Using the Land Potential Knowledge System (LandPKS) Mobile Technology for Agricultural Productivity and Resilience

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1.Introduction

Africa's continued agricultural growth over the last couple of years has come from land expansion rather than increased productivity[1]. However, available agricultural lands are rapidly diminishing due to urbanization, while soil fertility continue to decline due to land degradation, poor farming practices, soil erosion, and the impact of climate change. There are growing concerns to rethink current land use mechanisms, and devise innovative strategies that ensure that available land under agricultural production becomes more productive and sustainable. Efforts to achieve increased food productivity will come not only from agricultural intensification and land conversion production strategies but will require access to accurate, robust, and timely information and knowledge of land potential to support decision making at the various scales of the agricultural system. By empowering farmers with information via access to modern technology, they will be in a better position to innovate and effectively change the potential of their land through farm practices that enhance productivity as well as increase crop and land resilience to variable and changing climatic conditions.

Advances in mobile technological application are paving the way for the development of new innovative tools that can facilitate the integration of information and knowledge, using local knowledge and crowdsourcing technologies in effective decision-making on land management strategies for improved agricultural production. The rapid expansion of internet accessibility through mobile phone networks together with simple mobile applications provides new opportunities to connect farmers, extension workers, development planners, and policymakers with site-specific knowledge and information on land potentials. Leveraging the emerging technological trend, the Land-Potential Knowledge System (LandPKS) project presents a suite of mobile apps that allows individuals and organizations to use a mobile phone to determine land potential at a specific location based on local and global knowledge and information.

The LandPKS project is designed to directly support land management decisions by farmers, ranchers, and pastoralists; inform land use planning and investments in land management by governments, non-governmental and overseas development assistant organizations. The LandPKS development draws enormous data support and collaborative effort from the Food and Agriculture Organization; Global Soil Map; the International Soil Reference and Information Center, Conservation International's Vital Signs Project; Kenya Agricultural Research Institute; African Soil Information System; European Environment Agency, including Eye on Earth; and several Consultative Group on International Agricultural Research Centres; as well as a number of sustainable land management knowledge systems such as World Overview of Conservation Approaches and Technologies (WOCAT).

[1] *Fuglie,K. O and Rada, N. E. 2013. Resources, Policies, and Agricultural Productivity in Sub-Saharan Africa. Economic Research Report Number 145. Pp. 1-70.*

A shared understanding of land potential by governments, farmers, pastoralists, and development workers through LandPKS has the capacity to sustainably increase agricultural production, rangeland restoration and improvement of other ecosystem services[2].

2. Advancing Agricultural Production Through Information and Communication Technology (ICTs)

At the 2003 World Summit on the Information Society (WSIS) in Geneva, Switzerland, the role of Information and Communication Technology (ICT) in advancing agricultural development to enhance food security and support rural livelihoods was highly recognized and officially endorsed[3]. This effort has served as a springboard for ICT revolution in agriculture, culminating into the use of computers, geographic information systems, internet and mobile phones to contribute to agricultural development and poverty reduction in developing countries. Given that Africa's agriculture sector which employs about 73% of rural Africa has underperformed over the past 40 years[4], the strategic application of ICT offers a highly suitable pathway for Africa's agricultural sector to redeem itself as the backbone of economies of most African countries.

Farmers in sub-Saharan Africa are embracing mobile technology application in agriculture. This move is effectively shaping agricultural practices and improving market value chain. Several mobile phone based initiatives have been introduced. For example, the *m-farm* and *esoko* provide up-to-date market prices via an app or SMS for farmers' commodities as well as create a platform for knowledge sharing on farming practices. Other examples include *mAgric* and the *mfarmer* initiatives which were launched by the Groupe Speciale Mobile Association (GSMA) to improve productivity and incomes of smallholder farmers and benefit the agriculture sector in emerging markets. It improves their access to information, financial services and supply chain solutions and delivered via mobile phones using sustainable business models. Another mobile technology includes a tracking system application that contributes to improved supply chain efficiency for agricultural products by providing traceability of products in demand by consumers thereby potentially reducing food spoilage[5].

