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Adoption of Advanced Agricultural Technologies in Tanzania: A Review

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Abstract

The adoption of advanced agricultural technologies in Tanzania is a crucial opportunity to enhance agricultural productivity and sustainability among smallholder farmers. The benefits of using these technologies include increased yields, reduction in environmental impact, and improved resource efficiency. This review synthesized existing literature to explore the current state of advanced agricultural technology adoption in Tanzania, highlighting both the successes and the barriers that hinder the broader implementation of the technologies. The research revealed that smallholder farmers in Tanzania have a low rate of adopting these technologies. The identified challenges that obstruct the adoption and effective use of advanced agricultural technologies include inadequate infrastructure, limited digital literacy, limited extension services, insufficient market access for their products, limited awareness, inadequate financial support, and trust among farmers. The study recommends the need for targeted policy interventions and collaborative efforts among stakeholders involved to foster a supportive environment for the uptake of advanced agricultural technologies, thereby fostering sustainable agricultural development in Tanzania.

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Introduction

Advanced agricultural technologies (AATs) refer to tools that can be used individually or together to achieve precision agriculture [1]. As these AATs are being applied, the data gathered tend to help farmers make decisions on watering rates of plants, tillage practices, number of seeds to be used, and fertilizers and pesticides to be applied [2]. They are thought to offer various advantages in agricultural production, potentially resulting in significant potential benefits. Also, reducing the use of pesticides, seeds, and fertilizers, enables farmers to enhance farm activities' efficiency which results in deductions on input expenses [3]. Additionally, using these technologies has potential benefits as it enables farmers to increase production with the use of fewer inputs [3]. Large-scale farmers and small-scale farmers using AATs protect the environment while at the same time increasing the amount of output they produce, and income earned after the sale of their products [4].

Indeed, technological innovations have significantly transformed the agricultural sector, offering the potential for sustainable farming, enhanced productivity, increased income [5], and some degree of environmental preservation [6-12]. These advancements encompass big data technologies and analytics, the Internet of Things (IoT), artificial intelligence, virtual reality, robotics, and augmented reality [11]. Robert et al. mentioned some of the advanced farming technologies that include proximal remote centers, variable-rate applicators, yield monitors, and others [13]. The agricultural production system leverages advanced agricultural technologies to collect and analyze data together with big data and machine learning, thus boosting output production and profitability for farming enterprises and the industry at large [10]. Nevertheless, according to Mushi et al., these technological advancements are not equally available to farmers globally [10]. Advanced technologies are predominantly utilized by a small number of large-scale farmers whereas many smallholder farmers still rely on outdated and inefficient tools and production techniques. Large-scale farmers often benefit from modern technologies, while smallholder farmers face several challenges including inadequate access to credit, poor infrastructure, and limited digital literacy [14].

Numerous scientists and organizations have adopted various strategies to empower smallholder farmers with digital technology to boost productivity and income [15]. These initiatives include creating mobile applications that enable and support farmers to acquire a range of services and resources including weather updates, agriculture knowledge, marketing information, and trustworthy buyers for their products [16]. Despite all the initiatives, ensuring their sustainability poses a considerable challenge for attaining sustainable agriculture. The advancement of smart farming differs across countries; however, the adoption rate of digital technology is a common problem, especially in developing nations [17, 18]. Thus, the usage and continuous application of advanced farming technologies is still narrow in Tanzania as well [19]. This resulted from insufficient knowledge making farmers in the country not fully utilize the available finite resources, techniques, and prospective market [20]. Therefore, this study sought to investigate the current status of AAT adoption in Tanzania, emphasizing the main challenges and opportunities for sustainable agriculture development.

