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SWOT Analysis of Factors Influencing Maize Production in Rwanda

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***Abstract*: This study conducted a SWOT analysis to examine the internal and external factors influencing maize production in Rwanda and to formulate strategic development measures for the maize value chain. Maize is a key crop for Rwanda's food security and agribusiness. Although favorable climatic conditions and government support are present, the sector faces significant challenges such as limited access to modern agricultural technologies and high post-harvest losses. The research was carried out in Gatsibo District from September to November 2023, involving 300 maize farmers selected using the Yamane sampling formula. Data collection involved structured questionnaires, key informant interviews, and field observations. A four-stage SWOT analytical approach was used to identify strengths, weaknesses, opportunities, and threats affecting maize production. Findings revealed internal strengths such as a favorable climate and consistent government support, alongside weaknesses like technological gaps and critical post-harvest losses. External opportunities included regional export potential and possibilities for value addition, while major threats comprised climate variability and market price volatility. These insights highlight both key leverage points and structural challenges limiting productivity. The study provides practical evidence to guide policymakers and stakeholders in designing strategies to enhance maize production and ensure long-term food security in Rwanda.**

***Keywords*: Agricultural sustainability, Climate change, Food security, Maize production, Rwanda, SWOT analysis.**

1. Introduction

Maize is a critical staple crop in Rwanda, contributing significantly to food security and rural income [1]. However, its production faces various constraints such as post-harvest losses and limited access to modern farming inputs. A strategic assessment of these factors is essential to guide policy and investment decisions.

Furthermore, there is a growing domestic demand for maize, driven by rapid urbanization and population growth, which provides a stable market for smallholder farmers and energizes agribusiness activities throughout the value chain [2]. Maize also serves as an essential source of income for rural families, with surplus production sold at local and regional markets, thereby supporting household budgeting for necessities such as school fees and healthcare and contributing to the country's strategy for reducing rural poverty. The availability of fertile arable land, particularly in the Eastern Province, presents a significant benefit for the expansion of maize farming.

Moreover, strong government support policies, such as the Crop Intensification Program (CIP) and land consolidation schemes, have enhanced smallholders' access to quality inputs and extension services, positively impacting maize yields and reinforcing the maize value chain [3], [4]. Nevertheless, challenges persist.

Despite these inherent strengths and supportive policies, maize production in Rwanda faces significant challenges that impede its full potential. Smallholder farmers often face limited access to modern agricultural technologies, resulting in a reliance on traditional methods and a subsequent reduction in yield potential. High post-harvest losses in Rwanda, estimated at 32% in 2011 of maize production, are largely attributed to inadequate storage and drying methods, impacting both the quantity and quality of the crop [5].

In response, the Government of Rwanda launched the Post-Harvest Handling and Storage task force in 2010, leading to a reduction in losses to 16.4% by 2019 through improved farmer training and the distribution of modern storage technologies [6]. Fragmented landholdings pose a significant structural obstacle to modernization, hindering the adoption of mechanized farming and the realization of economies of scale. Additionally, farmers face limited access to formal financial services, restricting their ability to invest in essential agricultural inputs and advanced technologies. Underdeveloped rural infrastructure, including poor roads and insufficient storage facilities, contributes to high transportation costs and market constraints.

Furthermore, the high dependency on rain-fed agriculture makes maize cultivation highly susceptible to climate change and unpredictable weather patterns, such as delayed rains, prolonged dry spells, and flash floods, which severely impact yields and food security. Other external threats include soil degradation and erosion, competition from imported maize products, pests, and disease outbreaks (such as fall armyworm and MLN), as well as market price volatility for maize [7].

Addressing these multifaceted internal weaknesses and external threats while leveraging existing strengths and opportunities is crucial for enhancing maize productivity and ensuring agricultural sustainability in Rwanda. Therefore, this research aims to provide a comprehensive understanding of the

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factors influencing maize production performance in the country.

The primary objective of this study is to conduct a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of maize production in Rwanda, drawing on information from maize growers, extension officers, and traders. Specifically, the study aims to identify the key internal factors (strengths and weaknesses) and external factors (opportunities and threats) that influence maize production and, subsequently, to formulate strategic measures for the development of the maize value chain. The research was conducted in Gatsibo District, Eastern Province, Rwanda, between September and November 2023, utilizing structured interviews, key informant interviews, and field observations from a sample of 300 maize growers.