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[2] *http://landpotential.org/sites/landpotential.org/files/LandPKS%201%20page%20summary_ab%20jeh.pdf. Accessed 16 February 2015*

[3] *Stienen, J., Bruinsma, W and Neuman, F. 2007. How ICT can make a difference in agricultural livelihoods. http://www.iicd.org/files/ICT%20and%20agricultural%20livelihoods.pdf. Accessed on 14 December 2014*

[4] *Van Zyl, O. and Alexander, T., De Graaf L. and Mukherjee K. 2012. eTransform aFrica: ICTs for agriculture in Africa. http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1346223280837/Agriculture.pdf. Accessed 14 February 2015.*

[5] *Vodafone, Acceture and Oxfam 2011. Connected Agriculture: The role of mobile in driving efficiency and sustainability in the food and agriculture value chain. http://www.vodafone.com/content/dam/vodafone/about/sustainability/2011/pdf/connected_agriculture.pdf . Accessed 15 February 2015.*

Furthering the efforts to improve agriculture development through ICT application, the Land Potential Knowledge Systems (LandPKS) seeks to produce a suite of innovative mobile data collection and analysis tools to support local land management and land use planning to optimize food security, land restoration, climate change adaptation, and biodiversity conservation programs. The overall goal is to globalize knowledge by collecting, sharing and integrating local and scientific knowledge about the potential productivity and resilience in order to support long-term sustainable land productivity.

The LandPKS suite of integrated mobile phone applications will allow farmers, extension workers, development organizations, and national governments to access, share and apply the best available knowledge and information to inform choices of land management strategies, land use planning and specific types of interventions at field, regional, and national scales. The uniqueness of the LandPKS project is its development approach which is community-driven, offering room for feedbacks to be incorporated into the system. Currently, the project is being piloted in North-central Kenya and North-eastern Namibia, spearheaded by the US Department of Agriculture's Agricultural Research Service (USDA-ARS), the African Technology Policy Studies Network (ATPS) and other partners with funding support from the United States Agency for International Development (USAID)

3. LandPKS Applications and Opportunities for Agricultural Productivity and Resilience

Currently, two mobile apps namely **LandInfo** and **LandCover** apps have been produced under the LandPKS project**.** The apps already include multiple options depending on user knowledge and experience (e.g. for texture), and user guide videos that help users to improve their own estimates. These mobile apps produced from the LandPKS project are constantly reviewed and updated based on feedback from pilot field testing with farmers to improve the features, user functions as well as make them more user-friendly.

LandInfo and LandCover Apps: A Brief Description

The LandInfo mobile app produces knowledge and information that explicitly define land potential (relative productivity and degradation risk) by identifying the land management system that is most appropriate for local conditions[6]. Tapping into recent advances in cloud computing, digital soil mapping, Global Positioning

[6]*Herrick, J.E. et al. 2013. The global Land-Potential Knowledge System (LandPKS): supporting evidence-based, site specific land use and management through cloud computing, mobile apps and crowdsourcing. Journal of Soil and Water Conservation; Vol. 68 (1): 5A-12A.*
http://www.jswconline.org/content/68/1/5A.full.pdf+html Accessed 17 February 2015.

System (GPS) enabled camera phones, the LandInfo app allows users to enter point-specific information about soil texture, topography and easily observable soil properties and in turn obtain site-specific data including temperature, rainfall, estimated amount of water the soil can store for plants, and growing season length among others. The LandCover application functions using a stick method in assessing vegetation cover and structure of plot of land. The outputs of the Land cover provide important information such as percentages of bare ground and vegetation cover, which is important in rangeland health monitoring.

Potential Opportunity of LandPKS Technology for Enhancing Agricultural Productivity and Resilience

The introduction of LandPKS suite of mobile apps in agriculture is part of a wider effort to modernize and globalize agricultural knowledge, taking advantage of the current digital revolution. At the global level, the LandPKS technology aims to facilitate the development of knowledge system and make real-time information about crops, soil types, and land use strategies accessible for decision making in agricultural production. Scientists will have access to a global geo-referenced database for calibrating remote sensing imagery and testing hypotheses globally. At the regional level, the LandPKS system can be used to inform land-use planning at a finer scale than is possible with generalized soil maps. At the national level, governments, NGO's and donor agencies can use the system to help identify where support (development projects) for conservation, production type and other development efforts are likely to have the greatest impact, and avoid mistakes that sometimes increase, rather than reduce, land degradation. Policymakers will be able to aggregate data across larger areas without losing key information, such as the presence of small, highly productive, bio-diverse, or vulnerable sites within a region. At the Local level (farm/conservancy/watershed), farmers, extension agents, development planners, and consultants can use the system to supplement their own knowledge of land potential and answer questions about sustainable land management options at the field scale. LandPKS provides extension workers with the ability to instantaneously access the best available information and interpret it in the context of local socio-economic conditions and local values, including crop preferences for a particular farm location.

