Agricultural institutions and policies occupy a pivotal place in Africa’s development trajectory, because of the importance of the sector to political, economic and social relations. This article, against the backdrop of evaluation research, examines the role of disruptive technology in agricultural development – using the New Rice for Africa (NERICA) project as a case study. The article concludes that disruptive technology and evaluation research must bear in mind the complex interaction between the producers and users of knowledge and recognize their common interests and goals.
Key Messages

- African agriculture has no shortage of institutions and policies, but there is a lack of political commitment in terms of access to resources.

- Disruptive technology is not the magic bullet for evaluation research in African agriculture.

- Technology functions in a social and political context and its usefulness in development planning and evaluation is subject to both technical and non-technical considerations.

Introduction

The role and importance of institutions and policies in social change have been accepted as a universal statement of faith. Institutions provide the framework through which policies can drive the broad social agenda. As North (1990) points out, institutions offer the "rules of the game". In the African situation, agricultural institutions and policies occupy a pivotal place in the region's development trajectory, because of the importance of the agricultural sector to political, economic and social relations. Thus, the African state and external actors, as such development partners, have since the postcolonial era set up and initiated agricultural institutions and policies (ACBF 2012; Puplampu 2003). Indeed, there has not been a shortage of agricultural institutions and policies in African development. The problem, however, is "desirable policy and institutional outcomes in the face of available resources, because political commitment, although necessary, is a not a sufficient condition" (Puplampu and Essegbey 2018: 65). If political commitment is not a sufficient condition, what then would account for desirable outcomes of African agricultural institutions and policies?

It is generally known that technological changes are indispensable to the rational outcomes associated with developed societies, and that developing societies should employ technology in a significant way in agricultural institutions and policies to hasten national development. This article, against the backdrop of evaluation research, examines the role of disruptive technology in agricultural development. The analysis is based on the institutional and policy processes of the New Rice for Africa (NERICA) project. The article argues that technology is not a disembodied entity, but rather functions in a social setting that shapes the technology just as the technology also shapes society. Hence, technological changes require agency, and the outcomes are contingent and not predetermined. The article is structured into four parts: the first outlines salient aspects of agricultural development, disruptive technology and evaluation research. The second section presents the NERICA project. Section three is about analysis, and the last section concludes.
many African countries. These programs, however, did not dramatically improve agricultural development in Africa, due to political and non-technical factors (Griffin 1979) such as the cost of technology— in effect, its social situation. The question then becomes whether the character of disruptive technology is so unique to transcend non-technical issues and more useful to agricultural institutions and policies in Africa. Disruptive technology, popularized by Christenson (1997), is an innovative process that zeros in on how technological changes give rise to novel outcomes that can have consequences for institutional and policy evaluation. The driving force in the process is the advances in communications and information technologies, such as smartphones, global positioning systems, satellite imagery, data transmission, and artificial intelligence that have collectively given rise to the Internet of Things (IoT).

IoT involve interconnectivity of physical and virtual communication systems in which “items in the physical world, and sensors within or attached to those items, are connected to the Internet via wireless and wired Internet connections” (Ndubuaku and Okereafor 2015: 23). Bringing IoT to bear on agricultural institutions and policies has led to notions such as smart agriculture, digital agriculture and smart farming as critical aspects of the future of agriculture (Bacco et al. 2019; Eitzinger et al. 2019). Digital agriculture includes the use of robots, real time data collection and analytical systems that are amenable to measurement and careful calibration to ascertain outcomes. Digitalization can shore-up African agriculture and has the potential to improve institutional and policy outcomes, issues at the heart of evaluation research.

Evaluation research has an interest in policy or program impact, explicitly an analysis of whether policies or programs are attaining goals and objectives. According to Langbein (2012:3), evaluation research includes “the application of empirical social science research to the process of judging the effectiveness of... policies, programs, or projects, as well as their management and implementation for decision making purposes”. Evaluation research, especially in the case of agricultural development, raises questions such as what is working or not working and why; and how impact or effectiveness can be attained. There are issues of measurement involved in program or policy assessment, especially in the case of program evaluation. This kind of evaluation, as the name implies, is “directed at answering the question of whether a program, policy, or project worked” (Symbaluk 2014:271). It is the policy measurement processes in evaluation research that best demonstrate the role of technology, and in this case disruptive technology. Disruptive technology will make it possible to monitor outcomes, because of its physical attributes, including sensors that can be programmed for measurement and to generate the required data for subsequent analysis.