The findings of this study are expected to offer deep insights into the current state of Rwanda's maize production industry. By categorizing and analyzing internal and external factors, this research will identify leverage points and structural constraints, providing actionable strategies to enhance maize productivity. Ultimately, this research aims to support agricultural policymakers, researchers, and development organizations in providing the necessary resources, such as targeted extension services, inclusive policies, and improved access to modern inputs and markets, to facilitate a significant and sustainable transformation in maize farming practices across Rwanda.

2. Materials and Methods

Study Area and Population: The research, conducted with thoroughness and precision between September and November 2023, was carried out in Gatsibo District, the Eastern Province of Rwanda. The selection of sectors was purposively based on four sectors, including Kabarore, Gitoki, Kiramuruzi, and Rwimbogo. This selection was guided by the results of the Fifth Population and Housing Census of the year 2022, which identified them as the major maize-producing sectors with a high number of smallholder farmers operating in them [8].

Sampling and Respondents: The represented population or sample was composed of maize growers in these sectors. The number of samples collected in the study was 300 because of the Yamane formula (1967). This formula was adopted since it offers a simplified and statistically valid approach to calculating sample size when the population is known, as it makes it representative[9]. The authors decided to obtain a sample that was both manageable and statistically reliable; therefore, the best compromise option was to use a 95% confidence level with a 5% margin of error.

The sample was given homogenously: Kabarore (102), Rwimbogo (83), Gitoki (58), and Kiramuruzi (57) were selected through simple random sampling. To ensure the depth and thoroughness of our study, we used key informant interviews among extension officers and traders to supplement data collected on the farmers.

Data Collection Techniques: Structured interviews were used to give quantitative and qualitative data on the practices in farming, challenges, and areas of development. Key informant interviews and field observations were adopted as well.

Variables Examined: Respondent characteristics, internal factors (strengths, weaknesses), external factors (opportunities, threats), and strategies for maize value chain development.

Analytical Approach: The primary analysis was SWOT, following five stages adapted from Yuan [10]

1. Preliminary Assessment: Reviewed the current state of maize farming using literature and secondary sources.
2. Questionnaire Development: Created structured questions to assess SWOT components.
3. Field Survey: Conducted interviews and visits for primary data collection.
4. SWOT Analysis: Identified internal and external factors influencing maize production.
5. Strategic Formulation: Developed strategies to leverage strengths and opportunities, address weaknesses, and mitigate threats.

Secondary Data Sources: The information was collected from the Rwanda Land Management and Use Authority (www.lands.rw), the MINAGRI, and the NISR. Other details were taken from scientific articles, international reports, and government publications, which were critically analyzed to group the policies, institutional frameworks, and structural variables that influenced maize production.

SWOT Model Justification: The SWOT matrix was used due to its effectiveness in assessing internal and external factors influencing the sector performance, which is convenient in policy analysis [11]. Data were categorized as: Strengths and Weaknesses: Internal factors specific to Rwanda's maize system, and Opportunities and Threats: External factors like climate, market conditions, and policies. The data were analyzed to determine leverage points, structural constraints, as well as strategic measures to enhance maize productivity.

3. Results and Discussion

The table below summarizes the key demographic attributes of the 300 maize farmers who participated in the survey conducted in Gatsibo District.

The majority of the maize farmers who were surveyed in Gatsibo District are at the highest productivity age. 48.0% of the population is aged 26-30, 33.3% is 31-35, and 16.7 % is 21-25. The age group below 20 years comprises only 2.0 % of the respondents. This is an advancing demographic of a young and fresh breed of people, meaning that most farmers should be physically available and inspired to embrace some innovative farming techniques and technologies, which have the potential to revolutionize the farming sector.

With gender distribution, the farming population is skewed towards the male population, with 73.3% of the respondents taking a top position and females at the bottom with 26.7%. Such a gender disparity is indicative of conventional values and property structure. Nevertheless, it emphasizes the necessity and the urgency of enhancing the involvement of women in maize-growing programs and decision-making. It is not only about increasing the incomes of women but about harnessing a substantial part of the population to support the expansion of the agricultural sector.

