HARNESSING AND INTEGRATING INDIGENOUS KNOWLEDGE AND DIGITAL TECHNOLOGY FOR ENHANCED AGRICULTURAL RESEARCH, EXTENSION AND DEVELOPMENT IN NIGERIA

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Abstract

The review highlighted the need to harness both indigenous knowledge and digital technologies for sustainable agricultural research, extension and development in Nigeria. The review described farmers' indigenous knowledge, digital technologies to be adopted their potentials and also identified the problems of harnessing the indigenous knowledge. Digital agriculture involves the use of digital tools and platforms to collect, analyze, and share agricultural data. This includes mobile apps, satellite imagery, and digital marketplaces. Digital agriculture leverages data-driven insights to optimize farming practices, improve decision-making, and enhance market access for farmers. The review revealed that farmers have maintained agricultural production while managing their environment and biodiversity using the vast proven time long indigenous Knowledge. In an attempt to improve farmers productivity, scientist and researchers often ignore the peculiarities of , farmers, their knowledge of agriculture, technology and environment. This has been the cause of failure of many development efforts geared towards technology transfer in Nigeria. Similarly, the review identified ways of harnessing the farmers indigenous knowledge among which are: contractual, consultative, collaborative and collegial model Deforestation and concealment of indigenous knowledge by the custodians, language barriers, memory failure on the part of the resource persons among others were found to be the potential constraints to harnessing the knowledge for sustainable agricultural research, extension and development. The review also highlighted the importance of digital technologies in agricultural bextesion and development. The review concluded that indigenous knowledge were well established and practiced among farmers who are well experienced and knowledgeable and that integration with digital technology will lead to a more efficient Agriculture. It was recommended that enabling environment be put in place to facilitate the seamless integration of indigenous knowledge, and digital technology, and their transfer .Establishment of a national agricultural research database/ databank to enhance awareness, documentation, access and utilization of agricultural information and knowledge for agricultural development and hence overall national development.

Keywords: Harnessing, Indigenous Knowledge, Research, Sustainable, DigitalTechnology, Development

Introduction

In Nigeria, the increasing demand for agricultural product as a result of the geometric rise in human population has neccessitated intensifying the use of better agricultural practices and employing other scientific ways of increasing agricultural productivity. (Igene *et al,* 2023) Agricultural production has generally been affected by various factors such as the activities of pests and diseases, poor extension service, poor capital and use of unimproved technologies and most recently, climate change, stakeholders in agriculture are now seeking to have strategies to manage risks associated with climate change effects (Hansen, 2019). The negative effects of climate change are currently being felt in all spheres of life but effects are more severe in the agricultural sector (Olorunfemi *et al.,*2020). However, Small holders still dominate the farming Landscape, which is mostly rain fed, with farmers using simple farm tools and employing traditional methods of planting, controlling weeds, erosion, pest and diseases. The use of scientific and modern farming techniques is considered minimal among the farmers. Agricultural practices under this circumstance is therefore based on the use of indigenous knowledge system (IKS) and local resources including the management of Agro-biodiversity in the form of diversified agricultural system. This perhaps justifies why Quiroz (1994) opined that the survival of man depends on the diversity of the ecosystem. Indigenous knowledge which is passed from generation to generation through oral tradition and practice has been institutionalized and build upon in many farming communities in Nigeria (Olukosi, 1998). This body of knowledge remains largely untapped though it is very useful for developing farmer centered agricultural research and extension.

