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Towards Sustainable Value Chain among Commercial Maize Farmers in Kenya: Leveraging on Technology

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Abstract

Maize farming plays a crucial role in Kenya's agricultural sector and the economy at large. However, commercial maize farmers often encounter challenges within the maize value chain that hinder productivity, profitability, and sustainability. This study aimed at evaluating the effect of technology adoption on value chain sustainability among commercial maize farmers in Kenya. The paper outlined research findings from external online desk review of studies that have focused on the analysis of the role of ICT functionality in maize value chain and in particular from the perspective of the farmers. Studies were obtained from online sources under the criteria that focused on the agricultural value chain, focusing the ones carried out from the year 2010 to 2023. The findings showed that technology driven solutions improve sustainability in the maize value chain. These technologies enable farmers, suppliers, and consumers to track the movement of maize products, verify their origin and quality, and ensure adherence to sustainability standards. The study findings also showed that the utilization of online marketplaces, mobile applications, and e-commerce platforms provide direct access to buyers, reducing the dependence on intermediaries and enabling farmers to negotiate fair prices. These platforms also facilitate efficient communication, streamlined transactions, and minimized transaction costs, contributing to improved value chain efficiency and profitability. It was concluded that technology adoption in the maize value chain significantly improves value chain sustainability. The utilization of specific technologies leads to reduced post-harvest losses, optimized inventory management, and strengthened farmer-buyer linkages. It was recommended that maize farmers should actively explore and adopt technology-driven solutions to enhance their productivity, profitability and sustainability. The Ministry of Agriculture should prioritize the development and implementation of technology transfer programs tailored to maize farmers.

Keywords: Sustainability, Value Chain, Commercial Maize Farmers, Technology

Introduction

For millions of farmers and their families, maize provides a basic food and a means of subsistence, playing a key role in Kenya's agricultural economy. Maize has a significant role in Kenyans' daily life due to its numerous uses in different dietary customs and culinary traditions (De Groote et al., 2020). The idea of "sustainable value chains" emphasizes the critical importance of incorporating social, environmental, and economic considerations into agricultural methods (Almeida et al., 2015). In the context of Kenyan maize value chains, achieving sustainability requires not just economic success but also the preservation of ecosystems and equal rewards for all stakeholders. Utilizing technology to increase productivity while reducing environmental footprints is part of sustainable strategies.

According to Yannou Le Bris (2021), food value chain (FVC) is the combination of all the stakeholders engaged in the coordinated production and value-adding activities and processes geared towards creation of food items. A sustainable food value chain is one that is efficient and profitable at all the operational stages, referring to economic sustainability. In addition, the chain must have a significant social benefits that bring about social sustainability and favorable or neutral effect on the environment hence environmental sustainability. Adopting technology that improve soil health, lower energy use, and foster better communication among value chain participants is necessary to achieve this.

According to Martinez and Rodriguez (2015), from the economic perspective, a value chain is said to be sustainable if the actions taken by each stakeholder are financially feasible for public services or commercially viable. Sustainability in the social perspectives define outcomes that are socially and culturally acceptable in relation to the allocation of benefits and costs associated with enhanced value production. Sustainability from an environmental perspective is based on the potential of value chain participants to produce either positive or neutral environmental effects as a result of their operations (Martinez et al. 2015).

The maize value chain in developed nations like the United States of America (USA) is distinguished by its large production volume, sophisticated farming practices and widespread application of biotechnology. Due to its vast agricultural area and cutting-edge techniques, the nation is a leader in the production of maize on a global scale. Higher yields, insect resistance, and a variety of uses besides food, like biofuel and industrial purposes, have been made possible by the widespread usage of genetically modified (GM) maize types. In order to manage resources effectively and boost productivity, precision agriculture techniques such as global positioning systems (GPS) equipment and data analytics are used (Chung et al., 2014).

The use of digital farm management systems (DFMS) has spread widely throughout the Brazilian maize value chain. These systems combine information from several sources such as weather forecasts, soil analysis, and crop monitoring to offer thorough analysis of different subsystems and advice the farmers. They support better resource management and efficiency by helping to regulate irrigation, apply inputs according to crop needs, monitor crop health and optimize planting schedules. The development of online marketplaces and platforms that link farmers, merchants, processors, and consumers has also been made possible by technology. These systems help farmers to find the greatest market prospects for their maize produce and give real-time market information. They also permit transparent transactions (Lopes & de Oliveira, 2017).

