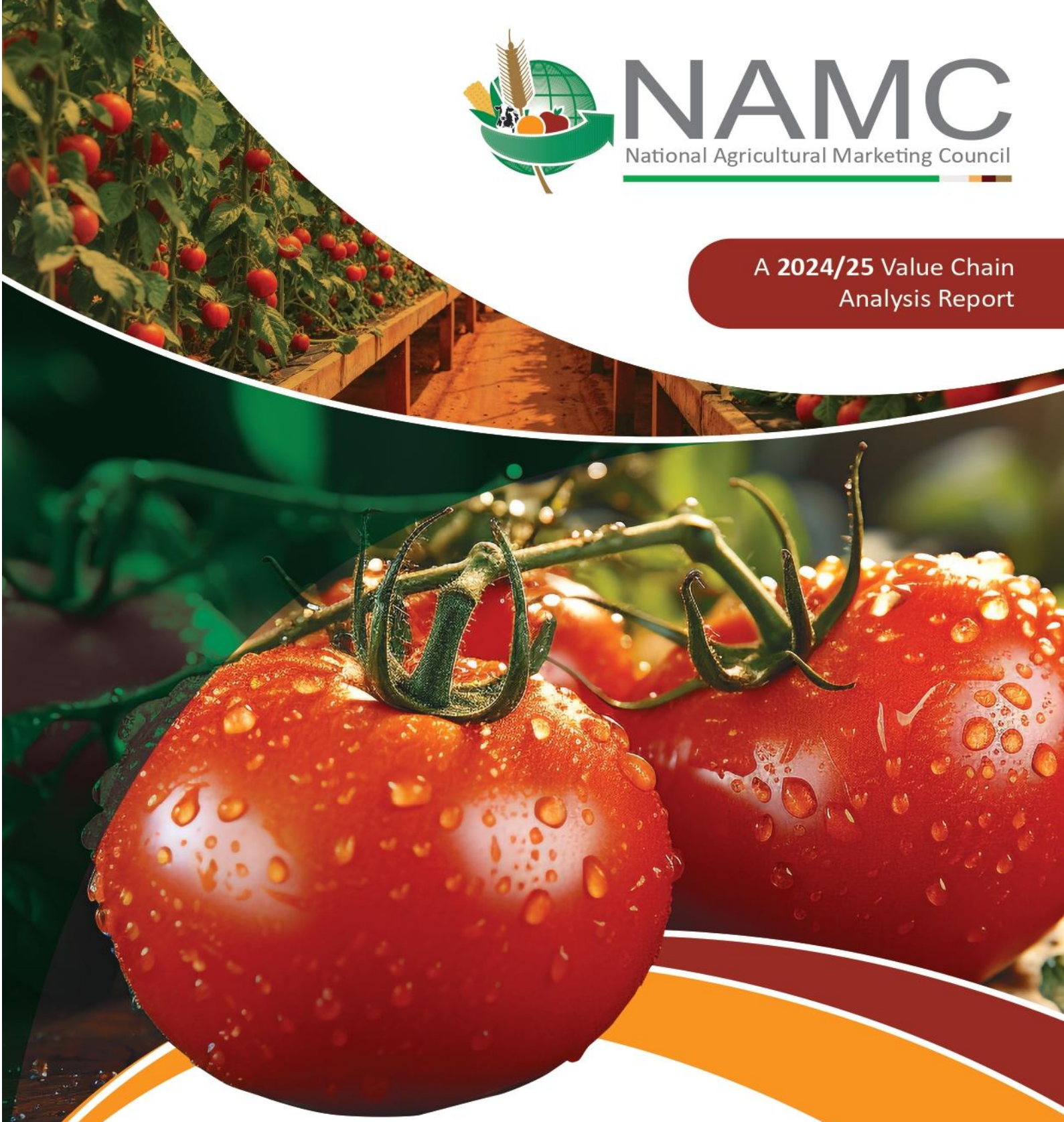
NAMC
National Agricultural Marketing Council

A **2024/25** Value Chain Analysis Report



Sustainable tomato production for smallholder farmers in South Africa

2030 NDP

30 YEARS OF FREEDOM

Executive summary

Despite the importance of tomatoes in South Africa, and the various tomato cultivars suitable for farming, the tomato industry is currently experiencing many challenges. Thus, this study's purpose was to scrutinize primary tomato production, a basis upon which further development of the value chain can be anchored while promoting the use of sustainable farming practices. Emphasis was put on unpacking the challenges hampering the production of tomatoes, a basis upon which practical recommendations through which to address some challenges are proposed. This work is a follow-up on the 2024 desktop study which recommended further scrutiny into production systems used by tomato farmers. Specifically, the study's aims are:

- To identify factors influencing farmers' choice of tomato cultivars to grow in South Africa.
- To comprehensively understand the challenges faced by small-scale tomato farmers in South Africa
- To describe smallholder market access estimates for the top-traded vegetables in 2024
- To identify the different sustainable farming techniques used in tomato production among small-scale farmers in South Africa.

The report is structured as follows: the first section provides the introduction, motivation, and objectives. Section 2 provides insights into relevant literature on various aspects including cultivars commonly produced in South Africa, factors influencing farmers' choice of cultivars, and challenges faced by tomato producers. Section 3 provides the methodology while the results are presented and discussed in section 4. Conclusions and recommendations are provided in Sections 5 and 6, respectively. Study limitations and areas for future research are provided in section 7.

KEY FINDINGS:

Factors influencing farmers' choice of tomato cultivars to grow in South Africa. According to the study, several factors influence tomato producers to grow various tomato varieties in South Africa. The factors include high yield, disease resistance, drought tolerance, and production costs. The results indicated that the majority of farmers (39%) who participated in the study reported high yield as the influencing factor to produce tomatoes commercially, followed by a cultivar's disease resistance (25%), drought tolerance (9.09%), and the associated production costs (2.27%). In terms of other factors farmers (46%) indicated that market prices and preferences have a moderate influence on cultivar selection, 32% of farmers expressed that the cost and availability of seeds have a moderate impact on the cultivar chosen, and tomato cultivars perceived to have the highest market demand and consumer preference in South Africa. Cherry tomatoes were the single most identified cultivar by 16% of growers to have the highest market demand and consumer preference, Collectively, 75% of the farmers indicated that all the other cultivars including Fi-Hybrid, Renka, GEM, Round tomato, and MONET also have high market demand and consumer preference.

Challenges faced by small-scale tomato farmers in South Africa

Identified challenges encountered are broadly categorized into two, namely environmental and economic challenges. Environment-related challenges are both biotic and abiotic. Biotic challenges entail pests and diseases, including Tutor absoluta, aphids, and the whitefly, among others. Manifestation of biotic challenges is exacerbated by abiotic challenges such as drought, and water shortages. On the other hand, more than 60% reckoned that the high cost of inputs was the major economic challenge factor, followed by barriers to market entry.

Smallholder market access estimates for the top-traded vegetables in 2024

The results indicate that tomatoes rank third among the top ten fresh produce markets, after potatoes and onions which contribute 46.9% and 18.0% of the total volume, respectively. Tomatoes account for 10.7% of the total volume of vegetables traded in the

top ten fresh produce markets, highlighting their importance to smallholder farmers. The aggregated Smallholder Market Access Estimates (SMAE) revenue for the top ten traded vegetables amounts to R4.4 billion of which tomatoes account for 17.0%. Therefore, smallholder tomato farmers have a strong market presence and significant income opportunities in the fresh produce sector.

Sustainable farming techniques

In a bid to sustain tomato production, farmers use various practices, including integrated pest management, organic farming, crop rotation, and cover cropping. A majority of the farmers (59.09%) who participated in the study use crop rotation, followed by organic farming practices. A small proportion of the farmers use integrated pest management and cover crop practices.

KEY RECOMMENDATIONS:

The following key recommendations are made based on the results of the study;

- ✓ It is recommended that smallholder farmers explore the use of preharvest bagging. The technology not only significantly reduces production costs coupled with the associated environmental attributes, it is documented to improve the quality of tomatoes. Preharvest bagging enhances a microclimate suitable for uniform ripening, increased dry matter content, and no sunburns and blemishes, while accelerating maturity, among other quality aspects. Preharvest bagging is very important since in most cases smallholder farmers' fruits hardly meet the high market quality standards, thereby being discriminated out of the formal market structure.
- ✓ It is further recommended to use biodegradable starch-based polymers since their development might be an alternative solution for reducing the use of plastics and the associated environmental problems. Biodegradable bags completely decompose within a reasonably short period (up to 5 years). A combination of cassava starch and polybutylene succinate provides a biodegradable material.