Most research and development workers often ignored the significance of indigenous knowledge system as they consider it to be primitive, Backward, Cultural bound and irrational. However, recent research findings indicate that some of the traditional farming practice once regarded as primitive and or misguided are being recognized and accepted as sophisticated and appropriate (Altieri, 1998; Gliesman, 1980). There is no doubt that researchers and extension workers in their desire to improve the productivity and standard of living of their clienteles at times treat the local population's indigenous knowledge with disdain, without time to listen to them. In this way they often miss the target, in light of this Olawoye (2002) asserts that in our concentration upon the problems of the local population we often overlook the positive aspect within rural areas that can contribute to solutions to these problems. To corroborate her position Olowoye (2002) opined "that people continue to function under extreme adversity and deprivation which is an indication of their fortitude and adaptability, not of their weakness". Therefore it is imperative for researchers and other development workers to spare time to listen and learn from the local population they are trying to help. This is important as most of these communites have local knowledge and ways of solving their problem from generation to generation (Ndaghu and Tashikalma, 2008). Recent development has shown that there are lots of potentials in indigenous knowledge that need to be harnessed for use in research and extension activities. Ignoring such volume of knowledge considered appropriate by the local population will spell doom for the target innovation and may jeopardize its sustainability. digital and Information and Communication Technology (ICT) are interconnected concepts that play a pivotal role in modern agricultural development. These concepts are critical for enhancing productivity, improving livelihoods, and ensuring food security in a rapidly changing world. As global populations grow and environmental challenges intensify, the need for sustainable and efficient agricultural practices becomes increasingly urgent.

This review highlights and discusses the need for harnessing indigenous knowledge amongst farmers and integrating them with digital technologies for sustainable agricultural research and extension delivery and agricultural development in Nigeria. By examining the synergies between the two concepts, we can better understand how they contribute to the transformation of agriculture into a more resilient and productive sector.

Review of Concepts

Agricultural Extension

Agricultural extension refers to the process of transferring knowledge, skills, and technologies from research institutions to farmers to improve agricultural practices and outcomes. It serves as a bridge between research and practice, ensuring that farmers adopt innovative and sustainable farming methods. Extension services are often delivered through field agents, training programs, and community workshops, which aim to empower farmers with the tools they need to enhance productivity and sustainability.

Agricultural extension is essential for disseminating new technologies and practices that increase crop yields, reduce post-harvest losses, and improve resource management. For example, extension services have been instrumental in promoting conservation agriculture in sub-Saharan Africa, leading to improved soil health and increased productivity (FAO, 2017). By educating farmers on the benefits of minimal soil disturbance, crop rotation, and mulching, extension programs have helped to combat soil degradation and enhance food security in the region. Furthermore, extension services play a critical role in addressing gender disparities in agriculture by providing women farmers with access to knowledge and resources, thereby promoting inclusive development.

Innovation

Innovation in agriculture refers to the development and application of new ideas, technologies, and practices to solve agricultural challenges. It encompasses technological advancements, such as improved seed varieties, as well as social innovations, such as farmer cooperatives and participatory approaches to agricultural research. Innovation is not limited to high-tech solutions but also includes low-cost, context-specific adaptations that address local challenges.

Innovation drives agricultural development by addressing challenges such as climate change, pest outbreaks, and resource scarcity. For instance, the adoption of drought-resistant maize varieties in East Africa has significantly improved food security in drought-prone regions (Kassie *et al.,* 2015). These varieties, developed through collaborative research between scientists and farmers, are tailored to withstand harsh climatic conditions while maintaining high yields. Additionally, innovations in farm management practices, such as integrated pest management (IPM), have reduced reliance on chemical pesticides, promoting environmental sustainability and reducing production costs for farmers.

Technology

Agricultural technology includes tools, machinery, and techniques used to enhance farming efficiency and productivity. Examples include precision farming equipment, irrigation systems, and biotechnology. Technological advancements have revolutionized agriculture by enabling farmers to monitor and manage their operations with greater precision and efficiency.

Technology adoption has transformed agriculture by enabling farmers to produce more with fewer

resources. For example, the use of drip irrigation systems in India has reduced water usage while increasing crop yields (Narayanamoorthy, 2005). This technology is particularly beneficial in arid and semi-arid regions where water scarcity is a major constraint. Similarly, the adoption of mechanized farming equipment, such as tractors and harvesters, has reduced labor requirements and increased productivity, particularly in large-scale farming systems. Biotechnology, including genetically modified crops, has also played a significant role in enhancing crop resilience and nutritional value, contributing to global food security.

Adoption

Adoption refers to the process by which farmers accept and implement new technologies or practices. It is influenced by factors such as affordability, accessibility, and perceived benefits. Adoption is a critical step in the innovation diffusion process, as it determines the extent to which new technologies are integrated into farming systems.

