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The Spate of Agricultural Technology and Innovation Generation in African Countries: A Meta-Analysis

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Abstract: Technology generation, transmission and adoption are vital to the development of agriculture and the derivation of social-economic benefits from the sector. African agricultural development is low compared to other continents in the world. This is often attributed to poor adoption of technologies with the speculation that the research sector in African countries is generating good technologies that are not adopted and used. This paper presents a meta-analysis of research reports from studies conducted in 12 African countries, to identify and document various technologies, knowledge and inventions generated from research activities in the last 30 years and the proportion that have already been translated into innovations with accompanying socio-economic benefits. This study showed a total of 1, 228 technologies with 71% related to crops, 8.8%, 3.3%, 5.0% and 5.9% attributed to livestock, fisheries, processing and natural resource management respectively. The last six percent covers other areas viz., value chain, marketing, governance, etc. Priority efforts were directed at cereal crops (46.7%) and root and tuber crops (14.5%), while cattle, dairy and small ruminants were in the range of 1.0%, 1.6% and 1.6% respectively. Horticulture value chains accounted for 3.4%. Comparative analysis with other countries indicated that mean technology generation per year in Africa was of only five technologies/country per year. Evidence from this study suggests that the poor performance of agriculture is still due to the low turnout of useful technologies especially in the high-value commodities with the potential to improve the nutrition and incomes of producers. The evidence further debunked the myth that Africa has a lot of useful technologies on the shelf that are not adopted.

Key words: Agricultural Technologies · Innovation · Science · Meta-analysis · Research

INTRODUCTION

In recent years, discussions on agricultural development have been focused on the need to develop effective agricultural innovation systems that will contribute to translating technologies into social and economic benefits [1]. The application of science and technologies in the search for agricultural innovation through applied research and extension has been shown to bring positive social returns in terms of food and nutritional security [2]. Although agricultural innovation has largely been understood as an invention or output that brings about measurable return on investment [3], the scope of what is considered agricultural innovation has been broadened to become more widely perceived as a process through which individuals and communities in specific localities share and adapt local knowledge, selectively integrate scientific knowledge and develop improved ways of optimizing and managing resources while responding to opportunities and overcoming local challenges [4, 5]. This makes innovation inherently social as exemplified by the "induced innovation" in agriculture and corresponding market creation by a relative scarcity of the two factors of production [6].

Despite the critical role of farmers in innovation to meet the growing demands and challenges of the global food system, there are few studies on their participation in the process to generate innovation in agriculture.

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This is even more obvious in Africa's agricultural production. Although an attempt has been made to analyze the effects of training, knowledge and new technological interventions on smallholder farmers' livelihood in Africa [7], there are few records on the inventory of innovations developed by farmers. The link between the poor performance of agriculture and the slow rate of adoption of new technologies in Africa has been established [8]. While agricultural research organizations have generated many technologies, the impact of such technologies on farmers' livelihood and quality of life has often been minimal. This is partly due to the failure to recognize the inputs and involvement of the non-research sector [9]. The roles of innovation initiatives in Africa agriculture as found on the Integrated Agriculture Research for Development (IAR4D), is therefore needed to generate a mega database that would allow the accompanying of research to support the scaling of agricultural innovations in Africa. Here, we present a report on meta-analyses based on rigorous research outlining the entire innovation and technologies developed in Africa, spanning 20 years.

Conceptual Framework: Because of the various understandings of the concept of innovation, we start by defining innovation. While some people understand innovation in terms of products/technologies; others suggest going beyond the products/technologies with the consideration of all processes that lead to perceived new understandings (knowledge/perception), new ways of doing things (methods, arrangements, etc.) and new (un)desired products (institutions, technologies, organizations; etc.). In this paper, we adopt the second understanding of innovation by integrating it into the findings and analyses, both technological and non-technological aspects of innovation. With this stance, agricultural innovation comprises all perceived (non)beneficial new/improved/renewed agriculture-related technologies, inputs, equipment, techniques/methods, management approaches, etc. This study aims specifically at inventorying existing and promising innovations with a view to:

- Identify gaps for research interventions along the specific value chains of interest and.
- Document information that can be used in the future to identify and explore possibilities of replicating successful innovations.