Table 1
Demographic characteristics of farmers

Categories	Variables	Respondents (n)	Percentage (%)
Age	Less than 20	6	2.0
	21-25	50	16.7
	26-30	144	48.0
	31-35	100	33.3
Gender	Male	220	73.3
	Female	80	26.7
Education level	None Education	20	6.7
	Primary Education	54	18.0
	Secondary Education	202	67.3
	University Education	24	8.0
Years' Experience	Less than 1 Year	16	5.3
	1-3 Years	88	29.3
	3-5 Years	154	51.3
	Above 5 Years	42	14.0
Sector	Kabarore	102	34.0
	Rwimbogo	83	27.7
	Gitoki	58	19.3
	Kiramuruzi	57	19.0

Regarding education levels, most (67.3%) of the respondents have acquired secondary education, which can assist in constructing and adopting better farming methods. There are also 18.0 % who have attended and finished primary education, 8.0% who have tertiary education, and 6.7% who are uneducated. This good educational status at secondary levels gives those farmers a sound footing to embrace extension services, digital technologies, and value-added farming activities, demonstrating their adaptability to new methods and technologies.

There is also a significant farming experience among farmers. More than half (51.3%) have at least 3 to 5 years of experience with maize farming, whereas 29.3% have between 1 and 3 years. The remaining 14.0% are experienced, having already achieved more than 5 years of agriculture, and barely 5.3% are below a year of experience. These numbers reveal that most respondents have gained practical field experience, instilling confidence in their ability to handle production issues and implement better practices.

Lastly, the geographic coverage of the respondents is good in the selected sectors. The highest percentage of the respondents falls to the Kabarore sector (34.0%), Rwimbogo (27.7%), Gitoki (19.3%), and Kiramuruzi (19.0%). This wide picture of the sector distribution gives a moderate view on how the benefits of maize farming practices vary in different locations in Gatsibo District.

Overall, the socioeconomic attributes of the maize farmers in the survey are promising. They are a younger, well-educated, and experienced farming community, making them ideal candidates for agricultural transformation. With the proper support, such as the selective extension services, inclusive policies, and improved access to modern inputs and markets that you, as agricultural policymakers, researchers, and development organizations, could provide, the potential for a significant shift in maize farming practices is within reach.

The following section discusses the internal and external factors influencing maize production, structured through a SWOT analysis.

The analytical results give us a deeper understanding of the state of the economy of the maize production industry in Rwanda. The findings are listed in four categories: Strengths, Weaknesses, Opportunities, and Threats. The Strengths section presents the key advantages of supporting government policy to enhance maize production in Rwanda.

A. Internal Factors

1) Strengths

1. Favorable Climate Conditions: The climatic conditions of Rwanda are characterized by moderate and stable rainfall patterns and comparatively warm temperatures that jointly offer desirable agroecological conditions for the growth of maize during most of the year [12]. It has two rainy seasons: September to December (Season A) and March to May (Season B), and therefore, two maize planting seasons

Table 2
SWOT matrix of maize production in Rwanda

Strengths	Weaknesses
1. Favorable Climate conditions	1. Technological Access Gaps Among Smallholders
2. Expanding Domestic Demand for Maize	2. Critical Postharvest Management Challenges
3. Embedded Indigenous Agricultural Knowledge	3. Land Fragmentation Limiting Mechanization
4. Crucial Livelihood Source for Rural Households	4. Financial Inclusion Barriers
5. Strategic Access to Arable Land	5. Inadequate Rural Infrastructure and Market Access
6. Robust Institutional and Policy Support	6. Reliance on Rain-Fed Systems and Climate Exposure
Opportunities	**Threats**
1. Regional Export Potential	1. Climate Variability and Weather Extremes
2. Productivity Enhancement Leverage	2. Ongoing Soil Erosion and Land Degradation
3. Agro-industrial Value Addition	3. Import-Driven Market Competition
4. Formalization of Contract Farming Models	4. Pest and Pathogen Pressure (e.g., FAW, MLN)
5. Climate Risk Mitigation via Crop Insurance	5. Unstable Maize Market Prices and Revenue Fluctuations
6. Public-Private Investment in Agricultural R&D	
7. Land Resource Optimization	

could be done each year. These two seasons have been observed to be the primary catalyst for rising maize yields and food supply in rural and urban settings. It is emphasized by previous research conducted by Abegunde et al. [13], stated that positive weather condition lowers the possibility of total crop loss and enable smallholder farmers to plan the production cycle more safely. Besides, the fact that maize can be cultivated twice annually is essential in providing household food security all year round. Therefore, this has been aligned with national policies that support the idea of cereal self-sufficiency. Additionally, Rwanda's stable climatic conditions are natural capital and strategic regarding maize cultivation, growth, and sustainability [14], [15].