4.Policy Considerations

A review of mobile phone services for supporting agricultural knowledge management and decision making has shown that leveraging mobile phone application for agricultural production can engender highly beneficial outcomes from the local to national, regional and global scales. These outcomes include among other things enhanced land and crop productivity, appropriate crop and land production choices, enhanced value-chain development, access to markets, and information on commodity prices. A recent report by Vodafone identified twelve ICT based opportunities that has the potential to deliver approximately

75% of agricultural income from access to financial services, markets, improving data visibility and agricultural information via mobile phone usage. These opportunities include: mobile payment system, micro-insurance system, micro-lending platform; mobile information platform, farmer helpline, smart logistics, traceability and tracking system, mobile management of supplier networks, mobile management of distribution networks, agricultural trading platform, agricultural tendering platform and agricultural bartering platform[7].

Using LandPKS to achieve sustainable agricultural development goals requires greater investments in networking, awareness creation, advocacy, and capacity building to promote transfer of this technology, its adoption and application and mainstreaming into local, national and regional agricultural/land policies. Highly important is the fact that, LandPKS application is demand driven and affordable with the ability to reach the majority of target beneficiaries. The long-term impact and sustainability of LandPKS will principally rely on instituting flexible but strongly supportive policies, technological appropriateness, and the enabling environments for innovation.
The following policy strategies are not exhaustive but serve as sound considerations to guide the development, application and sustainability of LandPKS in supporting agricultural development:

Creation of an Enabling Environment for Innovation
Implementing the LandPKS technology as an agricultural development intervention at a broader scale requires favourable but flexible regulatory and policy environments that foster the growth and integration of ICT in development planning. Governments should offer incentives for the telecommunication sector to make mobile broadband service and smart phones affordable and widely accessible particularly in rural communities. Incentives may be in the form of tax breaks for smart mobile phone manufacturers, reduction of duty on mobile phones, and public-private partnership investment in telecommunication infrastructure. Governments must capitalize on the potential contributions of technologies such as LandPKS to improve agricultural productivity, yield and sustainable land management by implementing robust and appropriate measures that would translate these potentials into real benefits. A case example is in Nigeria where the Federal Ministry of Agriculture announced in 2012 their plans to procure ten million mobile phones, worth about N60 billion, from China and the US for free distribution to rural farmers across the country as part of the Ministry of Agriculture's e-Wallet project. Under the initiative, the Ministry officials would be able to educate, inform and communicate with the farmers in the rural areas across the country on the latest and best agricultural practices, as well as

[7] *Vodafone 2012. Connected Agriculture The role of mobile in driving efficiency and sustainability in the food and agriculture value chain. http://www.vodafone.com/content/dam/vodafone/about/sustainability/2011/pdf/connected_agriculture.pdf Accessed 14 February 2015.*

the current prices of commodities in the market[8]. It will be interesting to evaluate the impact of such initiative on agricultural development in Nigeria.

Development of a National e-Agriculture Policy

As the role of mobile phone in agriculture deepens, African countries should as a matter of urgency formulate national e-Agriculture policy which would explore and outline the possibilities of leveraging mobile phone-enabled platforms to produce robust models/tools that deliver agricultural information services for effective decision making at various scales. Currently, many African countries have developed national e-health, e-governance, and e-education policy strategies but are yet to develop a national e-agriculture policy for the sector that contribute to the major part of their GDPs. Two countries, Ivory Coast and South Africa have so far taken the initiative to develop e-agriculture strategies in line with emerging global ICT trends[9]. Fundamental to the success of this policy will be the involvement of stakeholders and political commitment with the necessary budget allocation for policy implementation, research, and training.

Supporting Mobile Service Infrastructure

According to a recent report on mobile phone application and agriculture commissioned by Vodafone, the widespread of mobile technology deepens the prospect of increasing agricultural income to the tune of US$ 48 billion from emerging market in Africa by 2020[10]. The success of a wider coverage and use of mobile phone application in agriculture will partly depend on the combined effort of government and the private sector. The private sector continues to remain the engine of ICT growth in Africa. Effort by governments in African countries to improve ICT infrastructure remain minimal, however, there are some good initiatives by governments through the establishment of appropriate institutional arrangement to facilitate ICTs infrastructural development. A laudable example by the Rwandan government is the establishment of Rwanda Information Technology Authority (RITA) to implement the National Information and Communication Infrastructure (NICI) Plan. The plan specifically focuses on building an export-oriented ICT industry and to boost development through ICT use in sectors such as agriculture, education, health, etc. The government is also working with international IT companies, such as Cisco and Sun Microsystems, to develop ICT training facilities and Telecenters.

Creation of More Awareness on LandPKS Technology

Mobile phone application in agriculture is gradually gaining momentum in African countries and LandPKS technology is a new innovative knowledge system that

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[8]Daily Trust, 2013. Federal Government of Republic of Nigeria to give farmers N60 billion cell phones. Accessed 26 February 2015.

