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The Synergy Between Maize Productivity and Food Security Among Smallholder Farmers in Tanzania: Insights on Successes, Challenges, and Pathways Forward

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Abstract: *Maize (Zea mays) is the most widely grown crop among smallholder farmers in Tanzania, contributing significantly to both household food security and income generation. Accounting for 45% of the total caloric intake and cultivated by over 85% of rural households, maize plays a dual role in providing essential nutrients and as a key economic asset that facilitates the purchase of complementary food items. Despite its importance, the productivity of maize in Tanzania remains low, averaging 1.6 tons per hectare, far below the potential yield of 4-5 tons per hectare under optimal conditions. This paper critically reviews the synergies between maize productivity and food security among smallholder farmers by synthesizing findings from 59 peer-reviewed studies drawn from 1,100 English-language articles published between January 2000 and December 2022. By systematically analyzing these studies, the paper identifies: (i) successful strategies for improving maize productivity and their positive impacts on food security (what works), (ii) persistent challenges that hinder productivity growth (what doesn't work), and (iii) potential areas for further enhancing maize yields to address food insecurity (what could work). Drawing on the conservation and diffusion models, the analysis focuses on how the transfer of knowledge and adoption of innovative agricultural practices—such as the use of improved maize seeds, chemical fertilizers, pest and disease management, post-harvest storage improvements, and irrigation—can boost productivity and improve food security. However, the review reveals that despite the availability of these strategies, the adoption rate remains low, with only 30% of farmers consistently using high-yielding seeds and less than 20% applying adequate fertilizer, largely due to limited access to agricultural extension services and financial constraints. The paper problematizes the widespread reliance on rain-fed agriculture, which exacerbates vulnerability to climate variability, and highlights how systemic barriers—including poor infrastructure, limited market access, and insufficient government support—undermine the potential benefits of maize productivity interventions. The study concludes by emphasizing the need for context-specific, farmer-centered agricultural policies that prioritize capacity-building through tailored extension services, climate-resilient farming practices, and enhanced access to input markets. The findings underscore the urgency of addressing these structural challenges if Tanzania is to meet its national food security goals and improve rural livelihoods.*

Keywords: *Maize productivity, food security, smallholder farmers, agricultural innovations, Tanzania rural development*

1. Background Information

Agriculture has significantly contributed to Tanzania's economy and ensured food availability, with smallholder farmers estimated to have contributed approximately 70% to the country's food security (Reinke *et al.*, 2018). Among the primary crops cultivated in Tanzania, maize (*Zea mays*) emerged as the most widely produced and consumed by smallholder farmers (URT, 2010; Famine Early Warning System Network, 2018). In 2021, maize production reached about 3.9 million metric tons, yet the average yield remained low at 1.6 tons per hectare, compared to the potential of 4-5 tons per hectare under optimal conditions (FAOSTAT, 2022). This disparity highlights the need for interventions that can enhance productivity and food security among these farmers.

Historically, most smallholder farmers in Tanzania relied on rain-fed agriculture for maize production, which placed them in a precarious position, particularly during seasons of insufficient rainfall (Oestigaard, 2011; Olaniyi and Adewale, 2012). This reliance has perpetuated food insecurity, especially in rural areas where agriculture constitutes the

main economic activity. Food insecurity is evident when households fail to access enough and sufficient food throughout the year (Fawole *et al.,* 2015). A study indicated that over 30% of rural households faced food insecurity in 2019, underscoring the critical link between agricultural productivity and food availability (National Bureau of Statistics, 2019).

Empirical evidence suggested that smallholder maize producers could achieve food security if empowered with agricultural education and access to essential inputs (FAO, 2008). Several policies and programs have underscored the importance of agriculture in ensuring food security within the country. For instance, the National Agriculture Policy, revised in 2013, aimed to enhance productivity and achieve self-sufficiency in food production (Moshi, 2019). The policies emphasized improving land utilization and addressing gender inequalities related to land access. Moreover, the National Environmental Policy of 1997 aimed to conserve resources that support agricultural activities, while the National Irrigation Policy focused on ensuring water availability to enhance food security and reduce poverty (Moshi, 2019).