2. Expanding Domestic Demand for Maize: Domestic maize consumption in Rwanda has experienced a high growth rate due to fast urbanization and population increases. According to Rwamigabo [16] found that there has been a gradual growth in the quantity of maize consumed in the country, especially in the urban centers where it is consumed in flours, animal feeds, and brewing of beer. The expected significant demand will offer a stable market to the smallholder farmers, which will increase their pay and ensure more agricultural output. In another hand, the increasing urban demand for maize intensifies the rural-urban market interconnection and energizes all agribusiness activities throughout the value chain [17]. In addition, national policies focusing on the commercialization of staple crops by the government only add to this trend, which provides the government with policy back-up to expand its maize market. Rural economic transformation and agricultural development in Rwanda are, therefore, heavily fueled by the rising demand for maize generated by the country itself.
3. Embedded Indigenous Agricultural Knowledge: The maize production in Rwanda has been highly intact in generations of knowledge, and most smallholder farmers inherit the agricultural techniques of their parents and grandparents. It serves as a storehouse of traditional skills such as the selection of seeds, planting timing, and soil preparation. There are also methods of handling some pests based on local agroecological situations. According to research conducted by Danso-Abbeam et al. [18] showed that local practices have been deemed highly important and still form the basis of farming decisions in most rural societies. The established knowledge not only helps achieve relatively stable production of maize but also forms a solid basis for implementing better technologies and sustainable agricultural innovations. On the other hand, several studies showed that the scientific method of local wisdom in farming increases the success of extension to agriculture [19], [20]. Thus, the conventional grass-roots foundation in efficient farming provides an essential resource to boost productivity, adoption of technology, and resilience in maize production systems in Rwanda.
4. Crucial Livelihood Source for Rural Households: Maize production is an essential source of income for a significant percentage of rural-based families in Rwanda. Over and above the domestic consumption of maize by households, an excess can be sold at local and regional markets, a significant source of cash revenue for farmers. According to Nyirakanani et al. [21], Maize is one of the three cash crops that produce the most income for smallholder farmers, especially in high-yielding districts like Gatsibo and Nyagatare. These earnings can be instrumental in meeting the budgeting needs of the family, such as school fees, health, and agricultural inputs, which facilitate economic strength. Furthermore, the cultivation of maize contributes to rural development in more agricultural terms as it provokes a positive effect on employment in the value chain, including all stages, such as production, processing, and marketing. Thus, food security is mainly a pillar of household revenue and a primary tool in the country's strategy of reducing rural poverty [22].
5. Strategic Access to Arable Land: The physical geography of Rwanda provides an outstanding benefit to maize farmers, especially in areas like the Eastern Province, which has a vast supply of fertile and sloping land. The survey of agronomic land suitability has identified these regions as high-potential areas in terms of the production of maize because of their good soil texture, PH, and drainage properties [23]. Such arable land is a significant opening in maize farming without interfering with the production of other staple foods or threatening environmental sustainability. Additionally, Adequate land-use planning and climate-smart agricultural activities could balance the climate-smart agricultural needs and increase land productivity [15]. Moreover, land consolidation programs, which the government has facilitated, have ensured that smallholder farmers have free access and can effectively utilize the proper land portions. Therefore, the availability of fertile soils is one of the strategic advantages of increasing maize production in Rwanda.
6. Robust Institutional and Policy Support: The Rwandan government has been at the forefront of facilitating the production of maize with various scheduled agricultural policies and programs. These include the Crop Intensification Program (CIP), which, together with schemes of input subsidies and programs in land consolidation, has dramatically enhanced the capacity of smallholders to find quality seeds, fertilizers, and extension services. According to Bucagu et al. [23], Noted that the interventions have recorded positive improvements in the yield of maize, especially in places where the programs have had regular and coordinated implementation. The production cost has

decreased because of the availability of subsidized inputs, and the farming land has been consolidated, making the farming land more efficiently utilized and mechanized. Additionally, agricultural cooperatives and market facilitation programs have reinforced the maize value chain [24]. Due to this, Rwanda's policy environment is the friendliest towards cereal production, so government intervention is pivotal in enhancing productivity and increasing farmers' income in the maize sector.

