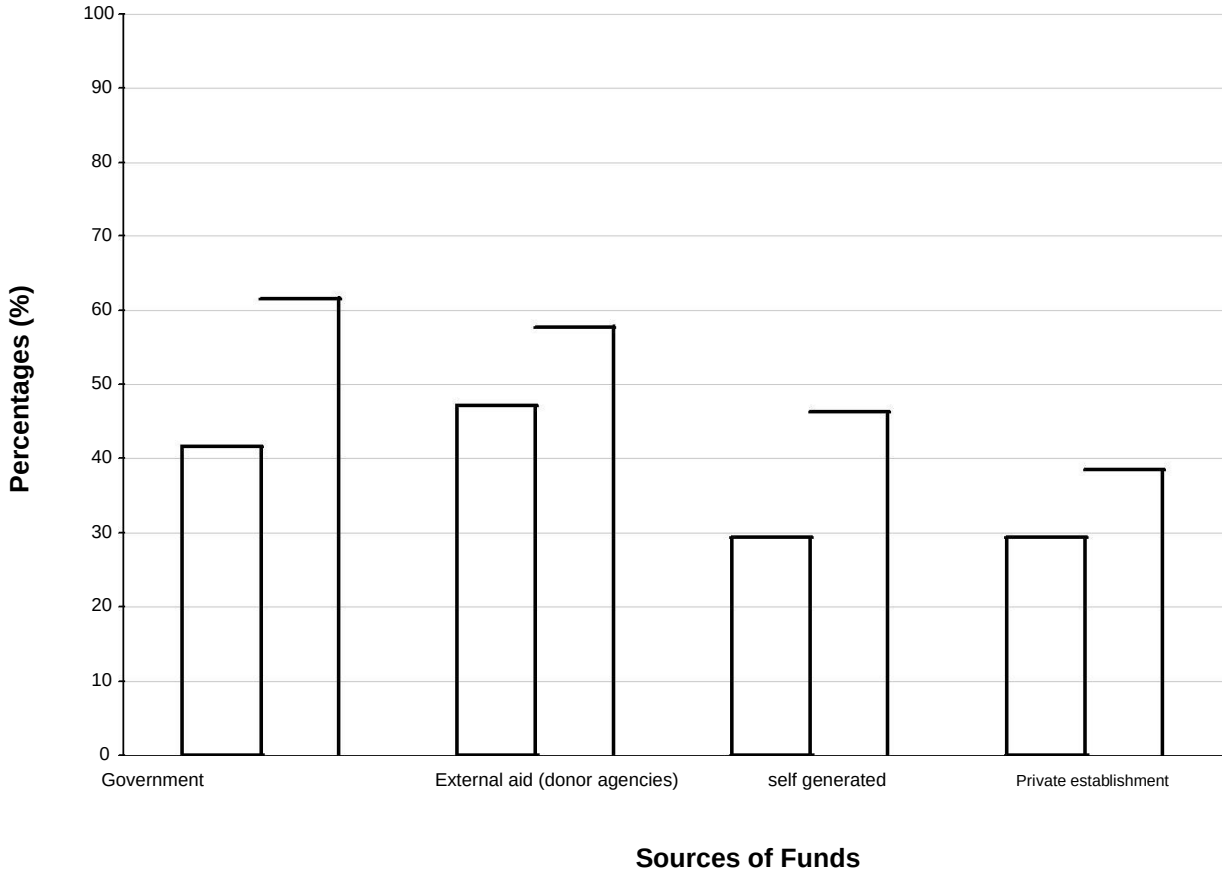

Figure 3. Percentage distribution of institutions based on source of funds available for biotechnology research. *Multiple responses

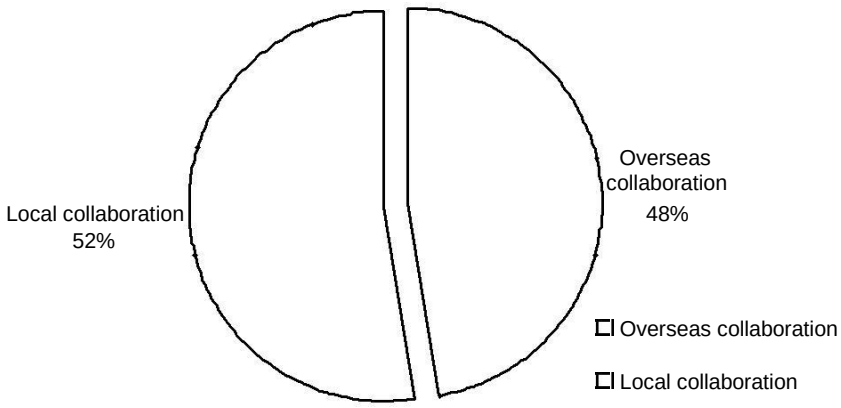

Figure 4. Percentage distribution of research institutions based on collaborations.

other actors. Collaboration among actors in the biotechnology innovation system is essential for relevance, capacity building and increase innovative performance of the actors and the system in general. The extent of collaboration also suggests the level of involvement in biotechnology activities.