Given that smallholder farmers in Tanzania produce maize for both local consumption and export, improving maize production remains crucial for rural livelihoods. Studies indicated that income from maize sales allowed farmers to purchase other nutritious foods, such as vegetables and fruits, enhancing overall dietary diversity (Wilson and Lewis, 2015). Literature has defined food security as the physical, social, and economic access to sufficient and nutritious food throughout the year (Sunderland *et al.,* 2013; Ruel *et al.,* 2017). Individuals who fail to meet their nutritional needs face "hidden hunger," leading to non-communicable diseases (Sunderland *et al.,* 2013).

Moreover, improved maize production not only provided essential carbohydrates but also increased access to vital vitamins A and C, particularly when maize was consumed in its immature state (Olaniyi and Adewale, 2012). However, despite the recognized importance of maize, previous reviews focused predominantly on specific aspects of food security in Tanzania, such as urban agriculture (Poulsen *et al.,* 2015; Warren *et al.,* 2016; Armanda *et al.,* 2019) and climate change impacts (Ardnt *et al.,* 2012; Mkonda and He, 2018), while discussions specifically addressing the synergy between maize productivity and food security among smallholder farmers remained minimal.

In light of this gap, it became imperative to synthesize the discourse on maize productivity to ensure food security for smallholder farmers in Tanzania. This paper aimed to explore the strategies employed to improve maize productivity and the socio-economic challenges smallholder farmers faced in adopting these strategies. The article posited that increasing maize yields could contribute to improved household incomes and food security, given that higher maize yields have been theoretically hypothesized to reduce food insecurity in rural societies. The study measured maize yield by the quantity harvested per unit area, acknowledging that rural farmers often cultivate larger areas without a corresponding increase in productivity.

Ultimately, the article sought to provide pathways for enhancing maize productivity, identifying: (i) successful strategies for improving food security through maize productivity (what worked), (ii) persistent challenges faced by smallholder farmers in enhancing productivity (what did not work), and (iii) opportunities for significant contributions to smallholder maize productivity beyond observed limitations. The synthesis and insights were derived from a comprehensive review of recent literature, analysis of existing data, and long-standing field experiences observing the dynamics of change and productivity growth in Tanzanian agriculture.

2.0 Theoretical Framework

This section explored the models that framed the review process. Various models and theories directed the formulation of different strategies to improve agricultural productivity. Agricultural productivity was observed positively when farmers employed technology leading to high returns from their produce (Jayne *et al.,* 2021) and negatively when the returns in terms of harvest were low (Gollin, 2013). This review employed the conservation and diffusion models to pinpoint some strategies that guided the review process (Udemezue and Osegbue, 2018).

The conservation model focused on increasing complex, land- and labour-intensive cropping systems, the production and use of organic manures, and capital formation in the form of physical facilities to effectively utilize land and water resources (Stanojevic, 2021). In Tanzania, the Food and Agriculture Organization (FAO) reported that over 50% of smallholder farmers utilized traditional farming methods, which resulted in significantly lower yields compared to those using improved practices. For instance, farmers who adopted conservation agriculture practices reported yield increases of up to 30% (FAO, 2019).

On the other hand, the diffusion model emphasized the dissemination of knowledge and technical know-how in agricultural practices (Udemezue and Osegbue, 2018). Studies indicated that knowledge transfer, particularly through agricultural extension services, was crucial for improving maize productivity among smallholders. The 2021 Tanzania Agricultural Sector Performance Report showed that only 25% of smallholder farmers had access to extension services, highlighting a significant gap in knowledge dissemination. This lack of access limited farmers' ability to

adopt modern practices, thereby affecting food security outcomes.

Thus, the two models were concerned with creating awareness of various strategies to improve maize productivity and ensure food security. Specifically, the conservation model applied to agricultural forums where professionals, including extension officers, empowered smallholder farmers on good agricultural practices. In this review, the conservation model explored strategies for improving agricultural practices for maize producers, and the analysis aimed to understand its applicability in the Tanzanian context.