2) Weaknesses

1. Technological Access Gaps Among Smallholders: Although the interventions by the government have increased the productivity of maize in certain parts, modern technologies in agriculture have not been equitable in Rwanda, especially for smallholder farmers in distant parts. Although adopting hybrid seeds, small-scale planters, and digital advisory services have been proven valuable, most rural farmers still use traditional hand tools and low-input techniques. Research conducted by Murindangabo et al. [25] found that a wide barrier to implementing modern technologies as they are costly and limited in local markets, as well as poor technical training. This technological gap's efficiency is inhibited and does not allow the farmers to extract their yield potential in high-potential zones. In addition, there is poor access to innovations like mobile-based weather forecasting and market information systems, which have undermined decision-making and farm management activities. Consequently, the lack of accessibility to modern tools blocks productivity and efficiency and makes Rwanda's maize sector unsustainable and uncompetitive in the long run [26].
2. Critical Postharvest Management Challenges: The post-harvest is undoubtedly a central potential area of improvement in the Rwandan maize chain, with farmer producers losing approximately 20-30% of their crop to improper storage and other drying methods [27]. The majority of the smallholder farmers depend on conventional practices like sun drying maize on the bare soil and keeping the grain in primitive silos, making it vulnerable to pests, moisture, and mould contamination. Additionally, the practice has significantly impacted the quantities and quality of stored maize, resulting in economic costs and low levels of food access at the household level [28]. Besides reducing marketable volumes, post-harvesting practices have adverse effects, such as poor food safety and nutrition. It is all aggravated by the absence of locally available storage facilities like hermetic bags or better granaries. It is essential to focus part of the efforts on targeting post-harvest losses to improve farmers' profitability and stabilize food production and overall resilience of the Rwandan maize production system.
3. Land Fragmentation Limiting Mechanization: Land fragmentation is another issue and a big structural obstacle to the modernization of maize farming in Rwanda. The majority of smallholder farmers cultivated land below 1 ha; some areas are distributed in different non-contiguous places [29]. This division into smaller pieces hinders the execution of the practice of mechanized farming, like the application of tractors or planters that are more effective in bigger, smoother fields. It also corresponds to an obstruction to economies of scale, a restriction to some private investment, and difficulty developing infrastructure, including irrigation and transport systems. Consequently, it has been common to see farmers resort to labor-intensive farming, narrowing productivity and consuming more time and resources. The research conducted by Hakorimana & Akcaoz [30] found that inefficiencies caused by dispersed landholdings also diminish the efficiency of extension services and agricultural input distribution. Therefore, it is essential to reduce land fragmentation by carrying out more land consolidation programs to facilitate the use of high-yield, high-technology maize farming practices in Rwanda.
4. Financial Inclusion Barriers: The possession of formal financial services is still a significant limitation to smallholder maize farmers in Rwanda. Although demand for agricultural credit and savings products has increased in Rwanda, many farmers, especially smallholders, remain excluded from the formal financial market due to high interest rates, stringent loan conditions, and insufficient collateral requirements imposed by financial institutions [31]. The fact is that the enrolment of rural farmers in the network of formal financial firms and microfinance organizations is still at a relatively low level, and often, the rural farmer has to resort to informal funding and lending channels that provide limited capital. Such financial marginalization would affect the capacity of farmers to make investments in required agri-inputs like seeds, fertilizers, mechanized equipment, and better sucking technologies. Therefore, productivity increases would be limited, and the chances of commercialization decrease. A lack of customized financial products for small-scale agriculture under development. To realize the full potential of Rwanda's maize farming sector and achieve sustainable livelihoods in the countryside, inclusive and agriculture-friendly financial services need to be increased.
5. Inadequate Rural Infrastructure and Market Access: The lack of good infrastructure in rural areas poses a consistent challenge to the smooth operation of Rwanda's maize value chain. Several maize-producing regions, especially far-flung districts, have poor roads, lack transport facilities, and have insufficient storage and processing plants. According to Ngango & Hong [32], noted that, infrastructure gaps

also significantly add to the cost and time in the transportation of maize between farms and markets, lowering farmers' profit margins and putting off potential buyers. Additionally, farmers in rural areas struggle to access agri-inputs due to the absence of feeder roads, and during the harvesting period, transportation of production, particularly rainy season still a problem, thus resulting in post-harvest losses. These market constraints limit the accessibility to the market and limit competitiveness by smallholder maize farmers [33]. Specifically, public investment in enhancing infrastructure in rural areas is essential to ensuring efficiency in the market, increasing farmer income, and improving the general development in Rwanda.