The adoption of improved technologies is critical for achieving sustainable agricultural development. For instance, the widespread adoption of hybrid rice varieties in China has significantly increased rice production, contributing to food security (Huang *et al.,* 2002). However, adoption rates vary widely depending on socio-economic factors, such as education levels, access to credit, and extension services. To promote adoption, it is essential to address barriers such as high initial costs, lack of awareness, and resistance to change. Participatory approaches, where farmers are involved in the development and testing of new technologies, have proven effective in increasing adoption rates by ensuring that innovations are tailored to local needs and conditions.

Digital Technology

Digital agriculture involves the use of digital tools and platforms to collect, analyze, and share agricultural data. This includes mobile apps, satellite imagery, and digital marketplaces. Digital agriculture leverages data-driven insights to optimize farming practices, improve decision-making, and enhance market access for farmers.

Digital tools empower farmers with real-time information on weather, market prices, and best practices. For example, the *e-Choupal* initiative in India provides farmers with digital access to market information, enabling them to negotiate better prices for their produce (Mittal & Mehar, 2016). By connecting farmers directly to buyers, this platform eliminates intermediaries, ensuring fairer prices and higher incomes for farmers. Additionally, digital platforms such as weather forecasting apps and soil health monitoring tools enable farmers to make informed decisions, reducing risks and improving productivity. The integration of digital technologies into agriculture also facilitates traceability and transparency in supply chains, enhancing consumer trust and marketability of agricultural products. By 2025, an estimated 330 million young Africans will enter the labour market. Hence, there is a need to match youth unemployment with the enormous potential of African agriculture. Young people picture the druggery of farming and perceive agriculture as low income employment sector in recent years though. Digitalization and agriculture technologies have enhanced the way that food is produced. ICT-enabled agriculture is gradually changing the mindset of young people and creating young entrepreneurs who are willing to take risks and invest in agriculture.

Digital solutions and platform, such as smart-mobile applications, remote sensing technology, big data, digital soil maps, social media, blockchain, drones, precision technology and cloud based computing, have the tendency to not only increase food production and market efficiency, but also accelerate youth involvement in agriculture. Over the past years, private sector companies and donor agencies have become increasingly aware of the role that digital agriculture can play in driving agriculture, Mobile applications and low tech solutions have been developed by different stakeholders, including young entrepreneurs, to tackle issues related to production, input supply, finance, processing, logistics, and marketing. The key question is whether digital agriculture is enough to drive growth and ensure sustained youth involvement in agriculture.(Spore Magazine, 2019)

ICT (Information and Communication Technology)

ICT encompasses technologies used to communicate, store, and process information. In agriculture, ICT includes mobile phones, internet platforms, and geographic information systems (GIS). ICT has become a powerful tool for bridging information gaps and connecting farmers to markets, services, and knowledge resources.

ICT facilitates the dissemination of agricultural knowledge and connects farmers to markets and services. For example, mobile-based advisory services like *Esoko* in Ghana provide farmers with timely information on weather and market prices, improving decision-making (Aker, 2011). These services are particularly valuable in remote areas where access to traditional extension services is limited. Additionally, ICT platforms such as GIS and remote sensing technologies enable precision agriculture by providing detailed insights into soil conditions, crop health, and resource availability. By leveraging ICT, farmers can optimize input use, reduce waste, and increase profitability, contributing to sustainable agricultural development.

Review and Discussion

Farmers Indigenous Knowledge and Its Potentials

Farmers around the world have developed indigenous knowledge through the process of learning, experimenting observing, teaching and