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Abbreviations

Agbiz	Agricultural Business Chamber of South Africa
ARC	Agricultural Research Council
CAGR	Compound Annual Growth Rate
DAFF	Department of Agriculture, Fisheries and Forestry
DALRRD	Department of Agriculture, Land Reform and Rural Development
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KZNDARD	KwaZulu Natal Department of Agriculture and Rural Development
NAMC	National Agricultural Marketing Council
NFPM	National Fresh Produce Market
SACN	South African Cities Network
SMAE	Smallholder Market Access Estimates
TIPS	Trade & Industrial Policy Strategies
US	United States

1. Introduction

Globally, the tomato industry is a key subsector where both commercial and smallholder farmers play a vital role in supporting agriculture and the broader economy (Arah et al., 2015). As one of the most widely cultivated vegetables worldwide, tomatoes rank second in production after potatoes (Dube et al., 2020; Kumar et al., 2020). In Sub-Saharan Africa, tomatoes are an important cash crop, contributing significantly to household incomes and food security (Fufa et al., 2009; Arah et al., 2015). Their versatility in culinary applications further enhances their economic value, as they can be consumed fresh in salads or prepared in various forms, including sautéed, fried, or sun-dried. Additionally, tomatoes are widely used in processed products such as jam, chutney, tomato sauce, canned tomatoes, and sun-dried tomatoes, which drive demand in both local and global markets (Tomato News, 2024). The industry also benefits from the availability of diverse tomato varieties, including fresh market cultivars, processing/canning cultivars, dual-purpose cultivars, and cherry tomatoes, each catering to different consumer preferences and processing needs (Agricultural Research Council, n.d).

The global production of tomatoes was estimated at approximately 182.05 million tons in 2021, with Africa contributing 11.8% of this total (Mohan et al., 2023; Olowe et al., 2022). In South Africa, tomatoes are the second most produced vegetable after potatoes, with an estimated production of 502,069 tons, followed by onions (Udoka et al., 2021; Food and Agriculture Organization of the United Nations, 2022). However, tomato production in South Africa has declined, dropping from 599 306 tons in 2020 to 464 563 tons in 2022 (Food and Agriculture Organization of the United Nations, 2022). Both commercial and smallholder farmers cultivate tomatoes across all provinces in South Africa, with Limpopo being the largest producing region, covering approximately 3 590 hectares (Department of Agriculture, Forestry and Fisheries (DAFF), 2019). Despite its agricultural significance, revenue from South Africa's tomato exports has been decreasing. Data from Trade Map indicates that export revenue declined from US$8.67 million in 2021 to US$4.96 million in 2022 and further to US$4.76 million in 2023.

Beyond its economic value, tomatoes contribute to addressing public health concerns in South Africa. Vitamin A deficiency has been identified as a major health issue (Harika et al., 2017), and tomatoes serve as an important dietary source of essential vitamins, including vitamins A, B, and C (Buthelezi *et al*., 2021; Malherbe & Marais, 2015; World Health Organization, 2004; Dam et al., 2005). This highlights the crop's significance not only in agriculture and trade but also in nutrition and public health.

Furthermore, the South African economy is currently faced with various socio-economic challenges such as the high unemployment rate of 31.9% (Stats SA, 2025), high levels of household food insecurity especially in rural areas (Simelane et al., 2023), declining Gross Domestic Product (GDP) and low income per capita (Taylor and Yu, 2009; Bayat et al., 2014; Mbunge, 2020). Notably, Surni et al (2020) and ADAMA (2024) identify the tomato industry as one of the avenues through which some of the socioeconomic challenges can be tackled since it offers significant income to farmers, supports job creation, fosters food and nutrition security, as well as boost local economic growth. Concerning income generation, Malherbe and Marais (2015) report that tomato producers in Limpopo province generally receive a higher average price per ton of tomatoes, with an estimated average income of R139 000 per hectare. The scholars further indicate that the income generated from tomatoes at the time was 2.5-fold more than the income generated from potatoes. According to ReportLinker (2025), the consumption of tomatoes in South Africa is bound to rise to about 0.543 million tons by 2026, equivalent to 0.1% year-on-year compound annual growth rate (CAGR) yet production is estimated to reach a 0.3%year-on-year CAGR by 2026.

1.1 Motivation

Despite the importance of tomatoes in South Africa, and the various tomato cultivars suitable for farming (Agricultural Research Council (ARC), *n.d*), the tomato industry is currently experiencing many challenges. Therefore, there is a need to understand the tomato industry, specifically at the production stage of the value chain. This work is a follow-up to the 2024 desktop tomato value chain study conducted by the NAMC which recommended further scrutiny of production systems used by tomato farmers. This study is intending to respond to the following research questions:

- What factors influence the choice of tomato cultivars grown by farmers in South Africa?
- What are the environmental and economic challenges faced by small-scale tomato farmers in South Africa?
- What are the smallholder market access estimates for the top-traded vegetables in 2024?
- What sustainable farming practices are used by tomato small-scale farmers in South Africa?

1.2 Purpose of the study

The purpose of this study is to scrutinize primary tomato production, a basis upon which further development of the value chain can be anchored while promoting the use of sustainable farming practices. This study focused on the production segment of the tomato value chain. Furthermore, by unpacking the challenges hampering the production of tomatoes, the study will propose recommendations through which to address some challenges.

1.3 Specific objectives

The study sought to explore the following specific objectives:

i. To identify factors influencing farmers' choice of tomato cultivars to grow in South Africa.
ii. To comprehensively understand the challenges faced by small-scale tomato farmers in South Africa.
iii. To describe smallholder market access estimates for the top-traded vegetables in 2024
iv. To identify the different sustainable farming techniques used in tomato production among small-scale farmers in South Africa.

1.4 Structure of the report

The report is organized as follows: The synthesis of relevant literature is covered in Section 2, and the methods used are presented in Section 3. Section 4 presents the results emanating from the survey and a discussion thereof, while section 5 covers the conclusion and recommendations. Section 6 highlights the study's shortcomings.

2. Literature synthesis

2.1. Tomato production in South Africa

Tomatoes are among the most popular foods for consumers globally. According to the Food and Agriculture Organization (FAO), tomatoes rank as the second most widely cultivated fruit in the world. The trends in tomato production in South Africa are shown in **Figure 1**. South Africa's tomato production has changed dramatically during the last 20 years. For instance, production reached a peak of 672,176 tons in 2017 after rising from 483,095 tons in 2004. Following a drop in 2018, production rebounded in 2019 and 2020 before declining once more in 2021 and then again in 2022. The proportion of tomatoes produced in South Africa is rather small and has decreased over the past few decades.

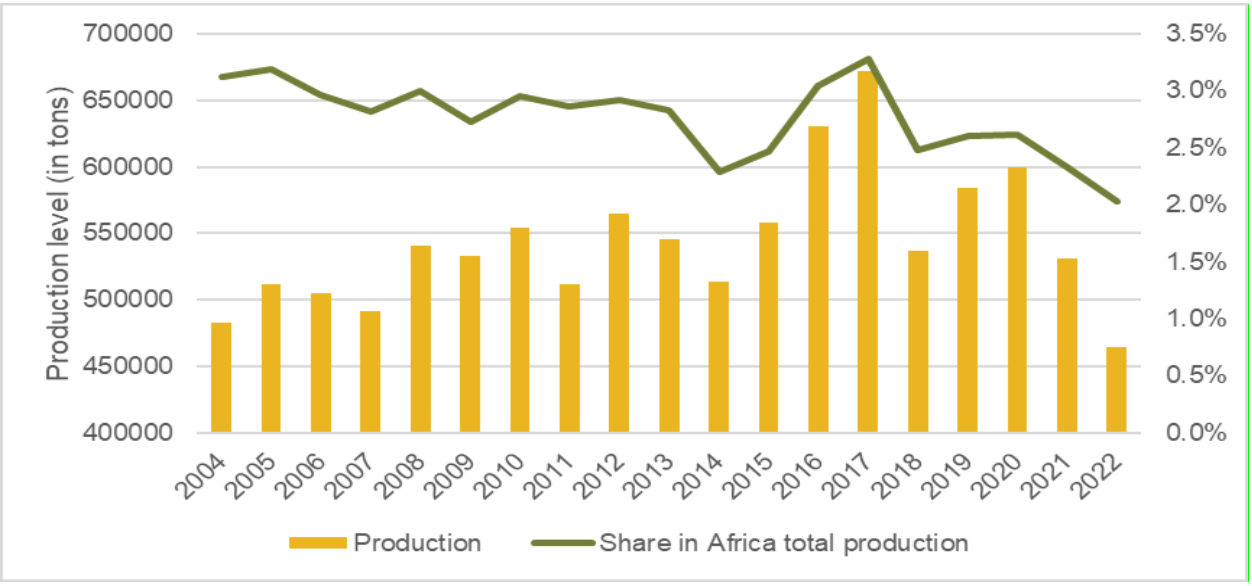

Figure 1. South African tomato production in tons
Source: FAOSTAT (2024)