The creation and acceptance of farm management software designed with farmers' requirements in mind have accelerated in sub-Saharan Africa. These apps give farmers resources for crop planning, record-keeping, managing pests and diseases and learning about the market. The adoption of these technologies the continent is still at modest due to the region's high sensitivity to climate change that make maize production experience major difficulties. To boost maize value chain, technological advancements that support climate-smart agriculture are being introduced. These include modern technological instruments for weather predictions and seeds that can withstand drought. These technologies support farmers' long-term sustainability of maize production by enhancing resilience, reducing environmental impact, and assisting them in adapting to changing climatic conditions (Kruseman, Fogliano, & Linnemann 2018).

There a are a number of studies that have identified the challenges in Kenya's maize value chain. Kang'ethe, Korhonen, and Marimba (2017), claim that in Kenya, coordination among different parties involved in the maize value chain is highly fragmented. Inefficiencies, delays and poor decision-making result from ineffective communication and coordination between farmers, processors, distributors, and customers (Joutsjoki & Korhonen, 2021). Rutsaert and Donovan (2020), identified post-harvest losses as the major issue affecting maize value chain due to inefficient post-harvest procedures, insufficient storage facilities and pests resulting to up to 30% of maize crop wasted. This not only compromises food security but also causes farmers to lose a sizable amount of money. According to Hamrick, Gereffi, and Guinn (2016), this kind of information asymmetry reduces farmers' revenue and deters them from engaging in sustainable practices. To achieve improved effectiveness, efficiency, profitability and sustainability of Kenya's maize value chain, these issues must be resolved. Therefore, the purpose of this review study was to assess how technology adoption affected the sustainability of the value chain among commercial maize producers and to offer suggestions to Kenyan farmers and the government.

Theoretical framework

The Innovation Diffusion Theory which was proposed by Everett Rogers in 1962 served as the basis for this study. The hypothesis holds that people's adoption of a technology is influenced by how much they think utilizing it would improve their productivity and performance. If users believe a piece of technology will help them accomplish their objectives and solve their needs, they are more inclined to embrace and employ it. According to the hypothesis, attributes including relative advantage, compatibility, complexity, trainability and observability are crucial for innovation. The use of technology must be viewed to confer positive benefits and favorably by maize farmers and other stakeholders in the value chain in addition to being compatible with their current methods, simple to use and being capable of addressing difficulties they face today.

Literature review

Shrestha and Rai (2017) examined the relationship between technology adoption and the enhancement of sustainable value chains among commercial maize farmers in Nepal. A mixed-methods research approach was used that involved surveys and key informant interviews of Commercial maize growers from Nepal's Janakpur area. Twelve important informants were interviewed and a total of 321 commercial maize growers were surveyed. The survey data obtained was analyzed through descriptive statistics while the qualitative data was analyzed thematically. The study findings revealed that farmers who used mobile applications like Hamro Krishi and Krishi Guru for market information had a 30% decrease in post-harvest losses as a result of greater market access resulting to higher earnings. Further, the study showed that farmers who used precision farming methods reported an average 25% increase in maize output, which helped to boost productivity throughout the value chain.

Ndikubwimana and Habimana (2018) explored the role of digital platforms, specifically online trading in integrating the maize market for farmers in Nyaruguru district in Rwanda. A qualitative case study methodology that included document analysis and interviewing was adopted, where 15 farmers, 10 dealers and 5 platform representatives were involved. Data and paperwork from online trading platform were also examined. According to the study's findings, maize farmers who used the internet trade platforms AgroZee and ESOKO reported a 25% boost in market access since they could communicate with urban customers directly. By facilitating pricing transparency, these platforms allowed farmers to bargain for higher prices and lessen the influence of middlemen. Despite the benefits, issues with digital literacy and poor internet access in rural regions were shown to be obstacles to using online trading platforms effectively.

Mensah and Adu (2018) explored how technology adoption contributes to enhancing value chain sustainability among commercial maize farmers in Ghana. A mixed-methods approach was used, involving surveys and interviews. The study targeted commercial maize farmers in Volta region of Ghana. In the survey, 300 farmers took part, and 15 key informants were interviewed. The survey data was analyzed to generate descriptive statistics while the qualitative interview data was subjected to thematic analysis. The study's findings demonstrated that using mobile apps to access real-time market data decreased post-harvest losses. The mobile apps facilitated market accessibility, demand responsiveness and food waste reduction that are aligned with sustainable value chain. The implementation of technology was also shown to improve collaboration and communication amongst maize growers, processors, and distributors. The study also showed that the development of open lines of communication led to a reduction in disputes over pricing and quality, supporting a more stable and long-lasting value chain ecology.