communicating. The process according to Haverkort (1998) have been going on for ages and the existing farmers knowledge is therefore, the result of social experience and it is location specific. It is the response of the local population to environmental conditions, the geography, climate, soils, vegetation and wildlife in a particular environment gave rise to certain agricultural practice which enable the population to survive and develop in its area. Peasant agricultural practice therefore emerged as a result of this adaptation to and manipulation of the physical environment. Paradoxically this is the type of agricultural that has often been described as stagnant, and that impetus for change must emanate from indigenous education and new technology. Any innovation or technological breakthrough made by farmers on their own is thought to be accidental and to have developed unsystematically through trial and error (Akinbile *et al.,* 2004) much of growing literature, however, challenged this view of the passive, small scale producers in developing countries, Rhodes (1997) Argues that archaeological and historical records show a long string of important agricultural technological breakthrough made by farmers in traditional societies. Although their rapidity and diffusion might have been slower than innovation of modem research and extension. Recent work on sustainable agriculture according to Titilola and Marsden (1995) cited by Akinbile *et al.* (2004) Focuses on the utilization of fewer external inputs and on utilizing the traditional knowledge of farmers. This is on the assumption that their methods, having been tried and tested over generations, represent the best fit under circumstances which are often marginal. The high use of chemical fertilizers, pesticides and herbicides is causing concern for human health and the long-term sustainability of agricultural practice and the environment. It has been argued that indigenous knowledge is included in the research and extension development process. This is paramount as the local farmers have their own sophisticated ways of looking at the world. According to Olukosi (1998), crop farmers have different names for different kinds of plants and different type of disease, fertile and infertile lands, when we will rain start and end among others. Similarly, Livestock Farmers (both ruminant and non-ruminant) Know how to diagnose and treat different types of diseases and methods, which plant and grass are poisonous to livestock. The knowledge of local farmer' indigenous methodology and decision making system could help explain the non-adaption by small scale farmers of technologies and researches being pushed through extension services in such a way as to ensure sustainable agriculture development.

Ways of Harnessing Indigenous Knowledge

Agricultural knowledge research and extension emerged as activities which make up the agricultural knowledge system in many African countries (Haverkort, 1988). These institutions are interrelated in the way they engage in processes of use and transformation of agricultural Knowledge. They can complement or influence they ways in which the farmers deal with knowledge (innovation) generated in the research centers. Therefore, Farmers' interest in the most important to be considered in any research to be conducted in research centers. Ironically most of the researches and extension approaches have predominantly taken a paternalistic top down approach to agricultural development in which farmer is the last person to be consulted. The has been identified as the major cause for the failure of these approaches to address the problem facing resource poor, and risk avoiding peasant farmers. Involving local people as active partners in research and development processes will help in bringing the gap between development professionals on one side and the resource poor farmers on the other in finding new ways to access local knowledge strengthen local capacities and meet local needs. Hansen (2004) Recommended a change from the conventional approaches to agricultural research and extension where participatory dialogue with farmer should replace the scientist managed research and extension. This new approaches advocated by Hansen (2004) is founded on the principles of:

1. Optimizing productivity under given environment conditions using combination of science and indigenous technical knowledge and keeping the use of external input to a minimum.
2. Participation of stakeholder in research process ensuring that outcome will be adapted to specific environmental and socio-economic situation.
3. A holistic approach using intern disciplinary research to analyze cross cutting natural resource issues.

The technical aspect to the new approach is use of low external input whereas the social aspect is participatory approaches to technology development in consultation with relevant stakeholders. Agricultural problems are identified in participatory manner, relevant stake holders being identified in research process in dialogue with farmers scientist and extension personal. The four models of farmers participation as elucidated by Biggs (1989). These are:

i. Contractual
ii. Consultative
iii. Collaborative and
iv. Collegial models

The key feature that distinguishes the different models of farmers participation is the researcher's attitude towards the farmer. Farmers through, may not be trained in formal scientific methods, carry out experimentation in a systematic manner as part of their everyday production activities. These types of research minded farmers contribute to the stock of indigenous technical know-how in rural and are important source of technological innovation (Biggs, 1989).

The informal research and development system operate side by side with formal system within the political, economic institutional and agro-climatic context. Researchers' Views and attitude concerning existence and use of the indigenous knowledge influence the mode of research that is adopted.

Contractual model of participation for example, the farmers are contracted to work in the research centers with the researchers (as assistants) while they also contribute their little indigenous technical knowledge.

Under the consultative and collaborative models of participation, scientist recognize that farmers and other people in the rural environment have indigenous knowledge which are useful to the formal research system and this information is collected and utilized. Scientist recognize that indigenous knowledge changes as a result of existence and dynamic nature of informal research and development system.

With collegial model the farmers and scientist are two complementary stake-holders having complementary skills and knowledge and they both need to support and strengthen each other.