MATERIALS AND METHODS

The work presentedin this paper used meta-analysis methods reported by [10], to arrive at its conclusion. A four-step method was employed to analyze the state of agricultural technology generation in Africa. Step one involved the development of appropriate research questions to source the needed data. Three research questions were projected, viz., (a). Did agricultural research in Africa truly turn out a lot of technologies? (b). In what areas were these technologies generated? (c). Did the true state of technology generation have any effect on the current state of agricultural development on the continent? Comprehensive answers to these questions yielded the needed inference on the quantum of technologies generated over the years and the relative effect of the technology generation on the performance of the sector. It will also provide the needed empirical evidence for the popular mantra that African agriculture has a lot of good technology on the shelf that is not adopted. Step two involved the definition of eligibility criteria for studies to be included in the analysis. In this study, we selected studies that were conducted under the Program of accompanying Research for agricultural Innovation (PARI). The PARI research program is supported by the government of Germany led by the Centre for Development Studies, the University of Bonn under the One World – No Hunger Initiative. The PARI research activities were implemented in 12 African countries in 2015 to provide a baseline on the state of agricultural innovation. The 12 countries used the same template to source the required data to articulate the state of agricultural innovation in different countries. The data included, among other key variables, a listing of technologies developed in the country by different research organizations in the last 30 years (1985 – 2015). The data were analyzed differently by the countries using varying econometric models to derive inferences. Reports of the 12 studies were considered eligible based on key similarities and availability of the core needed data. The third step involved extensive consultation of literature on the research systems in Africa and the linkages with open-source data from the World Bank data page and the FAO data repository [11]. The fourth step involved the use of statistical instruments to run a quantitative assessment of the available data. Summary statistical analysis was carried out on all data set to define the measure of dispersion and that of the central

tendencies. The precision of effects was determined with the use of standard error while the association among variables was determined with the use of Pearson correlation.

RESULTS

Innovations and Technologies: Overall, a total of one thousand two hundred and thirty (1, 230) technologies have been recorded across Africa over the last twenty years (Table 1). Of these, only 432 have been adopted in the different countries where they were developed, with 221 having the potential to become actively adopted (Table 2). From our findings, technologies that directly address the productivity of crops took the lion's share with 872 (representing 70%) of all the technologies developed being directed towards crops. This is irrespective of the nature of the innovation (whether it is a technical, institutional, or organizational innovation). The livestock domain experienced some reasonable emergence of innovation with 180 innovations developed over the last 20 years being targeted at improving livestock. Other domains recorded relatively low input with the processing of agricultural products having 61 technologies and fishing 41. Domains whose categorization falls under the improvement of the value chain and therefore tend to indirectly affect crop and fishing domains recorded 14 technologies. Innovations related to finance/market were 25 and those related to governance were 27. Finally, 15 innovations were recorded under the domain that qualifies them to cut across the different agricultural domains.

Of the countries studied, Ghana and Tunisia appear to have developed a higher number of technologies over the last 20 years (Table 1). However, this may not truly reflect the actual number of technologies by these countries since there is some degree of variation in terms of identification and recognition of what may be said to be an innovation from one country to another. In addition, many of these technologies were not fully inventoried. A case in point is Tunisia, where only a listing of some newly introduced varieties was the main source of data for the identification of a technology.

The Current Situation on Availability, Demand and Growth Potential of Innovations Generated: Based on the applicability of innovations and technologies derived therefrom, 432 technologies were identified and may be considered as being currently active, while 211 are only potentially active (Table 2). This categorization takes into consideration the applicability of the technology at least within the country it was developed. Again, a high number of technologies developed by a country may not necessarily reflect the true picture of innovation.

Drivers of Technology Generation and Influences of External Factors: The trend in statistics showed that agricultural innovations varied greatly among crop commodities compared to other agricultural commodities. (Table 3). While priority crops vary from one country to the other, there is convergence on staple crops such as maize, rice, cassava and potato. For example, because staple crops in most West African countries include cassava and cow pea, there are attempts to develop new technologies to improve the productivity of these crops in countries such as Ghana and Nigeria. A total of 872 technologies have been developed in Africa within the last 20 years for these commodities alone. As expected, cereal/grains, which are the most important crops in Africa, took the largest share of innovations with 411 technologies developed across the continent. This is followed by root and tuber crops with 128. Others are fruit crops (39), beef cattle (9), dairy (14), small ruminants (14), horticulture (30) and chicken (21). Still, others, represented by 191 technologies cut across the different value chains. In addition, 23 technologies, mainly targeting crops with export values (soybean, coffee and cocoa), were developed.

Taken together, the entire range of innovations and technologies in Africa over the last twenty years was driven by the need for improved productivity, which led to the development of 474 innovations (Table 4). Challenges due to adverse environmental effects inspired the development of 85 innovations. Depletion of natural resources led to 45 innovations and lack of qualitative products brought about 42 innovations. Innovations that emerged due to economic drivers include those based on low cash flow (5), boost in sales of agricultural products (18), difficulty in accessing credit (3), high cost of production (9), technical and market inefficiency (47) and reduction in product demand (3). The lack of a policy framework also led to the development of 22 innovations. Challenges in information sharing brought about 12 innovations while low technology adoption led to 14 innovations. Value addition served as a driver for up to 51 innovations while cross-cutting drivers led to 17 innovations.