6. Reliance on Rain-Fed Systems and Climate Exposure: Maize cultivation in Rwanda is also primarily based on rain-fed farming and, hence, is very susceptible to fluctuating climate and changing weather patterns. Large numbers of smallholders don't have irrigation facilities, so the actual performance of crops is more or less dependent upon seasonal rains. Additionally, research noted that postharvest losses for cereals are estimated to range between 16% and 22% in 2024 due to delays in accessing inputs and climate change [34]. Food security and income are destroyed because of this high dependency, which risks production. Moreover, a lack of adequate facilities limits the flexibility of planting and efficiency of input utilization, especially when using fertilizers that need appropriate moisture to absorb well [35]. The availability of reliable resources further restricts the adaptation of better agricultural technologies associated with good growing conditions. It necessitates expanding small-scale irrigation schemes and encouraging water-efficient agricultural activities to enhance resilience and have more stable yields of maize production.

B. External Factors

1) Opportunities

1. Regional Export Potential: Rwanda has a significant potential to increase the export of maize in the region, especially to neighboring countries like the Democratic Republic of Congo and Burundi, where demand for maize has consistently exceeded local production. Maize could become an export crop of economic significance with the help of enhanced quality assurance systems, better post-harvest management, and the strategic regional trade agreements [27], [36]. This potential also creates opportunities for technological advancements in maize farming and export, attracting tech-savvy investors and stakeholders. However, Rwanda's favourable climate and two annual growing seasons present an opportunity to produce maize efficiently and generate consistent surpluses. In addition, the attempts by the government to legalize cross-border trade and establish organized markets provide a solution to a couple of surplus-generating regions and gad markets with considerable demands. Increasing maize exports would not only generate additional revenue for the smallholder farmers but would also help Rwanda achieve its broader objectives of export diversification and agricultural commercialization, thus boosting the resilience of the rural economy and contributing to the sustainability of the national food system.
2. Productivity Enhancement Leverage: The agriculture sector, particularly the maize sub-sector in Rwanda, holds significant potential for further productivity improvements, largely because many farmers still rely on traditional cultivation methods. Additionally, the leading institution in agricultural development plays a crucial role in promoting modern agricultural practices such as high seed variety or balanced fertilizer application, integrated pest management, and practical training programs [37]. The modern technology appreciably benefits extensions in terms of access to them and practical training programs, which result in a remarkable influence on the intake of modern technologies. Moreover, the positive effect of enhanced practices is enhanced by the fact that the climate in Rwanda and the state of its soil are beneficial, as explained earlier. Consequently, scaling up agricultural extension and support has presented a strategic window to enhance maize productivity and decrease the level of food insecurity, as well as the livelihoods of farmers across the country.
3. Agro-industrial Value Addition: Value-added maize processing offers a good opportunity to boost farmers' incomes and improve rural economies in Rwanda. Farmers and cooperatives can earn a larger share of the market and escape speculative grain prices by processing raw maize into flour, cooking oil, animal feed, and starch-based products. Research fundings argued that small-scale maize processing enterprises increase profitability, generate local jobs, and reduce post-harvest losses due to the possibility of using perishable grain promptly [38]. It goes a long way, especially in rural regions with limited formal employment and restricted market access. In addition, minimizing intermediaries with an orientation on local processing enables the producers to enhance their value chain. The agro-processing infrastructure needs to be developed to increase the maize sector's contribution to rural economic diversification and development based on the land consolidation and extension service programs developed by the government.
4. Formalization of Contract Farming Models: Contract farming is an excellent chance to enhance the maize sector in Rwanda by making the associations between the buyers and producers formal through contracts. The model has many advantages, such as stable prices,

secured market access, and availability of inputs or technical guidance from contracting companies [39]. Additionally, the farmers under contract farming arrangements are subjected to higher incomes and larger options to implement advanced farming techniques, owing to the aid that buyers offer. With such arrangements, farmers acquire better control over the production cycles since the risks posed by market prices and after-harvest losses diminish, making farmers plan their production. In addition, contract farming conforms to the national policies geared towards transforming smallholder farmers into market-based farming. Contract farming can be used as an expandable instrument to enhance productivity, income predictability, and general chain performance within the maize sector of Rwanda when combined with government programs like the Crop Intensification Program and cooperative strengthening programs.