2.2. Commonly cultivated tomato cultivars in South Africa and their characteristics

Tomatoes are one of the most widely cultivated crops, with a variety of cultivars available for planting. In South Africa, it is a common practice to introduce new tomato cultivars to farmers from both local and international sources, thereby resulting in a fast turnover rate. This renders the selection of suitable cultivars by farmers somehow complicated since the cultivars vary significantly in many characteristics, including sensitivity to temperature extremes, tolerance or susceptibility to pests and diseases, fruit quality and size, as well as yield potential (Nieder-wieser, 2001). Notably, farmers mostly choose cultivars based on market demand, climate, and growing conditions, among other factors. While some cultivars are ideal for consumption when still fresh, others are specifically suited for processing (ADAMA, 2024).

Given that most tomato cultivars are imported into South Africa, knowledge of the optimal growing conditions for specific cultivars needs to be determined, as unfavourable cultivar choices can lead to large financial losses. Therefore, the sub-section 2.1.1. provides a brief description of some of the commonly grown tomato cultivars in South Africa.

2.2.1. Common tomato cultivars in South Africa

Roma VF plum tomato - The Roma VF plum tomato *(Solanum Lycopersicum*) is native to Central, South and Southern North America. It is a popular choice for processing (Naika et al., 2005; Buthelezi et al., 2022; Lawal et al, 2022). Known for its meaty texture and low moisture content, this variety is ideal for sauces, salsa, and canning (Naika *et al*., 2005; Nipa, et al. 2020). This cultivar requires less water and exhibits disease resistance, making it favorable among farmers. Roma VF plants are compact, high-yielding, and produce firm fruits with few seeds. Roma VF tomato is resistant to verticillium, tomato mosaic virus, Alternaria stem cancer, and Fusarium 1,2, coupled with high commercial value (Uguwuoke, 2011).

The Heinz 1370 - This cultivar is widely used for both fresh consumption and processing. It has a good flavour and firmness (KZNdard, 2012). This cultivar produces bright red, rounded fruit and is adaptable to various growing conditions, including container cultivation (Udoka, et.al, 2021). Heinz 1370 is an affordable, high-yielding variety that bears fruit throughout the season, with peak ripening in summer (ADAMA, 2024).

Rodade is a high-yielding, adaptable open-pollinated determinate cultivar. It is popular for fresh consumption purposes due to its uniform colour and good shelf life (SAKATA, 2014). It is resistant to Race 1 bacterial wilt, a significant threat to tomato production in South Africa as well as Race 1 and 2 of *Fusarium oxysporum* f.sp. *lycopersici* (Bosch and Louw, 1985). Rodade plants exhibit determinate growth habits, with dark green foliage and glossy, evenly ripening fruit (KZNdard, 2012). The harvested fruit has a characteristic stem scar and the plant features jointless traits, enhancing its market appeal (Bosch & Louw, 1985).

Floradade This variety is known for its ability to withstand heat and it is high-yielding (Gardening, 2025; Starke Ayres, 2019). This determinate variety produces flat, round, bright red fruit with a concentrated harvest period which makes harvesting operation simpler (SAKATA, 2014). Floradade is particularly suited for regions with high

temperatures and is highly regarded for its reliable performance (Goldfield Farm Supplies, 2025).

Additional tomato cultivars in South Africa

Other than the few cultivars highlighted in the foregoing paragraphs, there are many other cultivars cultivated in South Africa, each offering distinct advantages and limitations. However, from a use perspective, common fresh market varieties include Fresh market-Zeal, Score, Checha, STAR9003, Disco, Bravo, Stormer, Settler, Sundance, Rodade, Floradade, Fortress, and otam-4, among others. Varieties commonly used for processing include Roma VF, Legato, Rossol, UC82B, Kamatla, and Qwanto, among others (ARC, *n.d*; KZNDard, *n.d*)). Each year, new cultivars are developed to address challenges such as pest resistance, disease tolerance, and adaptability to changing climate conditions.

2.3. Factors influencing farmers' choice of tomato cultivars to produce in South Africa.

Several socioeconomic factors affect tomato production. For instance, climatic factors include temperature, light, water, and drought (Bozo, et.al. 2019; Ashraf *et al.,* 2024). However, whereas these climatic factors can be easily controlled through controlled environments, they exert a significant impact on the incidences of pest and disease infestation, the quality and quantity of tomatoes harvested, as well as the sustainability of the tomato industry in general. This inherently has a bearing on the extent to which such produce gains access to markets for either fresh consumption or processing. The cultivation of tomatoes in South Africa reflects the diverse needs of the agricultural and consumer markets. Some of the factors that influence the choice of tomato cultivars for production include climatic adaptation (Starke Ayres, 2019). Thus, it is fundamental for farmers to select cultivars that will be able to thrive in South Africa's diverse climatic regions. According to Bosch and Louw (1985), other factors include a cultivar's ability to resist certain pests and diseases, such as bacterial wilt, fusarium wilt, and nematodes which pose serious economic threats.

Other than the environmental factors highlighted in the preceding paragraph, farmers also consider economic-related factors including the market demand for a given cultivar. Market demand is driven by cultivar-specific attributes such as the shelf life of the fruit, the intended use of a specific cultivar (e.g. saladette for canning, salsa & sauces, etc..), and the appearance/size/shape of the fruit (oval, round, cylindrical, large, medium, blocky) (ARC, *n.d*). Notably, producers also consider if the cultivar is determinate or indeterminate. According to Ashraf *et al*. (2024) and Kellogg Garden Products (2021), indeterminate tomatoes vine continuously, forming flowers along the sides of their shoots. They continue to grow and produce tomatoes until when climatic such as frost become unfavorable and kill them. Conversely, determinate tomatoes tend to be bushier, growing into compact plants that attain an average height of three to five feet and develop their fruits on the ends of their branches. When flowers develop on their branch ends, shoot production ceases. Keen importance is also attached to the cultivar's yield potential. High-yielding cultivars are more attractive to farmers as they can be more profitable. By selecting cultivars suited to climatic conditions, disease pressures, and market demands, South African farmers ensure a steady supply of tomatoes for both the local and international markets.

2.4. Challenges faced by tomato growers in South Africa

In South Africa, despite the tomato industry's reputation for implementing best practices in tomato production, it is facing significant challenges (Gwebu, 2018). Some of these challenges include but are not limited to, pests and diseases (Rhoda *et al*., 2020; Retief *et al.,* 2023), high input costs, market price fluctuations, water scarcity, unreliable electricity supply, labor issues and inadequate transportation and export infrastructure (NAMC, 2024, Mboko, 2013, Maboko et al., 2009, Dumas *et al*., 2003).

2.4.1. South Africa's tomato processing potential and the associated producer-processor contracting challenges

Tomato processing includes canning, freezing, dehydration, and juice manufacturing. Tomatoes are processed into many products, including tomato sauce, whole peeled, tomato and onion bruises, paste, shredded, puree, and concentrate. The majority of tomatoes produced in South Africa are consumed locally, with only a small amount exported to other nations. According to DALRRD (2020), less than 1% of the processed are exported. Whereas South Africa exports fresh tomatoes, the country struggles to meet local demand for processed tomato products, particularly tomato paste, a clear indication of limited agro-processing capacity. Agbiz (2018) affirms that South Africa is a net importer of tomato paste due to growing demand, but the prospects are good given that processors are working to alleviate the shortage.

In general, just 10% of the tomatoes harvested in South Africa are processed, with tomato sauce accounting for the highest proportion (85%) and the 10% used for frozen products. NAMC (2024) elaborates that the value of tomato juice rose significantly by 156% while the value of frozen tomatoes dropped by 21.38% between 2017 and 2024. Unlike South Africa, developed economies such as the United States and the European Union process 50% and 30% of their harvested tomato, respectively. Given South Africa's high net import demand for several tomato-processed products as detailed by NAMC (2024), it is evident that there is an untapped opportunity to process fresh tomatoes into many high-value products (TIPS, 2024).