Overview of Adoption of Precision Agricultural Technologies

Numerous governments and non-governmental organizations including the ones in Tanzania have created several advanced farming technologies. Tanzanian smallholder farmers have been helped by the government continuously [14]. Almost 94 active and inactive smart farming technologies have been reported in Tanzania [21]. During the 1960s, 16 National Agriculture Input Voucher Systems were launched by the government which aimed to support farmers in the purchase and utilization of advanced agricultural supplies and fertilizers from partnered agro-dealers, ultimately aimed to increase farm yields and farmers' earnings [22]. However, insufficient government oversight along with deception resulted in approved farm distributors selling agricultural supplies at fair retail prices which diminished the effectiveness of the program for farmers [23]. To further support the farming industry, numerous information communication technology (ICT) initiatives have been put in place to overcome the existing challenges. These efforts prioritize sharing vital agricultural information and expertise through agro-research institutions and outreach programs, ultimately benefiting individual farmers and farmer organizations [15, 16]. The growing use of smartphone technology has sparked the development of various programs that provide

mobile agricultural assistance to farmers, including initiatives like “Mobile for Development” (Global System for Mobile Association) initiatives and application software that cater to the needs of farmers across different stages of the agricultural distribution networks [16]. Tanzania is pioneering digital advancement, fueled by the pervasive presence of wireless communication systems that are readily available and increasingly accessible [8]. This increase in networked communications through intensive mobile phone and internet usage, along with active social media participation as portrayed by Kitole et al., is transforming trade and opening new avenues [8]. Therefore, empowering farmers with digital tools is a good strategy and valuable investment, as significantly enhances their earnings, boosts their livelihood, and strengthens food and nutritional security [8].

The Tanzanian government via the Ministry of Agriculture made a great step by presenting advanced farming technologies like an agricultural application called M-Kilimo, the farm information center, the agriculture trade management system, and the digital fertilizer subsidy distribution and payment system [10]. Also, the creation and establishment of a farmers’ electronic advisory service called “Ushauri’ which aimed at enabling farmers to acquire agricultural-based knowledge from agricultural experts, enhances proper and effective farm-field decisions for sustainable agriculture [24]. These platforms are designed to support farming operations and deliver agro-climatic data and weather information, ultimately enhancing farmers’ livelihoods [8]. On top of that, as portrayed by Kitole et al., availability of government assistance, education opportunities, and financial support are the main factors influencing the uptake of AATs [8]. This indicates that the availability of financing and agricultural support services for smallholder farmers plays a decisive role in the uptake of AATs. [10].

Furthermore, Mushi et al. explained that Tanzanian farmers with advanced education have a higher probability of embracing digital technologies [14]. Despite the potential benefits, barriers like deficient and substandard infrastructure, digital incompetence, and limited access to reliable market information persist [10, 25]. Existing digital services are insufficient for supporting the full range of a farmer’s needs and lack long-term viability, as some services are either discontinued due to a lack of sustainability planning or remain unused by farmers [10]. Persistent obstacles in obtaining services from other agricultural partners contribute to the low adoption rate at which Tanzanian smallholder farmers adopt new and advanced technologies [19]. These advanced farming technologies have not attained widespread use among smallholder farmers [26]. A combination of difficulties with issues surrounding unreliable weather forecasts, restricted access to market and price data, and deficient extension services have resulted in a low adoption rate with detrimental effects on farmers’ production and quality of life at large [8, 27]. Moreover, deficient and substandard infrastructure located in remote areas makes the situation worse because farmers are unable to apply the advanced technologies, and since farmers are not well knowledgeable about the technologies thus making, they discontinue using the technologies or do not apply them at all [14, 28].

Difficulties in the Adoption of Advanced Agricultural Technologies

The uptake of AATs encounters several obstacles during its application. These obstacles can be grouped into several categories social, political, and economic barriers. These obstacles or difficulties are explained below as portrayed in various corresponding studies. Kitole et al. and Mushi et al. explained that digital competence and advanced education level are among the main factors for the uptake of AATs for farmers to be in a good position to operate and manage the equipment and tools [8, 11]. Unfortunately, many Tanzania smallholder farmers have informal education and have insufficient knowledge of digital tools usage due to the fact that they have inadequate training programs tailored to their needs. Information security and privacy issues, and usage of AATs collectively combine large amounts of data including the data from the farm field, which brings about issues in data privacy and security to farmers. Because of data misuse fear and illegal access, smallholder farmers opt not to uptake the technologies as they are unaware and have trust issues until they see tangible results from other farmers.