NERICA Project in West Africa: A Brief Overview

The agricultural sector in Africa has been the site of significant changes, especially with reference to technology and the role of the state (Satgar 2011; Puplampu 2006). All three sectors of agriculture—production, marketing and consumption—have experienced technological changes. Take the case of production, where contract farming systems involve technology as both a means and an end, introducing “distinctive work routines” (Watts 1990:149) and agricultural goods suitable for global supply chains respectively. Technological changes in production are best exemplified in the case of rice, a staple food in many African countries. There is a shortfall between domestic rice production and consumption, making it necessary for rice imports to meet increasing demand. According to Atera et al. (2011:60), "sub-Saharan Africa..."
produced about 21.6 million tons of rice in 2006 and accounted for 32% of rice imports in the global international market to meet its demand". The antecedent for rice imports can be traced to the low rice yield from domestic production due to several factors, ranging from seed varieties, differences in agro-climatic conditions, to the nature of agricultural research (Arounaa et al. 2017). These factors spurred the Africa Rice Centre, an affiliate of the Consultative Group on International Agricultural Research (CGIAR), into a novel research plan that eventually led to NERICA (Otsuka and Kijima 2010).

The NERICA research focused on inter-specific hybridization between Oryza glaberrima (African rice) and Oryza sativa (Asian rice), and the goal was to combine traits from the African variety, which is resistant to pests, weeds and difficult soil conditions, with the Asian variety, which is high yielding and ideal for mineral fertilization. Beginning with experiments in 1991, rice varieties were available by 1994 “through perseverance and the use of biotechnology tools such as anther culture and embryo rescue techniques” and this gave birth to NERICA (Diagne et al. 2011:255). By cross-breeding high-producing Asian plants with African varieties that thrived in the region’s poor soils and drought conditions, the significance of NERICA is the increase in yields of up to 250 percent while cutting growing time in half for rice farmers, potentially providing 240 million people with more food in West Africa and beyond (World Food Prize 2020).

The new and improved varieties were subsequently adopted by farmers in many African countries, notably Burkina Faso, Gambia, Ghana, Kenya and Uganda (Atera et al. 2011; Diagne et al. 2011).

Farmers adopted NERICA because the research methodology allowed them to choose from available crop varieties. Indeed, farmers were persuaded about their role in the development and dissemination of crop varieties, they were key participants in site-specific factors like agronomic and selection options (Diagne et al. 2011). The methodological orientation of NERICA made a major difference in its widespread utilization, in the sense that it made farmers co-knowledge creators in agricultural research (Kilelu, Klerkx and Leeuwis 2013). The implications of NERICA for food security in Africa have been rightfully noted (Anderson and Jackson 2005). The Africa Rice Centre and its director (Monty Jones) won CGIAR’s King Baudouin Award in 2000 and the World Food Prize in 2004 (with Yuan Longping, from China) (CGIAR 2020; World Food Prize 2020). NERICA, beyond its potential to feed millions of people in Africa, also aligns with both disruptive technology and evaluation research.

NERICA was a niche product suitable to the agronomic and social conditions of rice farmers in Africa. The disruptive aspects of NERICA can be attributed to two inter-related factors, first, the enhanced technological aspects of the crossbreeding process and second, the adoption rate and success in several African countries due to the methodological orientation of the research project. As an inter-specific hybrid, NERICA has several improved ‘lines’ which African rice farmers have adopted in various agro-climatic conditions. As Somado et al. (2008) show, NERICA is an extended family of various ‘lines’ and that means the agro-physiological traits of NERICA are not homogenous, giving rise to different varieties adopted or released in many countries. The emergence of the multiple ‘lines’ are technical processes embodied in novel techniques that are disruptive in nature and character.

The variety of the traits, in turn, account for the successes in adoption across Africa. Certainly, the technical details...
associated with each NERICA trait are easily discernable and farmers’ preferences can also be clearly identified and specified. Farmers in Côte d’Ivoire and Nigeria prefer NERICA 1 and 2, Guinea farmers adopt NERICA 1 and 6, and Mali and Uganda farmers opt for NERICA 4 (Somado et al. 2008). Atera et al. (2011), in a statistical study on the field evaluation of NERICA in western Kenya (NERICA 1, 4, 10 and 11), documented the superior qualities of NERICA compared to the traditional rice varieties in the region. Kijima et al. (2006) also found potential yield increases of NERICA compared to other varieties in Uganda. What is significant about these evaluation findings is the recognition of non-technical factors like the experience of the rice farmers, seed distribution and the availability and timing of fertilizer; in sum, conditions of access to relevant agricultural inputs.

Evaluation research and its focus on policy can shed light on the NERICA project. The research and innovation at the basis of the NERICA project reflected essential parts of disruptive technology, infusing technological changes into crop research. Agricultural innovation through smart agriculture made it possible to monitor and manage anther culture and other embryo rescue techniques. The ability to monitor microscopic and physiological changes in a research environment provides opportunities to generate data that can be captured in real time, verifiable and valuable to inform research outcomes. The preceding elements informed the GeoFarmer design and implementation projects in East and West Africa as well as Latin America (Eitzinger et al. 2019). For example, GeoFarmer had real-time data capture capabilities, two-way data flows and involved farmers as co-innovators in the respective agricultural development projects. The measurement capabilities of the sensors in digital agriculture and the recognition of the knowledge base of farmers represent a fundamental shift in agricultural research processes, akin to Kuhn’s (1970) idea of paradigm shift.