Concurrently, the diffusion model provided insights into the provision of agricultural knowledge on maize production and its adoption within the Tanzanian context. Technology adoption was evident in this study through the models mentioned. Jaleta *et al.* (2018) suggested empowering smallholder farmers by emphasizing the use of improved maize varieties, which yielded substantial benefits. Similarly, the adoption of technology in the form of new farming methods, improved fertilizers, and other agricultural inputs by smallholder farmers led to higher yields that contributed to food security (Kassie *et al.*, 2014; Gebre *et al.*, 2021).

These models were argued alongside Malthus's theory, which projected that the human population grew more rapidly than the food supply, leading to famine and food insecurity (Malthus, 1798). The review provided results that showed how the implementation of strategies from the mentioned models aimed to improve maize production and how these aligned or conflicted with Malthusian projections. Notably, the World Bank (2022) reported that food production in Tanzania had been increasing at a rate of 3.5% annually, which contradicted Malthus's assertion when viewed in the context of strategic agricultural interventions.

3.0 Methodology

The information for this paper was obtained through a systematic review, which involved categorizing, evaluating, interpreting, and comprehending cohort studies relevant to the topic of interest. This approach facilitated a thorough examination of the existing literature on strategies to enhance maize productivity while addressing the challenges associated with maize production. The methodology included a comprehensive search of pertinent scholarly articles across various academic search engines and databases, ensuring a robust selection of sources.

The databases searched encompassed Google Scholar, JSTOR, ProQuest, ResearchGate, ScienceDirect, and Scopus. These platforms were chosen for their extensive repositories of peer-reviewed articles, which are critical for conducting a systematic review. The search terms employed to locate relevant published documents included *"maize productivity and food security in Tanzania," "synergy between maize productivity and food security in Tanzania," "smallholder maize productivity and food security," "maize productivity in Tanzania," "influence of maize productivity on food security," and "challenges facing smallholder farmers to improve maize productivity."* By utilizing these targeted terms, the review aimed to capture a broad spectrum of insights related to maize productivity and food security in the Tanzanian context.

To maintain the review's focus, publications in languages other than English were excluded, ensuring consistency in comprehension and interpretation of the studies reviewed. The systematic search resulted in the identification of 1,100 relevant references pertaining to maize productivity and food security in Tanzania. From this pool, only 59 studies qualified for inclusion in the final analysis based on predefined criteria such as relevance, methodology, and quality of evidence. This selection process was crucial to ensure that the findings presented in this paper were grounded in reliable and valid research.

Figure 1 illustrates the literature review procedure, detailing the number of publications identified, excluded, selected, and included in the study. This visual representation not only enhances transparency in the review process but also underscores the rigor applied in curating the literature for analysis.