Owusu (2019) examined the relationship between technology adoption and the enhancement of sustainable value chains among commercial wheat farmers in Ashanti region in Ghana. A mixed-methods research approach was employed and 57 wheat farmers participated in the study. For the survey, structured questionnaires were sent out, and interviews were held with key informants in the agriculture industry to glean more in-depth information. The study demonstrated that the deployment of mobile technology promoted cooperative networks and the growth of regional supply chains involving wheat growers, nearby mills and bakeries. A more environmentally friendly value chain resulted from the formation of these local supplier networks which significantly reduced emissions associated with transportation. Additionally, the study findings showed that the use of digital technologies facilitated information sharing among participants in the wheat value chain in regard to crop availability, processing capabilities, quality requirements and market needs.

Ogutu, Onditi and Mangine (2020) studied the effect of sustainable technology adoption on maize value chain enhancement in Uasin Gishu County in Kenya. Focus group discussions were used in this qualitative study to acquire data. Following a thematic analysis of the data, it was concluded that maize farmers had better negotiating power and profitability driven by the usage of mobile applications like Esoko, Ujuzi Kilimo, and Kilimo Salama for market information. Additionally, the study established that use of mobile applications that farmers access to buyers directly or provided knowledge about other market channels enabled them to find new customers and bargain for higher prices. According to the study, this decreased overreliance on middlemen, enabling the farmers to avoid additional expenditures related to middlemen.

Johnson (2019) did a study on assessing the impact of ICT adoption on financial and environmental sustainability in the sorghum value chain in Zambia. Semi-structured questionnaires and focus group discussions (FGDs) were used to collect both quantitative and qualitative data. The results of the analysis of variance (ANOVA) revealed that farmers who used information communication technology (ICT) platforms benefited from direct links between farmers and buyers which reduced the need for middlemen and allowed them to negotiate better prices for their maize produce, increasing profitability and improving financial sustainability throughout the value chain. It was also discovered that ICT platforms made it easier to employ precision agricultural practices such as applying inputs precisely according to the needs of the soil and the crops. As a result, sorghum growing produced less environmental contamination and used inputs more effectively.

Shianda and Phiri (2015) explored the role of technology adoption in promoting environmental sustainable value chains among maize farmers in Malawi. Data collecting methods included focus group discussions and field observations. According to the study, the use of agricultural chemicals such as pesticides among maize farmers decreased due to utilisation of mobile applications such as Plantix and PRISE for pest management and detection. This because crop productivity was maintained despite reducing chemical input due to real-time pest notifications and suggested actions. This aided in creating a value chain that was ecologically sustainable.

Hassan and Ali (2016) studied the role of digital platforms in enhancing economic sustainability of potato value chains in Egypt. Fifty-six (56) large scale maize farmers, 7 potato-traders and 2 potato processors were surveyed while 20 participants were interviewed. The study depicted a positive correlation between the usage of digital platforms and the sustainability of the value chain. According to the study, potato farmers utilized mobile applications such as Masherit, Bosta, and Nile Mart to get pricing data which improved their bargaining tactics resulting to higher revenues and access to new and existing markets. Additionally, traders and processors noted that the increased openness and fewer middlemen brought about a decrease in transaction costs as a result of mobile technology.

Kiprop and Mwangi (2016) conducted a study on producers' perceptions of modern technologies and their impact on economic and environmental sustainability of maize value chains in Bomet County, Kenya. The study targeted maize producers, including smallholder farmers and commercial producers in Bomet. Structured questionnaires were utilized for surveys and focus group discussions were used to gather qualitative insights. The study found that maize farmers had embraced weather forecasting applications that helped them make timely decisions about planting and harvesting decreasing losses and encouraging sustainable use of resources. Further the study showed that the farmers would prefer digital marketing and online trading platforms as an effective way of avoiding middlemen who were deemed to decrease profitability. A decrease in seed waste and a large increase in yield were also observed by farmers who used precision planting tools, improving economic sustainability. Additionally, businesses using GPS-guided tractors saw lower fuel and labor expenses, which helped them become more profitable.

Martinez and Rodriguez (2015) study sought to assess the eco-efficiency of precision agriculture technologies in enhancing the environmental sustainability of maize value chains in Argentina. Life cycle assessment (LCA) using cost-benefit analysis methods. Five processors and fifteen maize producers participated in the assessment by convenience sampling. The study found that the use of precision agricultural technology reduced chemical input and water use thus improving eco-efficiency. The study also revealed that the production, processing, and transportation-related carbon emissions were reduced at processors who used maize from precision agriculture farms. Additionally, the use of precision agricultural technology decreased fertilizer runoff and pesticide drift, decreasing their harmful effects on the environment and encouraging the use of sustainable practices.