Thematic areas of biotechnology research

Entries in Table 1 show that majority (88.2%) of the research institutes were involved in cell and tissue culture, while 58.8% carry out researches in bio-processing. Other areas like diagnostic (17.9%), micro propagation of

Table 1. Thematic areas of biotechnology carried out by the institutions.

S/N	Area of biotechnology*	Research Institutes (n = 17)	Universities (n = 26)
1	Micro propagation of cassava, yam, plantain and banana	29.4	11.5
2	Genetic engineering of cowpea for virus and insect resistance	5.9	7.7
3	Marker assisted selection of maize and cassava	17.7	19.2
4	Recombinant DNA	5.9	11.5
5	Bio-processing	58.8	19.2
6	Cell and tissue culture	88.2	11.5
7	Genomic	5.9	-
8	Vaccine technology	11.8	3.9
9	Molecular breeding	11.8	11.5
10	Diagnostics	17.9	7.6

* Multiple responses.

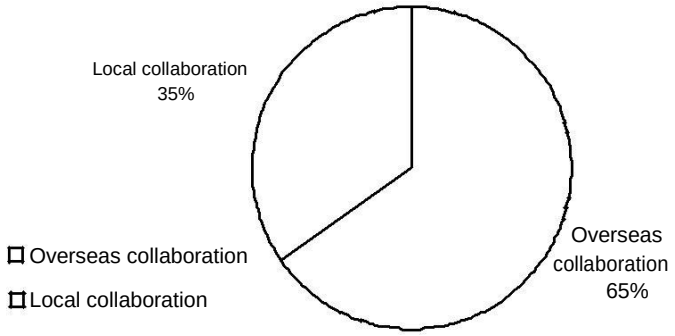

Figure 5. Percentage distribution of universities based on collaborations.

cassava, yam and banana (29.4%), marker assisted selection of maize and cassava (17.7%) and other areas of biotechnology research were less developed in research institutes. On the contrary, the universities were less involved in many areas of biotechnology research (Table 1). Generally most of the areas of biotechnology research in the institutions were poorly harnessed although the research institutes seem to be more proactive. The finding seems to confirm Machuka (2001) investigation which reported that the ability to carry out research in modern biotechnology in 17 institutes in Nigeria shows that at least 40% of the institutes are unsuitable to undertake researches due to lack of electricity and inadequate tissue culture facilities. Reasons for this may include poor funding, inadequate qualified professionals, public attitude to genetic engineering organisms and products, and inadequate infrastructural facilities. Beintema and Ayoola (2004) had earlier noted that support from donor agencies are declining and there has been a tendency to spread investments in research and extension over a large number of institutes, rather than developing a few quality ones. This hampers the performance of these institutions.

Determinants of biotechnology developed in the institutions

Majority (58.82%) of the research institutes reported that the needs of the farmers were the major determinants of technologies developed, while 41.13 and 35.29% considered the mandates of the institutes and the donor agencies as major determinants, respectively (Figure 6). On the other hand, most (61.54%) universities carry out biotechnology research based on the mandates of their institutions. About 42% were influenced by the mandates of donor agencies, while only 19.23% targets the needs of the farmers. This may be as a result of "publish or perish" syndrome in the universities. Moreover, it also characterized the conventional linear model of research and development, where the farmer has almost zero input in determining research priority. Ruivenkamp (1992) reported that research and development in biotechnology often reflects the interest of the transnational corporations and large commercial farmers neglecting the need of the poor-resource farmers. Equitable development and impact according to Dirar (1993), requires that research be geared towards meeting the need of poor resource farmers.

Constraints to biotechnology generation in the institutions

The major constraints to biotechnology research and development in research institutes include poor funding ($\bar{X}$ = 3.8), unavailability of equipment/materials to researchers ($\bar{X}$ = 3.8), lack of training opportunities ($\bar{X}$ = 3.1), inappropriate government policies ($\bar{X}$ = 3.7), and high cost of maintenance of equipment ($\bar{X}$ = 3.05). Other constraints include poor fringe benefit to researchers ($\bar{X}$ = 2.90), inadequate competent staff ($\bar{X}$ = 2.6) and among others. Similarly, the universities reported that their research activities were constrained by unavailability