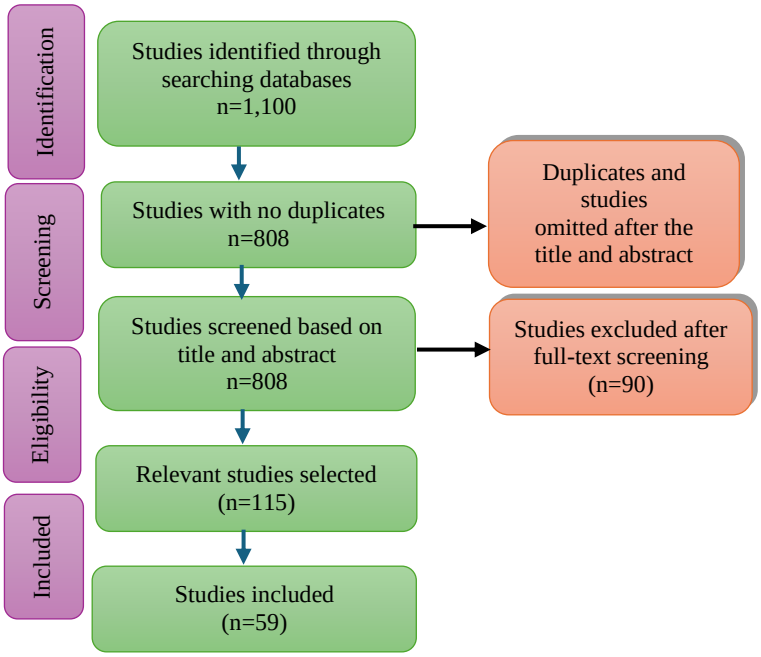

Figure 1: Procedure of literature review

The studies included in the review were critically assessed for their methodologies, findings, and implications. This included evaluating the effectiveness of various strategies employed to improve maize productivity, analyzing the persistence of challenges faced by smallholder farmers, and identifying potential pathways forward to enhance food

security. By synthesizing these insights, the review provided a comprehensive understanding of the synergies between maize productivity and food security in Tanzania, contributing to the existing body of knowledge and informing future agricultural policies.

4.0 Results and Discussion

This section presents and discusses the strategies to improve maize productivity, the socio-economic challenges faced by smallholder farmers, and the synergy between maize production and food security in Tanzania. The analysis integrates statistical data to support claims about awareness creation, the adoption of improved practices, and the effectiveness of various strategies for enhancing maize productivity among smallholder farmers.

4.1 Strategies to Improve Maize Production

The reviewed literature on maize production strategies is summarized in Table 1 below. These strategies focus on enhancing agricultural practices, adopting improved seed varieties, managing pests and diseases, and introducing irrigation systems. One prominent strategy, as highlighted by Baijukya *et al.* (2020), is intercropping maize with legumes, which has been shown to increase yields by 20-30% in some regions (Nassary *et al.*, 2020). In addition, the use of improved maize varieties such as drought-tolerant and pest-resistant seeds, as proposed by Kitinila *et al.* (1998) and further supported by the Tanzania Bureau of Standard (2021), can boost productivity by up to 40%, particularly in arid and semi-arid regions. They are aligned with theoretical frameworks such as the Conservation Model and the Diffusion of Innovations Model.

Table 1. Reviewed Strategies to Improve Maize Production

No.	Source (Author)	Strategies
1	Stanojevic (2021)	Complex land and labor-intensive cropping systems, organic manure, and capital formation
2	Udemezue & Osegbue (2018)	Dissemination of agricultural knowledge and technical know-how
3	Lymo *et al.* (2014)	Use of improved maize varieties, proper use of fertilizers
4	Kitinila *et al.* (1998)	Technological improvements in seed variety, planting techniques, and pest management
5	Volk *et al.* (2021)	Full and deficit irrigation systems
6	Tanzania Bureau of Standards (2021)	Use of high-quality seeds, pest and disease management, and irrigation
7	Baijukya *et al.* (2020)	Scientific procedures for land selection, intercropping, and crop rotation with legumes
8	Abass *et al.* (2014)	Pest management and use of appropriate storage techniques

The application of these strategies has led to various outcomes, discussed in the following subsections.

4.1.1 Awareness Creation on Maize Production in Tanzania

Awareness creation has been identified as a key driver in increasing maize production. The review of various studies (Table 2) shows significant gaps in the knowledge of smallholder farmers regarding critical agricultural practices. For instance, Magembe *et al.* (2016) found that 97% of farmers in Kilosa District were unaware of mold infection risks in stored maize, highlighting the need for improved post-harvest management training. Similarly, Monela (2014) observed that while 66% and 81% of households in Mbeya and Morogoro were aware of improved maize varieties, only 40.5% and 34.5% respectively, could access them due to financial and logistical constraints. This suggests a significant disparity between awareness and adoption, largely due to socio-economic constraints.