Despite the agro-processing potential for tomatoes, NAMC (2024) reckons that there is a major challenge due to the limited number of farmers in the country producing fresh tomatoes, which in turn constrains the supply of tomatoes along the value chain. This is caused in part by producers' reluctance to take on large-scale tomato production without properly executed contracts with processors, limited knowledge about tomato cultivation among South African farmers, and limited access to productive land. Furthermore, the fluctuating quantity of tomatoes processed into other products is attributed to changes in

weather conditions and diseases, especially drought which constrain production (Directorate Statistics, 2021)

2.4.2. Competition with similar imported products

One factor reducing the competitiveness of tomato producers and processors was found to be competition from other similar goods (NAMC, 2024). For instance, many low-income South African buyers struggle to pay for expensive, high-quality goods. As a result, they resort to more affordable similar imported products.

2.4.3. Climatic and environmental-related challenges

In many instances, tomatoes are found with cracks at the time of harvesting. The cracking of tomatoes is to a great extent caused by a sudden increase in temperature, due to the exposure of the fruit to higher temperatures (Bozo et al, 2019). The fluctuation in temperature results in the cracking of the fruit (Bozo et al, 2019). That is, the low night temperature is favorable to the negative pressure in the tomato fruit while the high temperature during the day increases both gas and hydrostatic pressure of the fruit pulp on the epidermis which causes the fruit to rapture. Hence, there is a need to try and control the environment in which tomatoes are grown.

One of the biggest obstacles to the development of the agricultural sector worldwide is drought. Although a significant portion of South Africa's territory is semi-arid and characterized by summer rains, the need to reduce the cost of water and its scarcity is imminent. Thus, Johnson and Leah (1990) emphasize the importance of using water more efficiently for agricultural production. The cost and availability of water for farming have increased, particularly for community initiatives and smallholder farmers (Bozo et al, 2019). With South Africa’s diverse climatic conditions and wide range of soil types, growing plants in open fields is unpredictable due to a wide range of challenges (ARC, *n.d*). These challenges include factors such as temperature fluctuations (Buthelezi et al., 2022; 2021), poor and contaminated soils (Rhoda et al. 2020), as well as pests and diseases (Baliyan *et al*., 2013).

2.5. Trade performance perspective by Africa's top 15 countries (2016–2023)

Africa's top 15 exporters[1] of fresh or chilled tomatoes on average exported 746 466 tons annually shown in **Figure 2**, representing a 16% annual growth rate between 2016 and 2023. Morocco was the leading exporter, shipping approximately 606 478 tons annually, followed by Egypt (29 849 tons), Ethiopia (25 135 tons), Tunisia (23 280 tons), and South Africa (22 898 tons) (Trade Map, 2024). While South Africa experienced a consistent decline in exports, countries like Kenya, Mali, and Namibia saw remarkable growth in their tomato exports. For instance, Kenya's exports increased significantly to reach 33 722 tons in 2023, from 100 tons only in 2016. Similarly, Mali recorded an increase from negligible volumes to over 11 000 tons in 2023.

Conversely, Africa's top 15 importers[2] of fresh or chilled tomatoes on average imported 74 704 tons annually from 2016 to 2023, representing a 161% increase (Trade Map, 2024). Somalia was the leading importer during this period, with an average of 15 801 tons annually, followed by Côte d'Ivoire (11 518 tons), Djibouti (10 394 tons), South Africa (7 920 tons), Mauritania (6 602 tons), Ghana (6 075 tons), and Libya (6 054), among others. Countries such as Uganda and Mauritania exhibited exceptionally high annual growth rates in tomato imports of 56988% and 13896%, respectively. Uganda's imports surged from 60 tons in 2016 to over 34 000 tons in 2023, while Mauritania's imports increased from 228 tons in 2016 to 31 912 tons in 2023.

Overall exports outweighed imports during this period, with an estimated annual growth rate of 2%. The trends highlight the significant regional variability in the production and demand for fresh or chilled tomatoes across Africa. Thus, the observed trends underline the importance of strengthening intra-African trade, while enhancing productivity to meet growing demand in countries reliant on imports. Furthermore, countries exhibiting

[1] Morocco, Kenya, Egypt, Tunisia, Ethiopia, South Africa, Mali, Namibia, Uganda, Senegal, Libya, Burkina Faso, Djibouti, Angola & Niger in that order.
[2] Uganda, Mauritania, Côte d'Ivoire, Somalia, South Africa, Djibouti, Mozambique, Tunisia, Rwanda, Ghana, Lesotho, Eswatini, Libya, South Sudan, and Namibia, in that order.

comparative advantage in producing tomatoes must be supported to explore markets that are less advantaged both within and beyond the African continent.

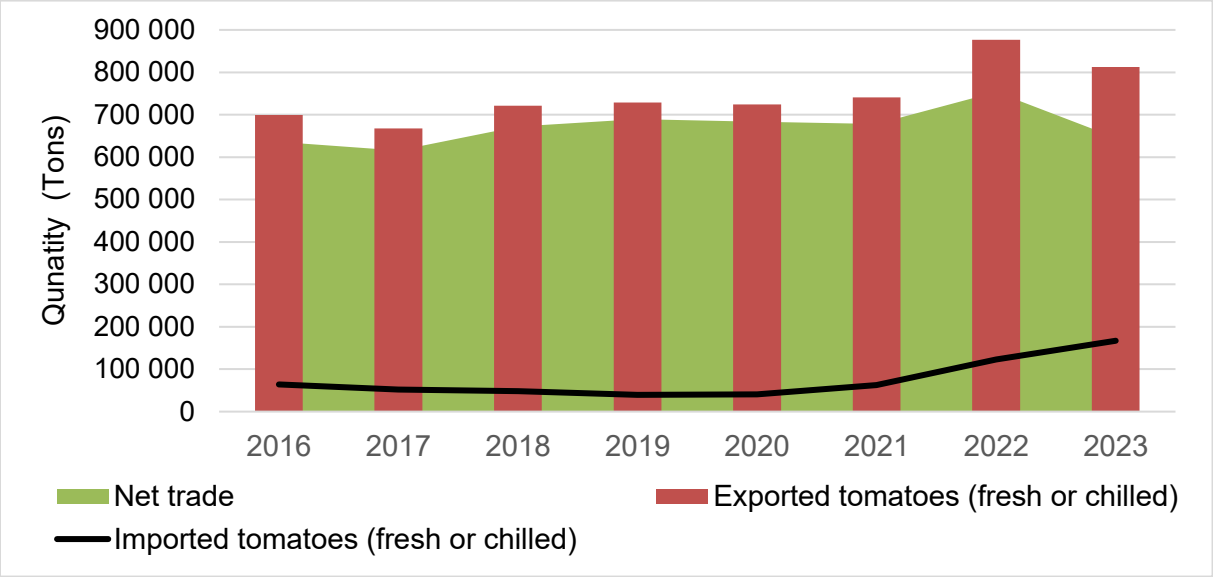

Figure 2: Trade performance in fresh or chilled tomatoes by Africa's top 15 states

Source: Trade Map, 2024

3. Methodology

This study adopted a mixed-method approach, which combines both quantitative and qualitative data to achieve the study's objectives. Harwell (2012) defines mixed methods as a research approach that integrates various concepts and techniques into a single study, offering flexibility in research design. The mixed-method approach is widely praised for its ability to efficiently collect and analyze large volumes of data, while also capturing rich contextual insights through qualitative methods (Fetters and Freshwater, 2015; Akimowicz et al., 2018). In this study, mixed methods involved literature and documentary reviews, key informant interviews, and a survey of tomato growers. The integration of these data collection methods was crucial in gathering empirical and theoretical evidence, leading to a better understanding of the complexities of sustainable tomato production in South Africa. This approach was particularly relevant as it allowed for capturing the voices of key informants, performing comprehensive analyses, and enhancing the validity of the findings.

3.1. Study area and scope of study

The study focused on the tomato value chain in South Africa. According to Post-Harvest Innovation (2024), tomatoes are the second most important vegetable in South Africa, with per capita consumption reaching approximately 12 kg annually in metropolitan areas (DALRRD, 2020). South African Cities Network (SACN) (2014) further reports that the average household in South Africa consumes five to ten tomatoes per week. However, data for this study were collected specifically from Limpopo and Gauteng provinces. Limpopo is recognized as one of the top producers of tomatoes in the country (Buthelezi *et al*., 2022; 2021). Post-Harvest Innovation (2024) states that South Africa produces approximately 600 000 tonnes of tomatoes annually, with three primary types being grown: round tomatoes for fresh consumption, Roma tomatoes for processing, and cherry tomatoes for dual purposes.