The model of farmer participation required for tapping indigenous knowledge should be those that recognized potential indigenous knowledge for agricultural development. Such participatory methods that ensure the active involvement of the target audience/Client in making decision that will affect them. This methodology span from the realization that the farmers are very knowledgeable about their practice and the environment.

i. Problems of Harnessing the indigenous knowledge among Farmers.

In a research conducted by Usman *et al.* (2015) they reported the problems that inhibit sharing and utilization of indigenous knowledge by the respondents as

Deforestation.

Most of the herbs used in prevention and treatment of livestock diseases are destroyed as a result of population increase which result to clearing of forest for housing, Farms and other human activities. Similarly, Martinez-Salas *et al.* (2008) revealed that natural habitat of many valuable plant were been lost to other land uses or been degraded as a result of population pressure.

Concealment of indigenous knowledge by the indigenous people. Mostly traditional people share the knowledge only to their trusted children.

Lack of co-ordination in documentation services is another challenge. There is no proper coordination mechanism in place in research institutes that could spell out the role of the different players, platforms for the best practices and lesson outcomes of the different approaches to be undertaken in documenting and disseminating indigenous knowledge. There is also lack of suitable equipment for documentation.

Cultural Barrier,

Memory Failure on the part of the resources persons as indigenous knowledge is orally passed from generation to generation, Particularly in most African societies, cultural practice such as requiring certain rites to be performed as a condition precedent to documentation. Intellectual Property right issues which might discourage full disclosure of indigenous knowledge.

The Potential of Digitalization

. Digital agriculture involves the use of digital tools and platforms to collect, analyze, and share agricultural data. This includes mobile apps, satellite imagery, and digital marketplaces. Digital agriculture leverages data-driven insights to optimize farming practices, improve decision-making, and enhance market access for farmers. digital adoption, and Information and Communication Technology (ICT) are interconnected concepts that play a pivotal role in modern agricultural development. These concepts are critical for enhancing productivity, improving livelihoods, and ensuring food security in a rapidly changing world. As global populations grow and environmental challenges intensify, the need for sustainable and efficient agricultural practices becomes increasingly urgent.

There is a popular assertion that on average, young people are smart, energetic, innovative and capable of integrating technology into their activities. These attributes are complementary to what digital agriculture can offer, enabling young people to transform agriculture in Africa from the palm of their hand. Across agricultural value chains, digital agriculture has proven to be a timely wat to attract youth into agriculture, but there is need to link youth involved in digital agriculture with substantial financial inclusion, investment support from both the private and public sectors, and tailored agricultural training. (Spore Magazine, 2018)

Dr Akinwunmi Adesina, president of the African Development Bank, emphasizes the potential of digital agricultural technology, such as digitally enabled agriculture, precision farming, hydroponics, robotics, and artificial intelligence, is expanding globally. The future farmers that is not physically engaged in agriculture. Theses farmers will take agriculture to the next level, a level shaped by innovation.

According to Dr Debisi Araba "prosperity approach needs to overtake a poverty reduction approach, to encourage young people into making a career in agribusiness. The future of Africa is not seeing more youth on the farm, but more youth at the top of the value chain pyramid where digital agriculture creates multiple entry points for young people looking to get involved in agribusiness

Conclusion and Recommendations

Conclusion

The integration of indigenous knowledge and digital technologies can synergistically address challenges such as food insecurity, climate change, and resource scarcity. By leveraging these tools and approaches, stakeholders can create a more sustainable and resilient agricultural sector. As the world continues to face unprecedented challenges, the role of these interconnected concepts in driving agricultural transformation cannot be overstated. Policymakers, researchers, and practitioners must work together to promote the adoption of innovative technologies, strengthen extension services, and harness the power of ICT to ensure a food-secure future for all.

Recommendations

The review recommends the integration of indigenous agricultural practice with modern research and innovation as well as digital technologies in the Nigeria agricultural sector. These will enable local communities to be integrated into other knowledge systems.

Establishment of a national agricultural research database /databank to enhance awareness, documentation, access and utilization of agricultural information and knowledge for overall national development.

Government should create enabling environment for a seamless integration of indigenous knowledge with digital technology

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