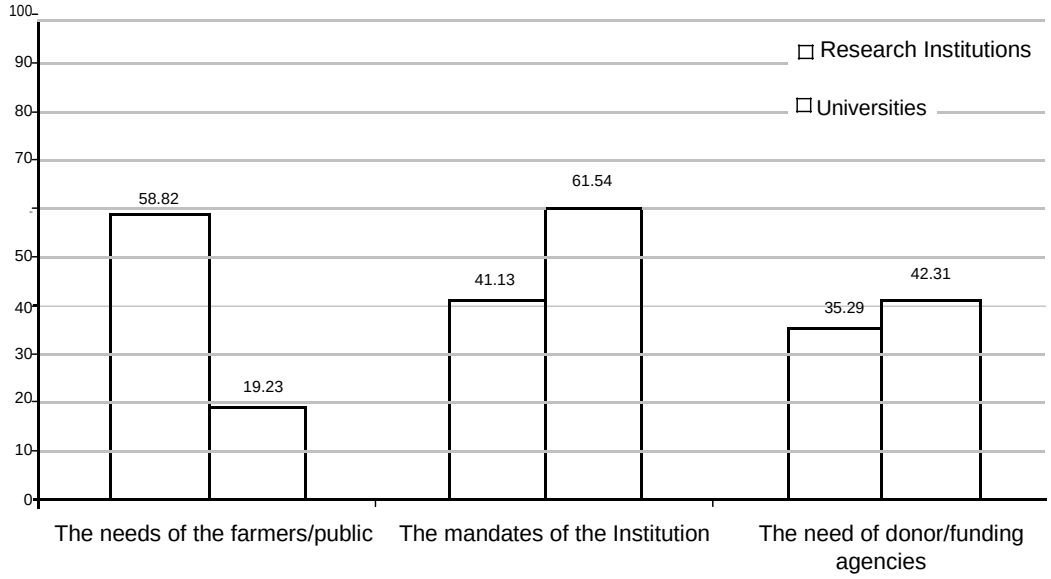

Figure 6. Percentage distribution of institutions based on the determinants of biotechnology to be developed. *Multiple responses.

Table 2. Mean scores of constraints to biotechnology generation in the institutions.

S/N	Constraints	Mean	
		Research Institutes (n = 17)	Universities (n = 26)
1.	Unavailability of research equipment/materials	3.8	3.9
2.	Poor funding	3.8	3.9
3.	Poor transportation facilities	2.6	3.0
4.	Poor demand of the product	2.5	2.5
5.	High cost of maintenance of equipment	3.1	3.7
6.	Lack of training opportunities	3.1	3.5
7.	Inadequate competent staff	2.6	3.5
8.	Poor fringe benefit to researchers	2.9	3.1
9.	Inappropriate government policy	3.7	3.3

of facilities ($\bar{X}$ = 3.9), high cost of maintenance of equipment ($\bar{X}$ = 3.7), lack of training ($\bar{X}$ = 3.5), inadequate competent staff ($\bar{X}$ = 3.5) and among others (Table 2). Generally, most of the constraints identified in the institutions are associated with poor funding. Biotechnology research and development need high inputs of finance, sophisticated facilities and skills including specialized maintenance of expensive equipment, which are lacking in most developing countries. Unfortunately, in Nigeria there has been decline in public and donor agencies funding and tendency to spread investment over large number of institutions and development programmes. Beintenia and Ayoola (2004) reported that total spending in research and development dropped by 66.6% from an average of about 130 million US dollars in the mid 1970 to less than 50 million US dollars in mid 1990s. The authors further noted that the number of full-time researchers in government research institutes declined in the late 1980s and early 1990s due to lack of funds. The implication is that government should create favourable environment to encourage private sector investment in biotechnology research.

Conclusion

The results show that the technology generating institutions in biotechnology innovation system particularly research institutes have been involved in biotechnology research for the past two decades, but the level of coverage is very limited. Many areas such as micro propagation of cassava, yam, plantain and banana, marker assisted selection of maize and cassava, genetic engi-

neering of cowpea for virus and insect-resistance and other areas which are relevant to achieving food security in the country were less harnessed and developed. Moreover, the mandate of the institutions and donor agencies significantly influenced the thematic areas of biotechnology research conducted. But for some of the research institutes, the resource poor farmers who constitute about 70% of the agrarian economy of the country had little or no influence on the technology priority of the institutions. The government and donor agencies were the major sources of funding, probably because the sector is presently dominated by the public sector. Private sectors should be encouraged to invest on biotechnology researches through appropriate policy framework and regulatory measures for wider coverage and enhanced development of the sector. Furthermore, the findings revealed several fund-related constraints to biotechnology development.

The study concludes that despite the adoption of biotechnology policy and strategic framework in Nigeria, biotechnology research is still less advanced in the institutions. In other words, the Federal Government should increase the volume of funds; invest on human resource human resource capacity building and infrastructural development for safe development and application of biotechnology. There is the need to create domestic environment that will foster public-private partnership and strong collaboration with local, international and transnational organizations for cost effective and remarkable innovative strides in biotechnology research. In addition, the government and policy makers should consider adopting innovation system approach to biotechnology research. According to Agwu et al. (2008) innovation system approach offers a more inclusive and holistic analytical framework, emphasizes wider stakeholders' participation and linkages as well as focuses on the farmer context which represents a significant change from the conventional linear approach to research and development. Above all, the need to create awareness among researchers, administrators, consumers and farmers on the potentials of biotechnology for improved production of tropical crops, new opportunities for the use of marginal lands and reduction in the use of agrochemicals is imperative.

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