[9]Lohento K., Speer, M, Kouable, N. 2013. e-agriculture strategies: the case of Ivory Coast. e-agriculture strategies. Issue No. 73.

[10] Vodafone 2012. Connected Agriculture The role of mobile in driving efficiency and sustainability in the food and agriculture value chain. http://www.vodafone.com/content/dam/vodafone/about/sustainability/2011/pdf/connected_agriculture.pdf. Accessed 14 February 2015

has the potential to turn the face of agriculture on the continent. Evidence has shown that creating awareness and access to information via mobile phones can contribute significantly to farmers' livelihood, yield and income. In the 2012 World Bank "Information and Communications for Development " report, farmer's income increased between 16.5% and 36% in Uganda and 10% in Ghana,following enhanced access to market information through mobile phones[11]. It is very important to create awareness about the technology and the potential it offers to the different user categories including policymakers, development planners, extension workers, pastoralists, and farmers among others. Only then can these stakeholders realise the potential of LandPKS technology and apply it accordingly in their respective areas of agricultural development systems. National awareness of the value and benefits of LandPKS technology may take time to realize, however, advocating and engaging stakeholders including government and development partners at the national policy level may create more visibility and provide incentives for higher adoption rate for the technology.

Strengthening of End-Users' Engagement from Onset

It is important for developers and investors of technological innovations to pay serious attention to investment in human capacity and end-users' participation in planning and design stages. Several years of agricultural development experience have shown the importance of engaging farmers and policymakers in new technology development projects from the beginning. Many technological innovations have experienced low uptake, lack of interest, and trust when developers have concentrated on the technology alone without integrating the interests and aspirations of other critical stakeholders in the entire process. As a long-term strategy towards integrating mobile phone application in development, effort to integrate information technology into education systems from the primary to tertiary levels should be strengthened. Establishing short training courses on emerging technologies and innovations, tailored to meet the needs of beneficiaries such rural farmers will boost their confidence, enhance adoption and expose them to the era of technological advancement. A good example is the "Agriculture, Rural Development and Youth in the Information Society" (ARDYIS) project of the Technical Centre for Agricultural and Rural Cooperation (CTA), which seeks to strengthen youth capacity and promote youth sensitization on ICTs for agriculture and rural sector development. The project is intended to facilitate the platform for engagement of African, Caribbean and Pacific (ACP) youth in agriculture, rural development information, and communication and technology sectors[12].

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[11] World Bank Report 2012. Information and Communications for Development: Maximizing Mobile. Washington, DC: World Bank. DOI: 10.1596/978-0-8213-8991-1; website: http://www.worldbank.org/ict/IC4D2012 . License: Creative Commons Attribution CC BY 3.0

[12] http://ardyis.cta.int/ Accessed 14 February 2015.

5.Conclusion

The emerging role of ICTs in sustainable agriculture as facilitator and their transformative effects on social and economic development can no doubt be underestimated. In this brief, we have highlighted successful cases of the impact of ICTs, particularly mobile phone technologies on agriculture, which accounts for the vast majority of rural employment. The LandPKS technology provides a suite of mobile apps that would contribute significantly to unleashing the potential of lands for productive uses, and building resilience in societies globally. Field piloting of the LandPKS system in North-central Kenya and North-eastern Namibia has provided promising evidence of LandInfo and LandCover app viability to provide vital information for decision making on land potential, restorative practices and resilience at local, national, regional, and global scales.

The ubiquitous status of mobile phone technology and its application in core sectors of the developing countries' economy, in particular agriculture, presents both opportunities and challenges. Like other mobile technologies before it, LandPKS risks being subjected to inflated expectation. While there is optimism about the prospects of LandPKS to play an important role in sustainable land management, we remain cautious about the multiple barriers that could impede practical implementation of LandPKS to benefit agriculture particularly issues related to the open access and crowdsourcing nature of LandPKS and the implications for intellectual property, legal protection and data privacy.

Highly essential to the success of implementation of LandPKS technology at a wider scale is to understand the obstacles for LandPKS application, acknowledging the limits, its capacity and relevant context within which LandPKS operates. In the longer term, a study would be necessary to examine the extended benefit of LandPKS technology towards addressing social economic issues such as poverty alleviation, migration and conflicts. In such circumstances, the LandPKS technology may offer sustainable solutions for better decision making and in empowering farmers at the local and national levels.

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[13] http://www.atpsnet.org/publications/technopolicy_briefs/index.php

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LandInfo