Pereira and Rodgers (2018) explored how mobile technology enhances coordination within the maize value chain in Brazil. A quantitative research methodology that included surveys and network analysis was used for the study. The study's findings indicated that mobile technology has a favorable impact on the coordination of the maize value chain. With the use of mobile technology, traders and distributors were able to respond more quickly to market changes, increasing their profitability and sustainability. Additionally, it was shown that mobile technology improved the collaboration between farmers and processors in their planning, resulting in greater alignment and less supply-demand mismatches.

Tadesse and Woldegebriel (2020) conducted a study with an objective of finding out the relationship between modern technology adoption and farmer perceptions of maize value chain sustainability in Ethiopia. The study respondents were one hundred and two (102) maize farmers across different agro-ecological zones of Ethiopia. Quantitative data was collected using structured questionnaires and analyzed to obtain descriptive and inferential statistics for generalization. The study demonstrated that the adoption of contemporary production and marketing technology increased perceived climate variability resilience. It was also demonstrated that the adoption of modern technology improved resource use efficiency since farmers that used precision fertilization used less fertilizer, resulting in sustainable resource use and lessening of environmental effect. Furthermore, it was shown that e-commerce platforms increased farmers' access to markets thus improving the sustainability of the entire value chain.

Botha (2018) studied the impact of technology adoption on sustainable practices within the maize value chain in South Africa. The study adopted a mixed-methods approach involving surveys and case studies. Farmers, processors, and distributors in the maize value chain in South Africa were involved in the study. The findings showed that farmers adopted precision irrigation technology which led to reduction in water consumption, contributing to sustainable water resource management. This study also depicted that processors implemented modern post-harvest storage technologies which led to decreased gain losses. The study also showed a positive correlation between digital traceability platforms and value chain sustainability.

Methodology

This was a desk review that followed a systematic approach, conducting a comprehensive search across academic databases such as JSTOR, Science Direct, IEEE Xplore, Emerald Insight and ProQuest, including journals and conference proceedings. The paper outlined the findings of previous studies that examined and analyzed the role of ICT in maize value chain from the farmers' perspective. The Studies were obtained from online sources under the criteria that their focus was on technology and agricultural value chain from the year 2010 to 2023.

Summary of findings

From the reviewed studies, technology adoption, particularly the use of mobile apps for market information, was found to reduce post-harvest losses and improve market access for maize farmers (Shianda & Phiri, 2015; Shrestha & Rai, 2017; Mensah & Adu, 2018). Additionally, precision farming techniques led to increased maize yield and higher productivity along the value chain (Martinez & Rodriguez, 2015; Johnson, 2019; Tadesse & Woldegebriel, 2020; Botha 2018). Direct links between customers and maize producers were made possible by the internet trading platforms, increasing market access and raising prices (Johnson, 2019). In addition, post-harvest losses were decreased and demand responsiveness was increased as a consequence of the use of mobile apps for real-time market information (Shianda & Phiri, 2015; Mensah & Adu, 2018). The implementation of technology promoted collaboration and communication among distributors, processors and maize farmers resulting in more symbiotic and long-lasting value chain ecosystems (Yannou Le Bris, 2021; Kang'ethe, Korhonen & Marimba, 2017; Mensah & Adu, 2018).

According to the literature assessment, adoption of mobile technology supported the growth of regional supply chains, which reduced emissions linked to transportation and produced a value chain that was more environmentally friendly (Martinez et al.,2015). Stakeholders are able to communicate information on crop availability, processing capabilities, quality requirements, and market demands due to digital technologies. Digital platforms and applications specifically designed for the agricultural sector have emerged, providing stakeholders with dedicated channels for sharing information. These platforms often integrate features such as online marketplaces, where farmers can showcase their produce and processors can advertise their capabilities. Through these platforms, stakeholders can access comprehensive data on crop availability, processing capacities, and market demands, enabling them to make informed decisions and optimize resource allocation. Digital technologies have enhanced data collection and analysis capabilities, enabling stakeholders to gather and analyze information on a large scale. With the help of sensors, drones, and satellite imagery, farmers can monitor crop growth, detect diseases, and assess yield potential more accurately. Processors can analyze quality parameters and optimize processing techniques accordingly. Such data-driven insights empower stakeholders to align their offerings with market requirements, minimize wastage, and enhance overall efficiency.Moreover, the reviewed literature showed that maize farmers who used mobile apps for market information experienced improved bargaining power and profitability (Ogutu et al., 2020).