The major tomato-producing areas in Limpopo province include Polokwane, Mooketsi, Giyani, Tom Burke, Ellisras, Baltimore, and the Limpopo River Valley. In Mpumalanga province, tomato production is eminent in the areas of Malelane and Komatopoort (Post-Harvest Innovation Programme, 20024 while in the Western Cape province, tomato production is mostly done around Robertson and Vredendal. In the North West and Eastern Cape provinces, production is eminent in Brits and East London, respectively. For KwaZulu Natal, tomatoes are produced in the Northern part of the province.

3.2. Sampling and sample selection

A combination of simple random sampling and purposive sampling techniques were used to identify key stakeholders across the value chain. A list of smallholder farmers was obtained from the Department of Agriculture in Limpopo, Westonaria Agri Park (Gauteng province), and seed companies from which an appropriate sample size for the study was drawn. Thus, the sample included smallholder farmers and representatives of seed breeders.

3.3. Data collection and data analysis

The study employed multiple data collection methods to gather data. Desktop literature and documentary reviews were conducted to ascertain the various tomato cultivars grown in South Africa as well as some of the sustainable farming being used in tomato production in South Africa. The reviews relied on information from journal articles, academic theses, policy briefs, newspaper articles, opinion pieces, and websites with relevant information related to sustainable tomato production. The study focused on literature from the Global South, particularly countries in Latin America, Asia, and Africa.

In addition, this study conducted face-to-face and/or virtual key informant interviews to gain insights into tomato production and the different cultivars grown in South Africa. The study carefully designed and executed interviews with key informants within the tomato industry. These interviews were conducted with five (5) industry stakeholders actively involved in the production of tomatoes including seed breeders, the Agricultural Research Council (ARC), academia, government institutions (Department of Agriculture, Land Reform and Rural Development (DALRRD) & the corresponding provincial departments of agriculture), and the relevant private of non-government organizations/associations. Following the simple random sampling and purposive sampling techniques described above, a total of 44 small-scale farmers from both Limpopo and Gauteng provinces were interviewed. Basic descriptive analysis based on frequencies and graphical illustrations was carried out using MS Excel software.

4. Results and discussion

4.1. General descriptives

Figure 3 below depicts the farmers' category. According to the data, 70% of farmers were smallholders, while 25% and 5% were subsistence and commercial farmers, respectively. This suggests that most farmers operate on a small scale, with limited market participation.

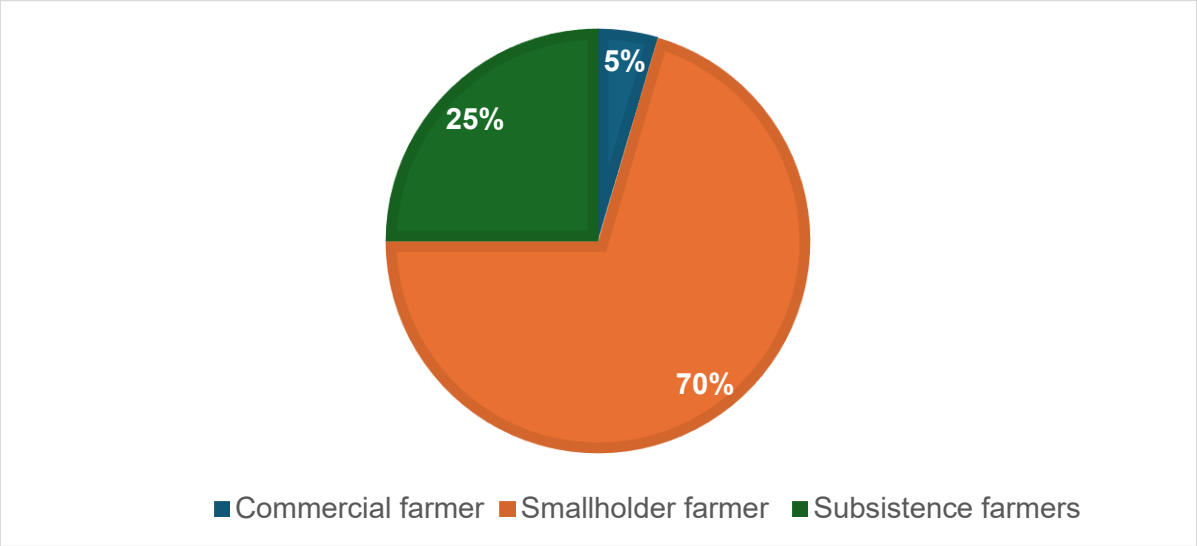

Figure 3: Categories of farmers
Source: NAMC survey data 2024

Figure 4 depicts statistics on the gender of tomato farmers. According to the data, male tomato producers accounted for approximately 52% of the total surveyed farmers, while female farmers accounted for roughly 48%.

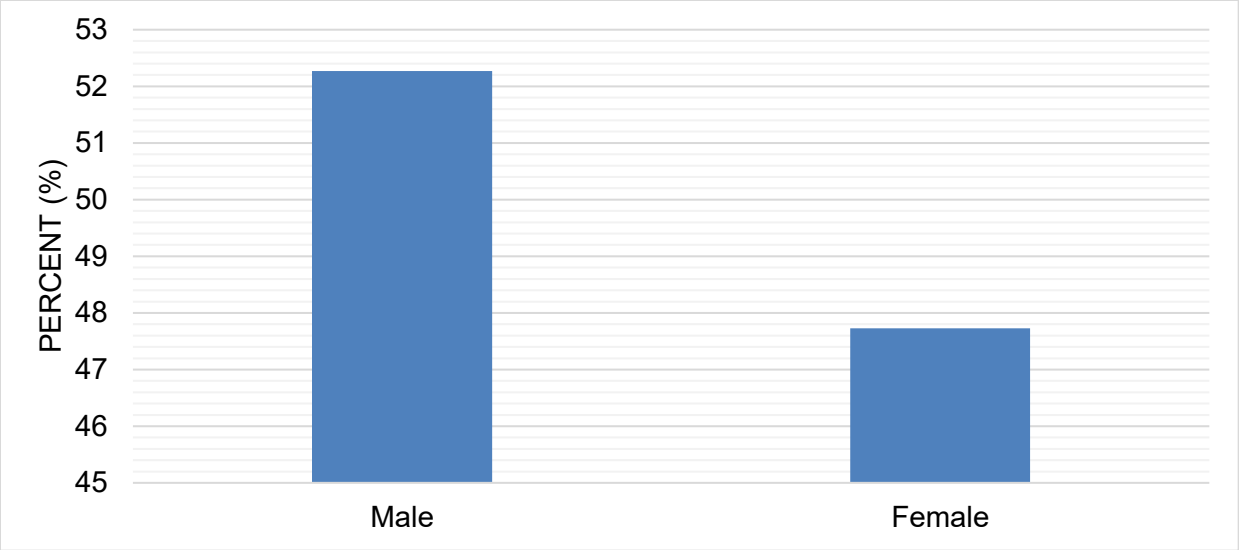

Figure 4: Gender
Source: NAMC Survey data

Figure 5 depicts data on the educational background of tomato farmers. The data shows that roughly 57% of tomato growers acquired secondary education, implying that the majority had completed basic schooling. Moreover, 43% had acquired tertiary education, showing that a large portion have pursued further education.