Table 1: Status of Agricultural Innovation in the last 20 years

Country	Cropping	Livestock	Fishing	Processing	Value chain	Natural Resource Management	Finance /market	Governance	Others	Total
Benin	130	22	13						1	166
Burkina Faso	29	18	1		11	23	18	3	1	103
Cameroon	51	24		10	1	6	4	15		111
Ethiopia					1		1	1		3
Ghana	175	30	6	48		5			7	271
Kenya	29	5		2	1		1	5		43
Malawi	61	1				2				64
Mali	25	1		1						27
Nigeria	109	4	2			1				116
Togo	48	2	19			26				95
Tunisia	193							2		195
Zambia	22	1				9	1	1		34
Total	872	108	40	61	14	72	25	27	9	1228
% of total	71.0	8.8	3.3	5.0	1.1	5.9	2.0	2.2	0.7	

Source: PARI country studies, 2016

Table 2: Availability of agricultural technologies in Africa

Country	Active technologies	Innovations with potential
Benin	166	45
Burkina Faso	35	53
Cameroon	33	5
Ethiopia		
Ghana	133	17
Kenya	28	15
Malawi		
Mali		
Nigeria	37	76
Togo		
Tunisia		
Zambia		
Total	432	211

Source: PARI country studies, 2016

Table 3: Distribution of technologies developed over the last 20 years among different value chains

Value chain	Cereal Grains	Roots and Tubers	Export* Crops	Fruit crops	Beef cattle	Dairy	Small ruminants	Horticulture	Chicken	Others	Total
Country											
Benin	-	-	-	-	-	-	-	-	-	-	-
Burkina Faso	8	1	-	1	4	7	1	3	4	19	48
Cameroon	7	4		2	1	1	1	3		34	53
Ethiopia	-	-	-	-	-	-	-	-	-	-	-
Ghana	95	44	8	10	4	1	10	3	10	79	264
Kenya	13	8	2	4		5	1	1		10	44
Malawi	33	21	-	-	-	-	-	11	-	-	65
Mali	24			1					1	1	27
Nigeria	52	34	13				1	4	5	10	119
Togo	22	12	-	-	-	-	-	-	-	-	34
Tunisia	146	-	-	20	-	-	-	-	-	27	193
Zambia	11	4	-	1	-	-	-	5	1	11	33
Total	411	128	23	39	9	14	14	30	21	191	880
% of total	46.7	14.5	2.6	4.4	1.0	1.6	1.6	3.4	2.4	21.7	

Source: PARI country studies, 2016. * Crops with high export value: soybean, cotton and cocoa

Table 4: Distribution of technologies developed in Africa over the last 20 years based on drivers

Country	*Burkina F.*	*Cameroon*	*Ghana*	*Kenya*	*Nigeria*	*Togo*	*Zambia*	Total
Driver								
Low Productivity	17	11	181	12	208	40	5	474
Technical & Market inefficiency	1	3	22	7	11	2	1	47
Depletion of natural resources	-	-	-	4	-	-	4	8
Challenges in information sharing	2	5	-	2	-	1	2	12
Lack of quality product	1	1	38	2	-	-	-	42
Low adoption of technology		4	5	2	1	2		14
Low cash flow	1	1	-	2	-	-	1	5
Vulnerability to adverse effect	10	5	3	2	49	13	3	85
High risk of productivity		5		2			2	9
Lack of policy framework	14	3	-	2	-	-	3	22
Boost sales of products		9		1			8	18
Difficulty accessing credit	-	2	-	1	-	-	-	3
High cost of production	2	2		1	4			9
Product counterfeiting	-	-	-	1	-	-	-	1
Reduced demand for products	1	-	-	1	-	-	1	3
Value addition	-	4	26	1	2	14	4	51
Others	6	3	7	-	-	-	1	17
Total	55	58	282	43	275	72	35	820

DISCUSSION

Despite the 4.7% increase in GDP recorded across Africa in 2016, low commodity price associated with limited access to technologies and therefore low agricultural productivity, is a source of concern [12]. This is partly due to the rate at which innovations and technologies have evolved on the continent over the years. Agricultural innovation over the last twenty years across Africa suggests that such interventions have focused intensively on crop value chains and very little on the other domains. This points to the existence of more challenges in crop value chains than in other agricultural aspects. While there is no clear link between the development of these technologies and the possible emergence of a new generation of policy makers [13], it would appear that agricultural growth that seeks to reduce poverty among poor farmers [14] must entail applying new technologies in which farmers are not only recipients of technical messages but also originators of both technical knowledge or improved practice [14].

CONCLUSION AND PERSPECTIVES

Technology generation is largely driven by the need to bridge the yield gap and enhance productivity. This affects commodity prices, quality and competitiveness. Beyond technology development, innovations that are related to the processing and management of the commodities also need to be addressed. Challenges unearthed from the study include low adoption of agricultural innovations of researchers, poor quality and quantity of production, inadequate infrastructure and capacities for processing, storage, conservation and trading of agricultural products. These challenges may be due to a lack of commitment from stakeholders.

Further investigations need to be carried out to understand the causes of the challenges listed. In addition, studies should be conducted on the conditions for better adoption of agricultural technologies as well as the evaluation of stakeholder involvement in the development of agricultural technologies. This is necessary to allow for the design of innovations that may be better fitted to resolve specific problems in all the value chains.

In conclusion, only a handful of the technologies outlined in this research report have been translated into innovations and adopted. However, there is no clear relationship between the volume of technologies generated and their adoption /use. We are of the view that the notion that Africa has many technologies on the shelf is subjective.

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