5. Climate Risk Mitigation via Crop Insurance: Enhancing the climate resilience of smallholder maize farmers using crop insurance in Rwanda is a strategically introduced approach. The government supports these schemes through private insurance providers, thus providing a much-needed security net to the farmer in case they lose their yield [40]. This not only protects their investment but also instills a sense of confidence, encouraging them to invest more in the enhanced input and practice. However, despite the current low levels of adoption, increasing insurance coverage can play a critical role in providing farmers with the confidence and risk tolerance necessary to invest in improved agricultural practices and technologies. Crop insurance can become an essential component of Rwanda's safer and more prosperous maize sector when implemented alongside other interventions, including contract farming, input subsidies, and extension services.
6. Public-Private Investment in Agricultural R&D: Constant investment in agricultural research and development (R&D) presents an important window of opportunity to improve the sustainability and productivity of the Rwanda maize industry. It is not an individual initiative but a joint venture that involves government organizations and other international organizations such as Alliance for a Green Revolution in Africa (AGRA), and the surrounding community [41]. These efforts are being made to provide scientific solutions to Serious problems like soil fertility decline resulting from nutrient depletion, pest epidemics, and unpredictable weather. The use of drought-tolerant and pest-resistant maize seeds is already in production and being distributed in different regions, and it has already shown promising results. The development of the adaptive capacity of smallholder farmers will be further enhanced due to the support of R&D based on traditional knowledge and favorable climatic conditions [42]. The extension of the current innovation through the services and public-private partnerships may achieve a massive turnaround in the level of maize production and achieve the long-term sustainability of agricultural regimes in Rwanda.
7. Land Resource Optimization: The Eastern Province of Rwanda has considerable quantities of arable land that have not been well utilized and, therefore, could be developed to increase the production of maize. Eastern province has arable land that is agroecologically suitable for maize cultivation [39]. Notably, the suitability of land resources indicates that agricultural expansion is possible in these areas without encroaching on protected forests and key ecosystems. Combined with land use planning and conservation agriculture, this could significantly increase maize production in the Eastern Province as well as across the country. The possibility of increased maize production in the Eastern Province should serve as a source of hope for all stakeholders as it is likely to create new employment opportunities, reduce underemployment, and enhance food security. This optimism is also reinforced by the fact that government initiatives such as land consolidation, irrigation development, and mechanization can aid the promising future of agriculture in the Eastern Province.

2) Threats

1. Climate Variability and Weather Extremes: Maize production in Rwanda is facing an increasing and serious risk brought about by climate change, which is mainly caused by the growing incidence of unpredictable weather, where rain is delayed rain, prolonged dry spells, and flash floods. Maize is particularly sensitive to changes in temperatures and rainfall, such that even slight weather fluctuations during the growth period can lead to a drastic drop in yields. As reported by Uwimbabazi et al. [43], Farmers of several districts have complained of changed timing of planting and increased rates of agricultural failure due to unpredictable weather patterns. These patterns reduce food security and make maize farming less attractive. Rwanda has not yet successfully invested in applying climate-resilient solutions like drought-tolerant seed, conservation farming, and small-scale irrigation. This makes the maize sector quite vulnerable. According to Okolie et al. [44], Noted that climate-smart methods and national extension services play a significant role in building resilience and sustaining productivity in maize production as climate patterns increasingly fluctuate.
2. Ongoing Soil Erosion and Land Degradation: The topography of Rwanda, which is characterized by hilly terrains and intense uses of land, has predisposed soil degradation, and soil erosion continues to pose a serious challenge to agricultural productivity. Additionally, the high rate of population increases and

the practice of cultivating such lands regularly have significantly depleted the nutrients and lost a lot of topsoil, especially in areas with large concentrations of maize crops [45]. This environmental challenge requires an immediate investment in sustainable land management practices like terracing, agroforestry, cover cropping, and mulching. These techniques not only improve soil fertility and reduce erosion but also have the potential to increase crop yields and, consequently, improve farmers' incomes. According to Mosier et al. [46]. Their findings of the study reinforce earlier evidence that combining traditional knowledge with soil restoration methods has the potential to enhance soil quality and achieve long-term land productivity. Until more vigorous soil conservation efforts are implemented, Rwanda's potential to expand maize production and significantly increase yields over the long term will remain greatly limited.