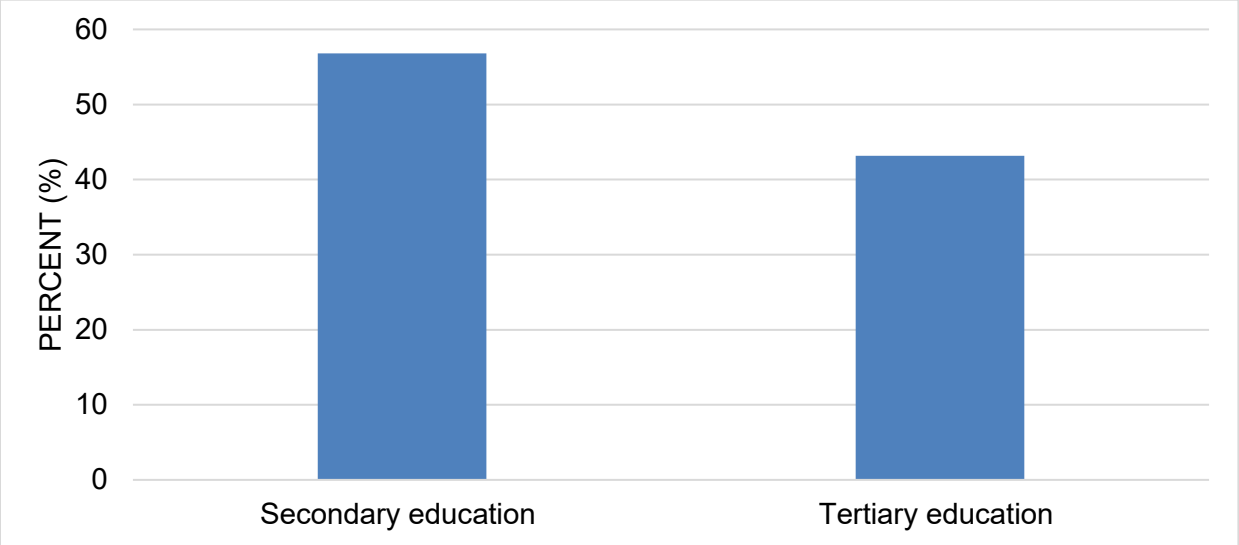

Figure 5: Level of education attained by farmers
Source: NAMC survey data

Figure 6 depicts data on landownership among tomato farmers. Approximately 39% of the surveyed farmers own land, 34% rent it, and 27% use community land.

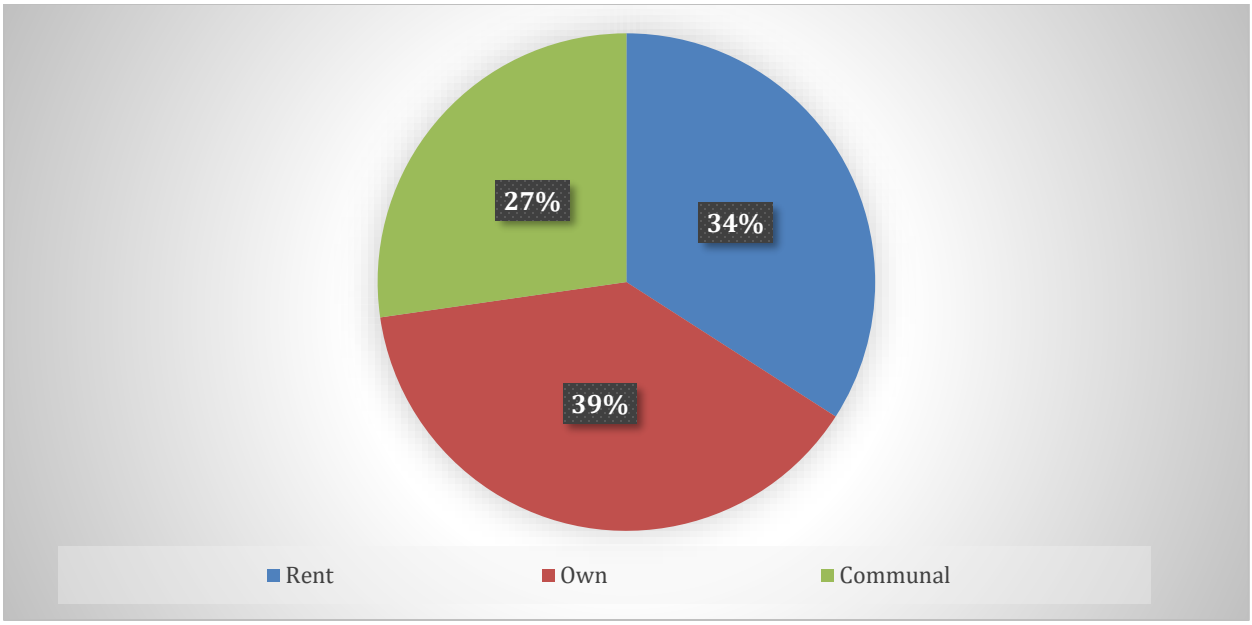

Figure 6: Land ownership
Source: NAMC survey data

Figure 7 shows statistics on tomato producers' access to extension services. About 84% of tomato farmers have access to extension services, which can boost productivity and encourage the use of best practices. However, approximately 16% of tomato farmers reported not have access to extension services.

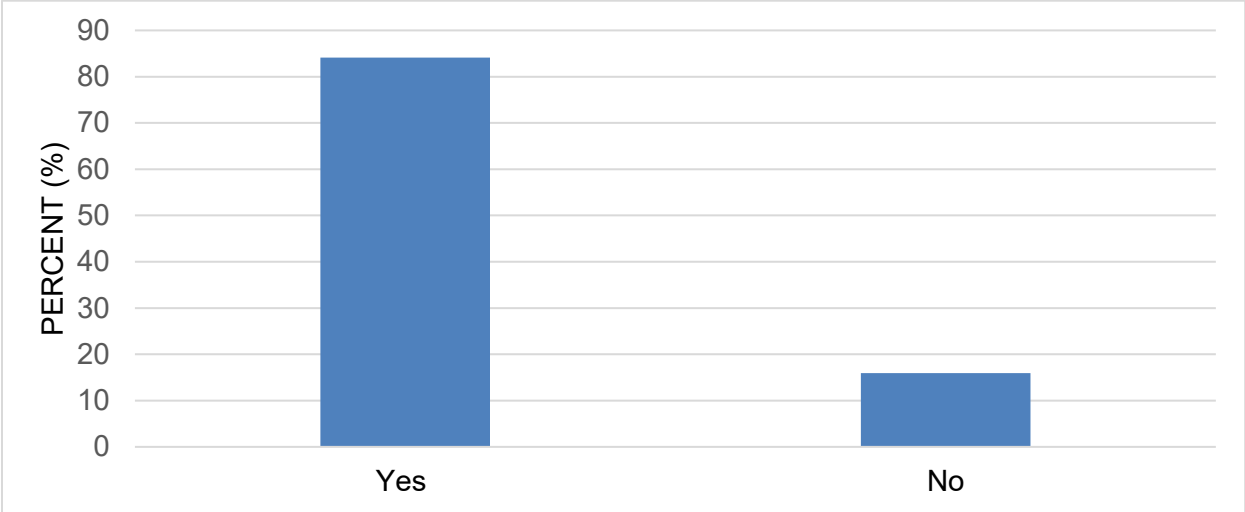

Figure 7: Access to extension services
Source: NAMC survey data

Figure 8 depicts statistics on tomato producers' membership in farmers' organizations. Most tomato growers, roughly 68%, were not ascribed to any farmer's organization, while 32% belonged to at least one farmer's organization.

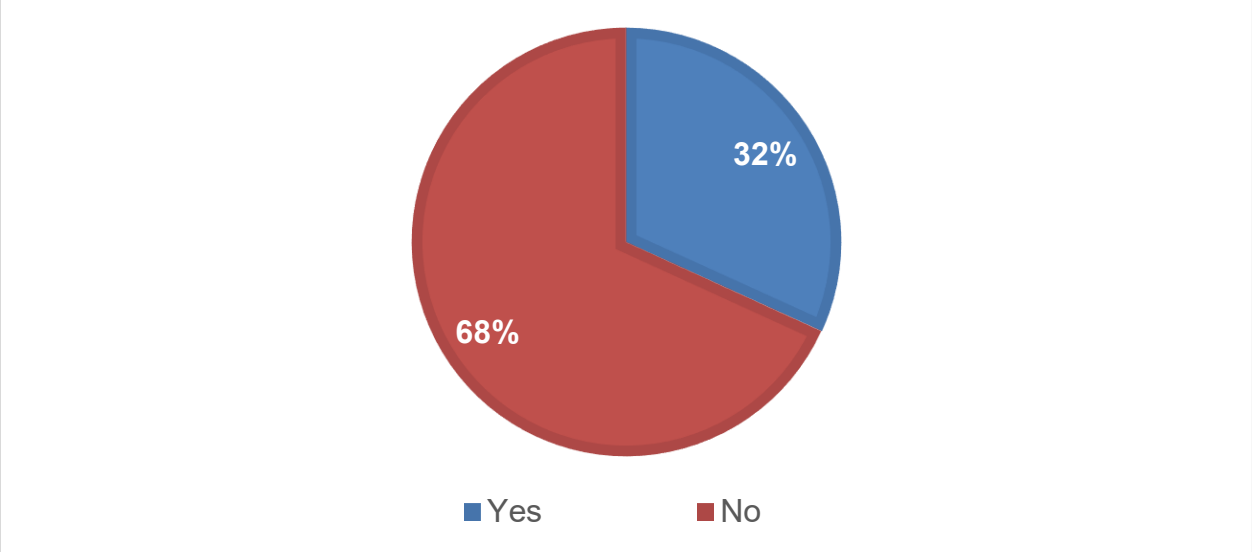

Figure 8: Membership to a farmers' organization
Source: NAMC survey data

Figure 9 shows tomato producers' access to financial services. According to the data, the majority (93%) of tomato producers had not accessed financial services, but only 7% had had access to the services.