Statistical data from Matata *et al.* (2010) revealed that in Western Tanzania, farmers who were unaware of agricultural technology produced 20-30% less yield than those who applied modern farming techniques. These findings underline the importance of disseminating knowledge on proper land preparation, seed selection, fertilizer application, pest control, and storage techniques, all of which are critical for improving food security (Msuya *et al.*, 2008).

Table 2. Awareness of Maize Production Among Smallholder Farmers

No.	Author	Study Area	Findings
1	Magembe *et al.* (2016)	Kilosa District	97% of respondents were unaware of mold infections in stored maize
2	Monela (2014)	Mbeya and Morogoro Regions	66% and 81% of household heads were aware of improved maize seeds
3	Nassary *et al.* (2020)	Tanzania	Smallholder farmers lacked knowledge of intercropping
4	Msuya *et al.* (2008)	Tanzania	Low levels of education, poor extension services, and land fragmentation
5	Matata *et al.* (2010)	Western Tanzania	Limited awareness of agricultural technology

4.1.2. Challenges in Adopting Improved Maize Production Strategies

The adoption of improved maize production strategies is hindered by a range of socio-economic challenges. According to Lymo *et al.* (2014), high input costs, poor availability of improved seeds, and lack of extension services are among the most significant barriers. Misaki *et al.* (2017) found that food insecurity, lack of access to credit, and poor infrastructure further exacerbate these challenges. The cost of improved maize seeds and fertilizers has been cited as a major constraint, with over 60% of farmers in some regions reporting difficulty affording these inputs (Mukasa, 2018).

Studies have also shown that farmers with access to extension services and credit are more likely to adopt improved agricultural technologies. For example, Kaliba *et al.* (2015) reported a 45% increase in maize yields among farmers who had access to extension services, compared to those who did not. Additionally, Amare *et al.* (2011) found that access to credit significantly influenced the adoption of improved maize seeds, with farmers who secured loans being 33% more likely to invest in high-yielding varieties.

4.1.3. Impact of Irrigation and Fertilizer Use

Irrigation has been identified as a key factor in increasing maize yields in Tanzania. Volk *et al.* (2021) demonstrated that full and deficit irrigation could improve yields by 25-35%, particularly in water-scarce regions. Despite this, only 5% of smallholder farmers in Tanzania have access to irrigation facilities (Tanzania Bureau of Standard, 2021). This lack of infrastructure limits the potential for scaling up maize production, especially in drought-prone areas.

Fertilizer use is another critical factor influencing maize productivity. According to Di Falco *et al.* (2010), proper application of fertilizer can increase maize yields by up to 50%, yet many farmers are unable to access or afford fertilizers. The average maize yield in Tanzania is only 1.5 tons per hectare, compared to a potential yield of 4-5 tons per hectare with the proper use of fertilizer and improved seeds (Chete, 2021).

4.1.4 Socio-Economic Challenges in Maize Production

Smallholder farmers in Tanzania face numerous socio-economic challenges that limit their ability to adopt improved maize production techniques. These challenges are outlined in Table 3 below:

Table 3. Socio-Economic Challenges Facing Small-Scale Maize Producers

No.	Source (Author)	Challenges
1	Lymo *et al.* (2014)	Low produce prices, high input costs, pest and disease challenges
2	Misaki *et al.* (2017)	Food insecurity, lack of infrastructure, limited access to credit
3	Isaga (2018)	Lack of access to bank credit
4	Msuya *et al.* (2008)	Low education levels, land fragmentation, unavailability of inputs
5	Tefera (2012)	Post-harvest losses due to poor storage

The key socio-economic barriers faced by smallholder farmers include high input costs, limited access to financial services, and land fragmentation. The study by Misaki *et al.* (2017) highlighted that infrastructural challenges and inadequate access to reliable market information hinder farmers' ability to improve their production and access markets effectively. Moreover, post-harvest losses due to poor storage methods contribute to food insecurity, with estimates showing up to 36% of maize grains are lost (Tefera, 2012).