The increased adoption of NERICA was due to the methodological orientation of the project, a change from the system in agricultural research focused on technical questions and where research scientists, as experts, set and drove the research agenda. In such cases, farmers, as end-users of research did not play any role and were simply expected to trust the work of experts. Thus, when the agricultural research system, for example, did not contribute to agricultural development, it was because farmers “refused” to use new technologies. However, no attention was paid to the problems in setting the research agenda, the power play among the various actors in agricultural research, and the lack of representation of the farmers’ viewpoint within the research system. These are issues researchers must address for farmers to embrace and integrate research findings into their production practices.

The NERICA project, however, moved away from the perennial issue of the participation of farmers as legitimate actors in agricultural research and integrated them as co-knowledge creators. Participation is premised on the assumption that groups partake in decisions that affect them (Brett 2003). Participation also engenders a sense of ownership and the subsequent acceptance of a specific policy. NERICA shows that when farmers are properly involved in agricultural research, there are positive outcomes. As rational actors, farmers are concerned about their food security needs and thus cautious in adopting any technology, especially in cases where they have no role in the agricultural research agenda in the first place.

The change in orientation in the NERICA project is consistent with an agricultural research that factors in both technical and non-technical or social considerations. These considerations are significant because they intersect at the farm level, where production takes place, the community, where support services for agricultural production are located,
and at a societal level, where consumers make use of agricultural produce (Ruttan 1982). This approach therefore recognizes a close collaboration between technical and social aspects of research, what Biggs and Farrington (1991) call the social science analysis of agricultural research. Technical and social aspects of agricultural research, they argue, "are continuously and inextricably interwoven. To pull them apart leads to situations where policies and programs designed to achieve one set of objectives result in very different outcomes" (Biggs and Farrington 1991:3).

At stake is the fact that the social environment shapes research outcomes and vice versa. Explaining agricultural research outcomes should, therefore, begin with an understanding of the social and technical aspects of the process. Clearly, any analysis of agricultural research outcomes should go beyond technical concerns and focus on farmers’ knowledge and their role in creating new forms of knowledge. Agricultural research in most African countries is basic research, and the scientific investigation that advances the frontiers of knowledge is minimal. At the same time, the bulk of research is adaptive, aiming at adjusting knowledge gained elsewhere to local conditions. NERICA proved that adaptive research can be useful only when social and local conditions are considered. Thus, a focus on the social conditions of farmers is critical in terms of the processes of adaptation that will be implemented for successful outcomes.

Conclusion

This article has shown the possibilities that technological changes can bring to agricultural development, and the interaction between technology and evaluation research. Specifically, the article focused on disruptive technology and its implications for evaluation research taking the case of NERICA as an example. Rice production benefited from research and innovation as well as the integration of technical and non-technical issues into the research agenda. There are several valuable lessons for the future. First, disruptive technology and evaluation research must bear in mind the complex interaction between the producers and users of knowledge and recognize their common interests and goals. Traditional models of agricultural research neglected farmers’ knowledge as a starting base of their research agenda, while evaluation researchers also focused on the technical at the expense of non-technical issues. Put differently, when it comes to evaluation research and agricultural research systems, the focus must be on both technical and non-technical factors, especially the location of farmers. This must be stressed because NERICA conclusively established that a concerted effort is needed to genuinely involve farmers in agricultural research institutions and policies, if the policy objective is to increase agricultural production and ultimately agricultural and national development in Africa.

Second, technology is not neutral in its impact. The focus on non-technical variables should be sensitive to, for example, the digital divide, which brings to the fore questions such as the access to and related cost of technology and the type of farmers. Two issues are at play. On the one hand, smart farming has undermined the historical split between large-scale and small-scale farmers in Africa, in which the former produced export agriculture and the latter produced for the local market (AGRA 2017). On the other hand, the rural-urban divide, a feature of many African societies, also reflects the location of the relevant infrastructure. Internet connectivity and bandwidth matters must be addressed for farmers, so that irrespective of their location, IoT and evaluation research can better contribute to the performance of African agricultural institutions and policies in our increasingly interconnected and wired 21st century society.
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Korbla P. Puplampu is in the Department of Sociology at Grant MacEwan University, Edmonton, Alberta, Canada. His research interests include the global restructuring of agriculture and the politics of identity in multicultural societies. Dr. Puplampu has publications in academic journals such as Canadian Journal of Learning and Technology and Perspectives on Global Development and Technology. He has also co-edited and contributed to several books including From Millennium Development Goals to Sustainable Development Goals: Rethinking African Development (with Hanson & Shaw) and The Public Sphere and the Politics of Survival: Voice, Sustainability and Public Policy in Ghana (with Tettey).