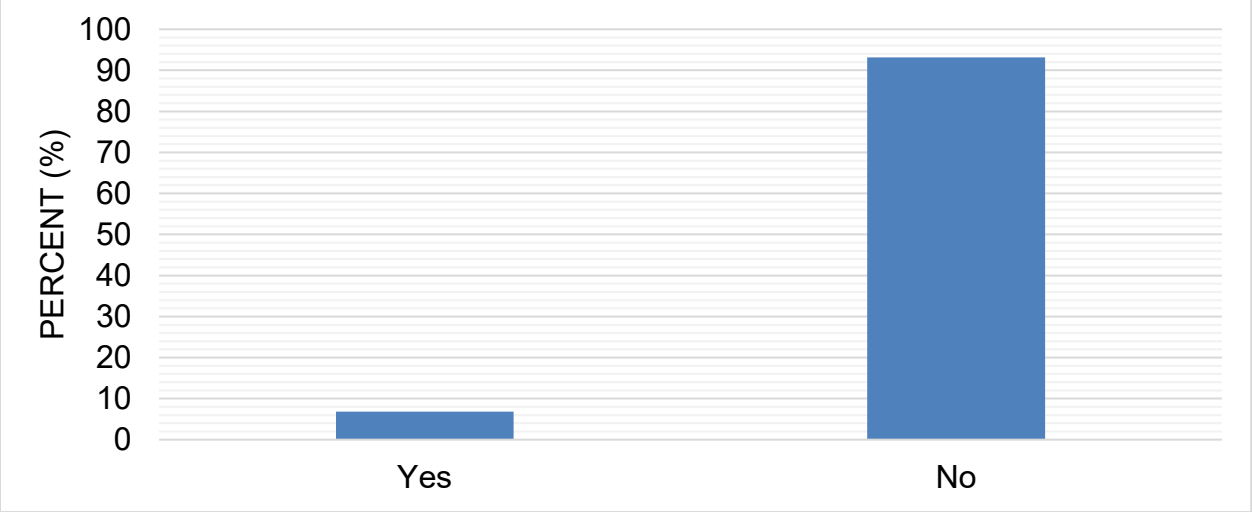

Figure 9: Access to financial services
Source: NAMC survey data

Figure 10 shows the different tomato cultivars planted by farmers during the last 12 months. Notably, the cherry tomato cultivar was the single most type grown by farmers in the past 12 months, accounting for 15.91% as reported by the farmers. The second most popular type was plum tomatoes (6.82%), while Green Beefsteak, Campari, Green Zebra, and Kumamoto tomatoes were produced by a few farmers (2.27% for each cultivar). Most farmers (68.18%) collectively reported growing other cultivars such as Fi-Hybrid, Renka, GEM, Round tomato, and Monet Red. It is worthwhile to note due to the many tomato cultivars on the market, in many instances, farmers could find difficulty in articulating the actual name of the cultivar but made descriptions a basis upon which a researcher accordingly linked the description to some of the most known cultivars.

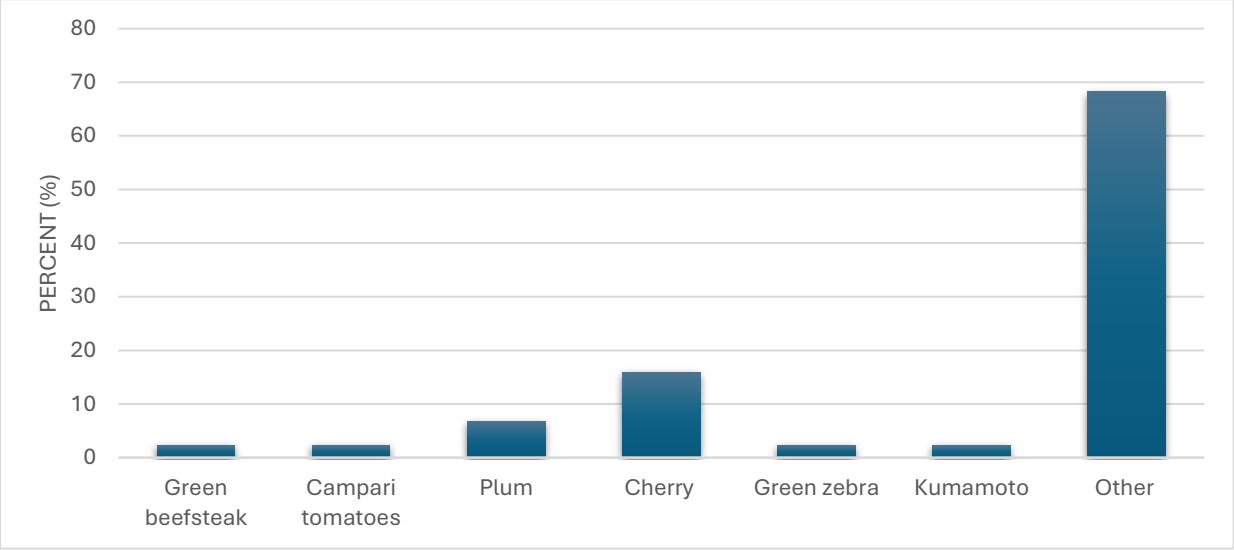

Figure 10: Tomato cultivars identified by farmers
Source: NAMC survey data

4.2. Factors influencing farmers' choice of cultivars for commercial production

Figure 11 depicts data on factors influencing tomato producers to grow various tomato varieties commercially. Most farmers (39%) reported high yield as the influencing factor to produce tomatoes commercially, followed by a cultivar's disease resistance (25%), drought tolerance (9.09%), and the associated production costs (2.27%). 25% of the respondents considered all the other factors collectively.

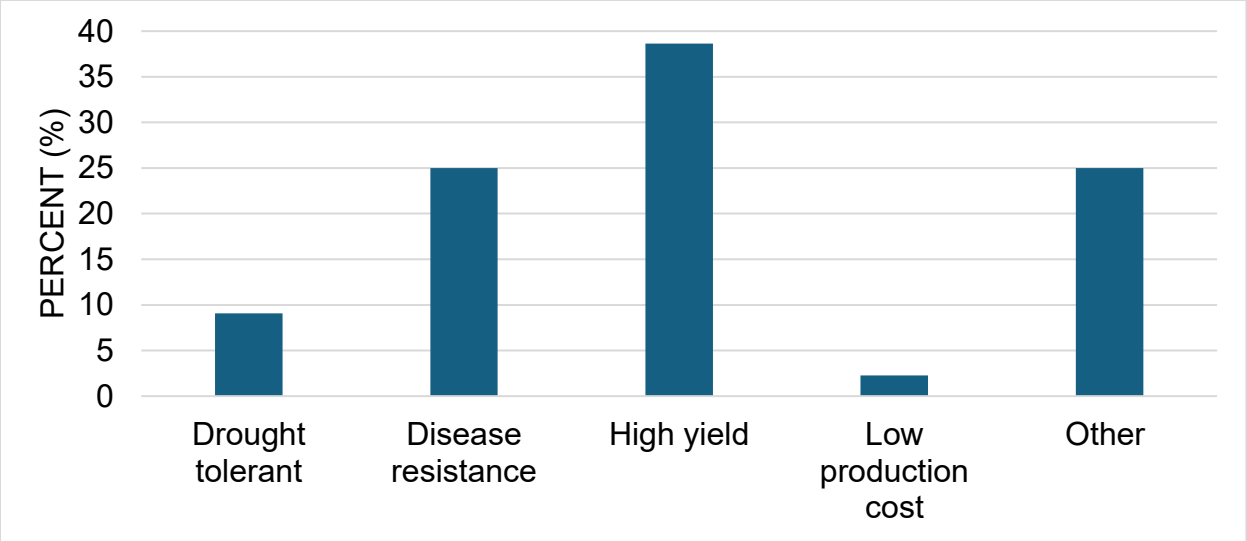

Figure 11: Factors influencing farmers' choice of cultivars for commercial production
Source: NAMC survey data

Figure 12 shows the extent to which market prices and preferences influence tomato cultivar selection. According to the data presented, market prices and preferences have a moderate influence on cultivar selection for 46% of farmers, while 25% of the farmers reported that market prices and preferences greatly affect cultivar selection. Other farmers (11%) reported that market prices and preferences slightly affect the tomato cultivar selection while 18% of the farmers expressed that they are not at all affected by market prices and preferences.