Analysis of household-level data shows a significant relationship between access to improved seeds and household food security. For instance, a logistic regression analysis by Monela (2014) found that households with access to improved maize seeds were 2.5 times more likely to achieve food security compared to those using traditional varieties ($p < 0.05$). However, only 35% of households reported having adequate access to these seeds, underscoring the need for improved distribution networks.

Table 4. Impact of Improved Maize Seed Adoption on Food Security (Monela, 2014)

Factor	Odds Ratio	p-value
Use of Improved Seeds	2.5	0.013
Access to Extension Services	1.8	0.027
Farm Size (above 2 hectares)	1.7	0.045
Use of Fertilizers	2.3	0.018

The findings demonstrate that improving access to extension services, increasing farm sizes, and promoting the use of fertilizers can enhance food security among smallholder farmers.

4.2 Pathways Forward: Enhancing Maize Productivity and Food Security in Tanzania

Addressing the interconnected challenges of maize productivity and food security in Tanzania requires a multifaceted approach, targeting both the agricultural sector and broader socioeconomic factors. Maize is a critical staple crop for millions of Tanzanians, and its productivity directly impacts food security, income generation, and national economic growth. Several key interventions are recommended to strengthen the synergy between maize production and food security, particularly among smallholder farmers, who are the backbone of the country's agricultural sector.

4.2.1 Improved Access to Agricultural Inputs

One of the primary barriers to increased maize productivity is the limited access to high-quality agricultural inputs such as improved seeds, fertilizers, and pesticides. Smallholder farmers, who produce the majority of the country’s maize, often struggle to access these essential resources due to high costs, inadequate supply chains, and limited market access. Research shows that the availability of improved maize seeds, which are drought-resistant and more productive, combined with the appropriate use of fertilizers and pest control measures, can significantly increase crop yields and enhance food security outcomes (Kaliba et al., 2015). However, ensuring that these inputs are both affordable and accessible to smallholder farmers remains a critical challenge. Policymakers need to work toward improving input distribution systems and providing subsidies or financial support programs that make these inputs available at lower costs, particularly for farmers in remote or resource-constrained areas. Addressing these barriers is essential for

empowering farmers to boost their yields and secure food supplies for both their households and the broader market.

4.2.2 Expansion of Irrigation Infrastructure

Another crucial intervention is the expansion of irrigation infrastructure, especially in regions prone to drought and erratic rainfall. Rain-fed agriculture is vulnerable to climate variability, which has become more pronounced in recent years due to climate change. Smallholder farmers, particularly in semi-arid and arid regions, face significant risks from prolonged dry spells, which can decimate crops and lead to food shortages. Investing in irrigation systems can help mitigate these risks and substantially increase maize productivity by providing a reliable water source during dry periods. Policymakers and development partners must prioritize the development of water management systems that are accessible to smallholder farmers and designed to be sustainable and efficient (Volk et al., 2021). Small-scale irrigation schemes, which require lower capital investment but deliver substantial productivity gains, should be scaled up across the country. Additionally, training farmers in efficient water use practices, such as drip irrigation, can help ensure that these systems are used effectively and sustainably. The expansion of irrigation infrastructure is crucial not only for increasing maize yields but also for building resilience against the growing impacts of climate change.

4.2.3 Strengthening Agricultural Extension Services

The role of agricultural extension services cannot be overstated in improving maize productivity and food security. Extension services provide smallholder farmers with access to critical knowledge and skills on modern farming practices, pest and disease management, and efficient use of inputs. However, the coverage and quality of extension services in Tanzania are often limited, particularly in rural and remote areas. Strengthening these services by increasing the number of extension workers, improving their training, and ensuring they are equipped with the necessary tools and resources is vital (Monela, 2014). Moreover, innovative approaches, such as using digital platforms and mobile technology, can expand the reach of extension services, allowing farmers to access timely information and advice even in hard-to-reach areas. Studies have shown that farmers who regularly engage with extension services are more likely to adopt improved farming practices, which leads to higher yields and enhanced food security (Msuya et al., 2008). Therefore, strengthening the capacity and reach of these services is crucial for empowering farmers to adopt innovations and improve their agricultural productivity.