Mushi et al. described the limitation of institutional capacity to support the uptake of AATs in Tanzania [11]. Moreover, he further described that the institutional capacity to support the adoption of AATs in Tanzania is limited. Many smallholder farmers in Tanzania fail to uptake the technologies as they cannot receive training and extension services due to challenges falling on the institution's side like

shortage of skilled agricultural experts, poor collaboration among private and public sector stakeholders, and insufficient funding for the research development programs. Besides, accessing markets for their products has been an obstruction too. The uptake rate of these technologies by farmers decreases due to insufficient market information and limited access to buyers, as they cannot see a clear and immediate connection between technology applications and better market opportunities [8].

Furthermore, rural areas are hindered by the inaccessibility of agricultural support. Smallholder farmers do not receive the required and timely extension services from the responsible agricultural experts located in their areas. This becomes a barrier to them as they do not get guidance on the use of AATs hence slowing down the uptake rate [8]. Also, inadequate financial support is among the difficulties encountered by farmers in the application of advanced farming techniques. Since usage of AATs requires high capital investment, smallholder farmers do not opt to use the technologies because the capital investment in their farms is limited hence making them rely on subsistence farming [29]. Similarly, Mushi et al. portrayed that effective utilization of AATs requires the ability to gather and analyze large amounts of data which many smallholder farmers in Tanzania are not in a position to manage and clarify this data, thus limiting the effective uptake of advance farming technologies [14]. The presence of insufficient and substandard transportation networks in village areas accelerates the slow uptake rate of these technologies. This makes supplies such as machines, fertilizers, and seeds not to be delivered on time for the effective application of AATs; hence this stands as an obstacle for proper utilization of the technologies [8, 29]. Consequently, multiple strategies are required to be undertaken to overcome these difficulties. Multiple strategies should include outreach programs for farmers, emphasizing awareness of the advanced technologies and trust among farmers, enhancing institutional capacity, financial support availability, and building and upgrading standard infrastructure. All stakeholders involved, including the government and non-government organizations, should work together to create a better environment for the uptake of AATs, ultimately enhancing farmers' productivity and farm earnings.

Conclusions

Uptake of AATs is the key as it enhances farm yields and sustainability in agriculture and strengthens nutritional security. Nevertheless, tackling the difficulties encountered to realize the benefits is crucial because the uptake rate is not widespread among farmers within the country. This review recommends financial support provision to farmers which should be prioritized and will enable them to get loans specifically for the investment in the use of these technologies. Hence this will accelerate the growth rate in terms of using advanced technologies. Additionally, investment in infrastructure, particularly in ICT infrastructure should be prioritized in rural areas to enable farmers to access essential services and markets thus facilitating effectiveness in utilizing AATs. Also, comprehensive training programs should be undertaken to improve farmers' digital literacy, hence enabling them to use AATs and make informed decisions. On top of that, the government should ensure that each village has adequate agricultural experts and enhance the quality of agricultural support and guidance to offer farmers with good services required for successfully adopting and implementing AATs with better results. The government can succeed in all this when there is a good collaboration with other stakeholders involved. Thus, the study recommends good cooperation among them hence ensuring that farmers benefit from these technologies. By addressing these challenges through the implementation of the mentioned recommendations, Tanzania can enhance the potential of AATs utilization to alter its agricultural sector thus, improving smallholder farmers' livelihoods and ensuring sustainable agricultural practice.

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Conflict of Interest

The authors do not have any conflict of interest to declare.

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