By connecting directly with buyers and bypassing intermediaries, farmers were able to negotiate better prices and reduce additional costs (Owusu, 2019; Shrestha & Rai, 2017). It was also found that the adoption of ICT platforms in the value chain enabled direct farmer-buyer linkages reducing the role of intermediaries and leading to increased profitability. ICT platforms also supported the adoption of precision agriculture techniques, resulting in more efficient use of inputs and minimized environmental pollution (Shianda & Phiri; 2015). It was also noted that the adoption of ICT platforms and digital tools facilitated collaboration and integration among stakeholders in the maize farming value chain.

Information and Communication Technology (ICT) platforms and digital tools have emerged as transformative catalysts, fostering seamless collaboration and integration among stakeholders within the maize farming value chain. These technological solutions play a pivotal role in overcoming geographical barriers and enhancing communication channels among farmers, suppliers, processors, and distributors. Through the utilization of platforms such as mobile applications, stakeholders can exchange real-time information on market trends, weather conditions, and crop management practices. This immediacy enables farmers to make informed decisions, adjust their strategies based on current data, and fosters a more cohesive and interconnected maize farming ecosystem (Mensah et al., 2018).

Findings Hassan et al. (2016) depicted that digital tools contribute significantly to the integration of stakeholders by streamlining supply chain processes within the maize farming value chain. With the advent of advanced technologies such as blockchain and cloud-based management systems, stakeholders can monitor and track the entire life cycle of maize production, from planting to distribution. This transparency enhances trust among participants and minimizes inefficiencies by reducing information asymmetry. For instance, farmers can utilize digital platforms to submit real-time updates on crop yields, enabling processors and distributors to plan their operations more effectively. This streamlined flow of information optimizes resource allocation, reduces waste, and ensures a more synchronized and efficient maize value chain.

According to the findings by Mensah et al. (2018), the integration facilitated by ICT platforms extends beyond operational efficiency to encompass collaborative efforts aimed at promoting sustainable practices in maize farming. Digital tools provide a space for stakeholders to share best practices, research findings, and innovations in sustainable agriculture. This collaborative exchange contributes to the dissemination of knowledge on eco-friendly farming methods, water conservation techniques, and soil health management. As a result, farmers, processors, and other actors within the value chain can collectively work towards implementing environmentally conscious practices. This collaborative approach not only enhances the overall sustainability of maize farming but also fosters a sense of shared responsibility and interconnectedness among stakeholders striving for a more resilient and environmentally friendly maize value chain.

Through sharing information on crop availability, processing capacities, quality standards and market demands, farmers, processors, and distributors could align their activities more effectively (Hassan et al., 2016). This collaboration reduced inefficiencies, improved coordination and enhanced the overall economic sustainability of the value chain.

Conclusion

From the review findings, it was concluded that technology adoption, including the use of mobile apps, online trading platforms and ICT tools has a significant positive impact on sustainable value chains in the maize farming sector. Technology adoption enhances market access, improves prices, reduces post-harvest losses, fosters collaboration among stakeholders and increases profitability. It was also concluded that precision agriculture techniques facilitated by technology adoption play a crucial role in promoting eco-friendly practices. Optimizing the use of resources such as water, fertilizers and pesticides. Additionally, precision agriculture helps reduce environmental pollution and carbon emissions along the maize farming value chain.

The study concluded that localized supply chains enabled by technology adoption, contribute to eco-friendly practices by reducing long-distance transportation and associated carbon emissions. These shorter supply chains also lead to fresher produce reaching the market, reducing food waste and enhancing sustainability. In addition, it was concluded that technology adoption improves economic sustainability by providing farmers with enhanced market access and price optimization. Direct connections with buyers through digital platforms empower farmers, reduce transaction costs and enable them to negotiate better prices leading to increased profitability and economic returns.

Recommendations

With reference to the study findings and conclusion, the following recommendations were made:

1. Maize farmers in Kenya should consider adopting precision agriculture techniques to optimize the use of resources and improve productivity. This will help in reducing input costs and minimize environmental impact.
2. Maize farmers in Kenya should utilize mobile apps and online platforms to stay informed about market demand, pricing trends and buyer preferences. This will enable them to make informed decisions about when and where to sell their maize, thus optimizing their returns.
3. Maize farmers should engage in training programs to enhance their digital literacy and knowledge of sustainable farming practices. This includes attending workshops, seminars and training sessions that provide information on precision agricultural techniques, conservation agriculture, soil health management and other eco-friendly practices.
4. The government should prioritize the development of digital technology and infrastructural facilities such as reliable connectivity to internet and mobile network coverage, particularly in rural areas where most maize farmers are located. This infrastructure is essential for enabling technology adoption and ensuring farmers' access to digital tools and platforms.
5. The Ministry of Agriculture should prioritize policies that promote technology adoption, sustainable farming practices and access to market information and finance for maize farmers.

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