4.2.4 Promotion of Financial Inclusion

Financial inclusion is another key factor that influences maize productivity and food security. Smallholder farmers often lack access to credit and financial services, which are critical for investing in agricultural inputs such as improved seeds, fertilizers, and irrigation systems. Without access to affordable financing options, many farmers are unable to make the necessary investments to improve their productivity. Promoting financial inclusion by expanding access to credit, microfinance, and agricultural insurance can help farmers manage risks and increase their investment in farming (Amare et al., 2011). Financial institutions and policymakers must work together to develop innovative financial products tailored to the needs of smallholder farmers, such as low-interest loans, savings schemes, and insurance products that protect against crop failure due to drought or other disasters. Additionally, promoting the use of mobile banking platforms can help extend financial services to rural farmers who may not have access to traditional banking infrastructure. By improving financial inclusion, smallholder farmers will be better positioned to invest in their farms, adopt new technologies, and improve their overall productivity and food security.

5.0 Conclusion and Recommendations

The study highlights the complex challenges and opportunities surrounding maize production and its role in ensuring food security for smallholder farmers in Tanzania. Key strategies for improving maize productivity include adopting improved seed varieties, expanding irrigation infrastructure, enhancing pest management practices, and increasing farmers' access to agricultural inputs and extension services. Despite the availability of these strategies, socio-economic barriers such as high input costs, limited access to credit, poor infrastructure, and inadequate extension services continue to hinder widespread adoption among smallholder farmers. The findings indicate that improving maize productivity is critical for addressing food security challenges, but this requires targeted interventions that address both the technical and socio-economic factors affecting maize production.

Increased awareness among farmers about modern agricultural techniques, combined with better access to improved inputs such as drought-tolerant and pest-resistant maize varieties, can significantly boost productivity. However, socio-economic constraints, including financial limitations, inadequate infrastructure, and the lack of accessible markets, present substantial hurdles. Additionally, the results underscore the importance of strengthening agricultural extension services to bridge knowledge gaps and promote the adoption of improved farming practices. Furthermore, expanding irrigation infrastructure and promoting financial inclusion are crucial to mitigating the risks posed by climate change and enhancing farmers' capacity to invest in sustainable agricultural practices.

Based on the findings, several recommendations are proposed to enhance maize productivity and food security

among smallholder farmers in Tanzania. First, policymakers should prioritize improving access to agricultural inputs by enhancing distribution networks for essential resources such as improved maize seeds, fertilizers, and pesticides. Implementing subsidies or financial support programs will help make these inputs more affordable, particularly for farmers in remote or economically constrained areas. Strengthening the supply chain and reducing input costs will empower smallholder farmers to adopt better agricultural practices and significantly increase their yields. Additionally, expanding irrigation infrastructure in drought-prone regions is crucial. Investments should focus on promoting small-scale, sustainable irrigation systems like drip irrigation to enhance water use efficiency, providing a reliable water source during dry periods and mitigating the risks associated with climate variability.

Moreover, strengthening agricultural extension services is vital for improving the coverage and quality of support provided to farmers. Increasing the number of trained extension workers and leveraging digital platforms and mobile technology can ensure that rural farmers receive timely advice on modern farming practices, pest management, and efficient input usage. Financial inclusion is another critical area; financial institutions should develop tailored products, such as low-interest loans and agricultural insurance schemes, to meet the specific needs of smallholder farmers. This will enable them to invest in improved inputs and irrigation systems while also helping mitigate risks associated with climate variability and crop failures. Furthermore, enhancing farmer training and awareness programs is essential to educate smallholder farmers about modern agricultural techniques and post-harvest management. Lastly, addressing infrastructural challenges through investments in rural road networks, storage facilities, and market information systems will improve market access, enabling farmers to sell their produce at fair prices and ultimately enhancing their income and food security. Implementing these recommendations will create a supportive environment for smallholder farmers, leading to increased maize productivity and contributing to national economic growth.

Declaration of Conflict of Interest

We declare that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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