3. Import-Driven Market Competition: The imported cheap maize products from the countries in the region, especially Uganda and Tanzania, are a key threat to Rwanda's competitiveness in terms of domestic maize. Foreign maize grain and flour sometimes sell at low prices because of the economies of scale and better processing facilities of the countries exporting these products. According to Weatherspoon et al. [47], Noted that the price difference has resulted in lower demand for locally produced maize, thereby making Rwandan farmers sell at a lower profit or being locked out of the market. This pattern undermines farmers' profitability and discourages investment in maize farming and value addition. Domestic producers could continue to be vulnerable in the absence of these strategic protection measures, including seasonal restriction of imports, implementation of quality standards, and support of local agro-processing. Increased product quality and traceability through training and certification programs of farmers would also contribute to the Rwandan maize competing better in both local and regional markets and, hence, protecting livelihoods and national food sovereignty.
4. Pest and Pathogen Pressure (e.g., FAW, MLN): Pest and disease outbreaks pose a growing threat to maize production, and even conditions that would typically support high yields have recently resulted in significant losses due to infestations. According to Tambo et al. [48], The simultaneous presence of fall armyworm and MLN poses a dual threat to maize production in Rwanda. The situation is compounded by farmers having fewer opportunities to have timely pest diagnosis, cheap pest control products, and extension services. However, farmers play a crucial role in the solution; once they are trained on Integrated Pest Management (IPM), they could be oriented to react swiftly and successfully, especially at low farm levels. With Rwanda's initiative to maximize maize production, the risk of pest and disease outbreaks is likely to increase unless mitigation strategies are strengthened [49]. It is, therefore, essential to strengthen pest monitoring mechanisms, increase the education of farmers, and subsidize the use of bio-safe pest control tools to safeguard production and attain food security.
5. Unstable Maize Market Prices and Revenue Fluctuations: Fluctuations in the maize market prices pose a constant risk to farmers' incomes and structural investment in maize production in Rwanda. Excess supply, inadequate storage facilities, and exposure to unorganized markets often force smallholder farmers to sell their maize immediately after harvest, when prices are lowest, due to a lack of proper post-harvest storage options. According to Ngango & Hong [32], noted that instability affected the profitability, discouraging farmers from designing yield-enhancing technologies or increasing production, which is especially evident among institutional buyers. The urgency and importance of addressing such threats are underscored by the need for greater market connections. The development of the warehouse receipt system and the emphasis on minimum price guarantees or strategic grain reserves are crucial steps in this direction. The development of the price stabilization measures would guard farmers against shock, increase income, and enhance a stronger and more appealing maize value chain in the broader Rwanda agriculture sector.

4. Conclusion

This study successfully conducted a comprehensive SWOT analysis of maize production in Rwanda, clearly addressing its primary objective to evaluate the feasibility of establishing a modern, sustainable, and competitive maize production system. Key strengths such as a favorable dual-season climate, rising domestic demand, fertile land in the Eastern Province, and strong government support provide a solid foundation for sectoral advancement. However, the analysis also exposed critical weaknesses, including limited access to modern technology, fragmented landholdings, high post-harvest losses,16.4%, inadequate rural infrastructure, and a heavy reliance on rain-fed systems. These internal constraints must be addressed to realize productivity gains.

Externally, the research identified promising opportunities like export potential, contract farming models, value-added maize enterprises, and increased agricultural R&D investment. Simultaneously, substantial threats to climate variability, soil degradation, pest and disease pressures (e.g., fall armyworm, MLN), import competition, and market volatility pose serious risks to both production stability and farmers' livelihoods.

The synthesis of these findings reveals specific leverage points: enhancing mechanization, improving post-harvest handling, strengthening rural finance and infrastructure, promoting insurance schemes, and boosting agro-processing capabilities. To translate potential into performance, future

interventions must integrate these insights, aligning them with farmer skill levels and institutional capacities.

While this study reveals a coherent pathway for transforming Rwanda's maize sector, it is limited by its geographical focus (Gatsibo District) and its cross-sectional design. Longitudinal studies in other agro-ecological zones, economic modeling of proposed interventions, and evaluation of climate-resilience technologies are recommended for future research.

This research contributes original and actionable evidence that can inform policymakers, agribusiness stakeholders, and development agencies. By strategically leveraging strengths and opportunities while addressing identified constraints and external threats, Rwanda can advance toward a more productive, sustainable, and inclusive maize production system, ultimately bolstering food security and rural prosperity.

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