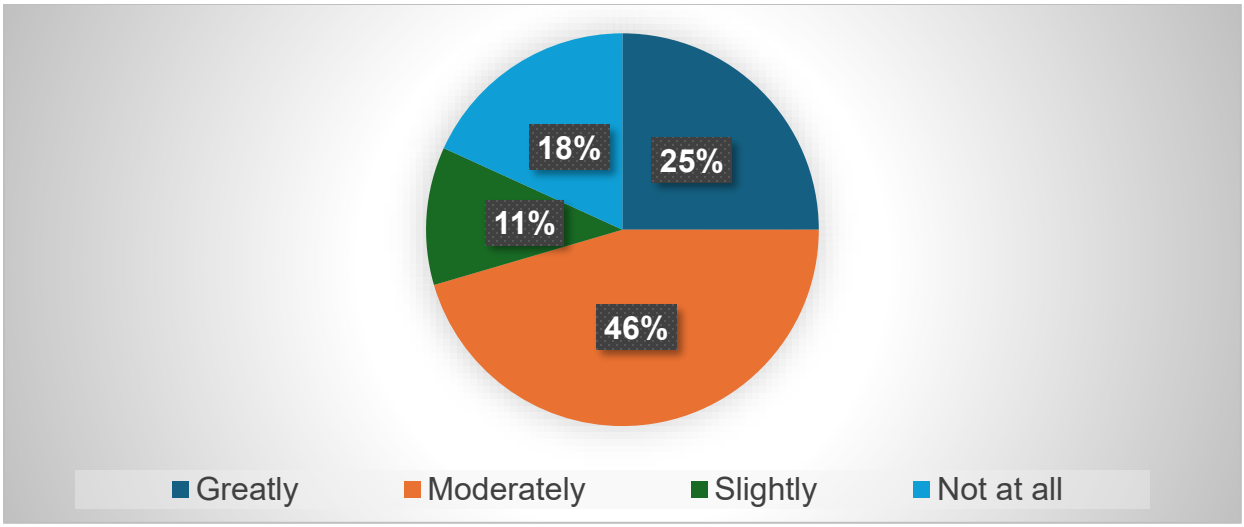

Figure 12: Effect of market price and preferences on tomato cultivar selection
Source: NAMC survey data

Figure 13 shows how the cost and availability of seeds influence cultivar choice among farmers. 32% of farmers expressed that the cost and availability of seeds have a moderate impact on the cultivar chosen, while 25% of farmers indicated that these factors greatly affect the type of tomato cultivars grown by the farmers. Approximately 23% of farmers believe that the cost and availability of seeds slightly influence the choice of cultivars grown by farmers.

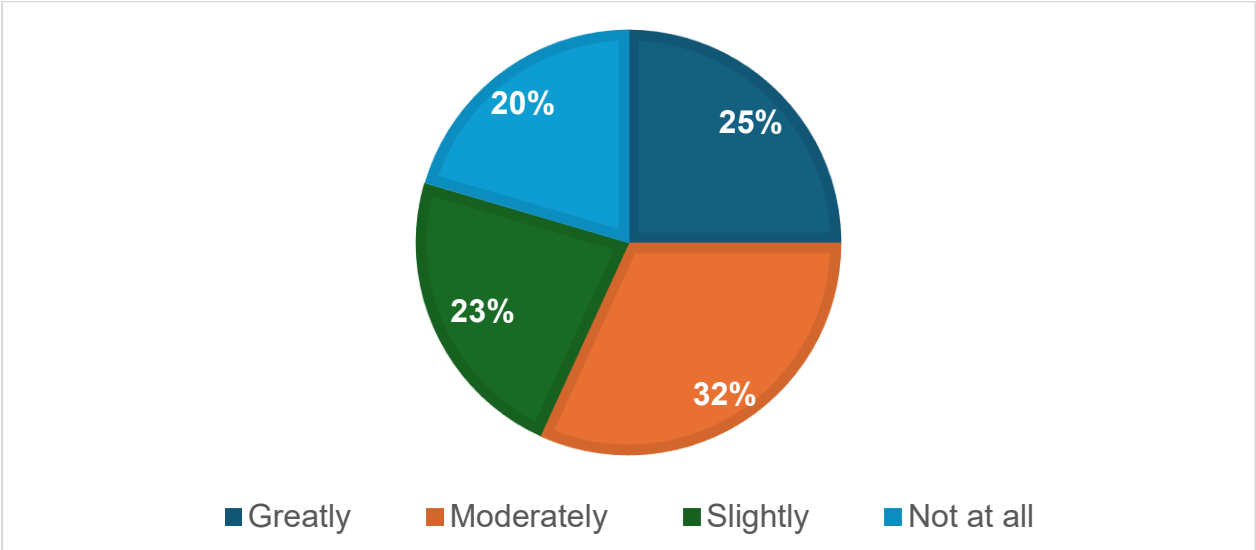

Figure 13: The influence of the cost and availability of seed on farmers' choice of cultivars
Source: NAMC survey data

Figure 14 presents data on which tomato cultivars are the most resistant to water scarcity and stress in the South African climate. According to the data below, which represents tomato farmers' replies, most farmers (72.73%) believe that other cultivars such as Fi-Hybrid, Renka, GEM, Round tomato, and MONET. Cherry tomatoes (13.64%) show good tolerance, followed by plums (about 7%), and Campari, Green Zebra, and Kumamoto (nearly 2%).

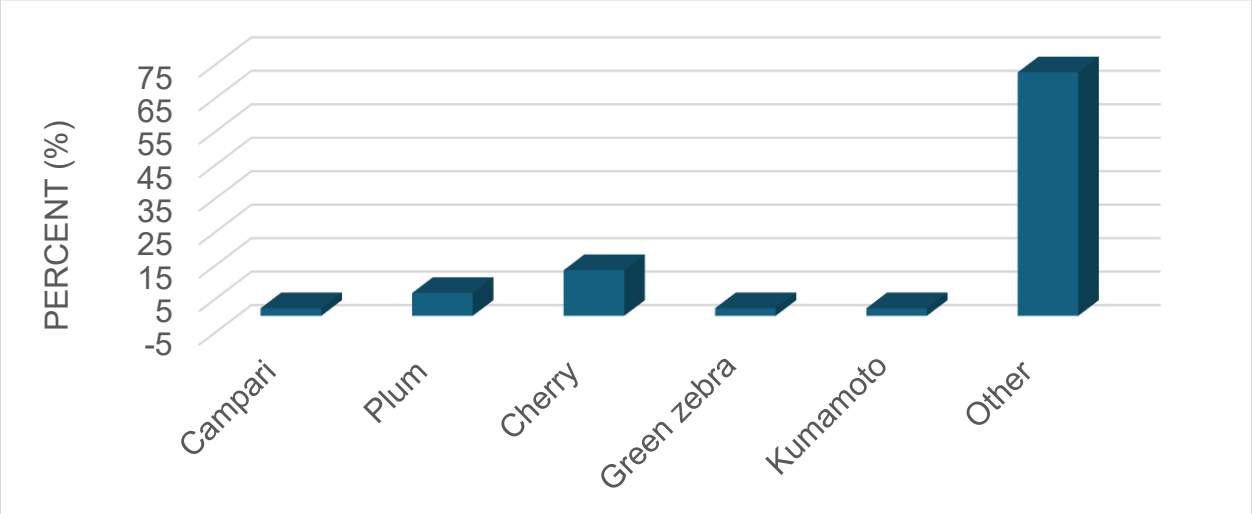

Figure 14: Highest tolerance tomato cultivars
Source: NAMC survey data

Figure 15 provides statistics on tomato cultivars perceived to have the highest market demand and consumer preference in South Africa. Cherry tomatoes were the single most identified cultivar by 16% of growers to have the highest market demand and consumer preference, followed by plum tomatoes, as reported by 7% of the farmers who participated in the study. Collectively, 75% of the farmers indicated that all the other cultivars including Fi-Hybrid, Renka, GEM, Round tomato and MONET also have high market demand and consumer preference.

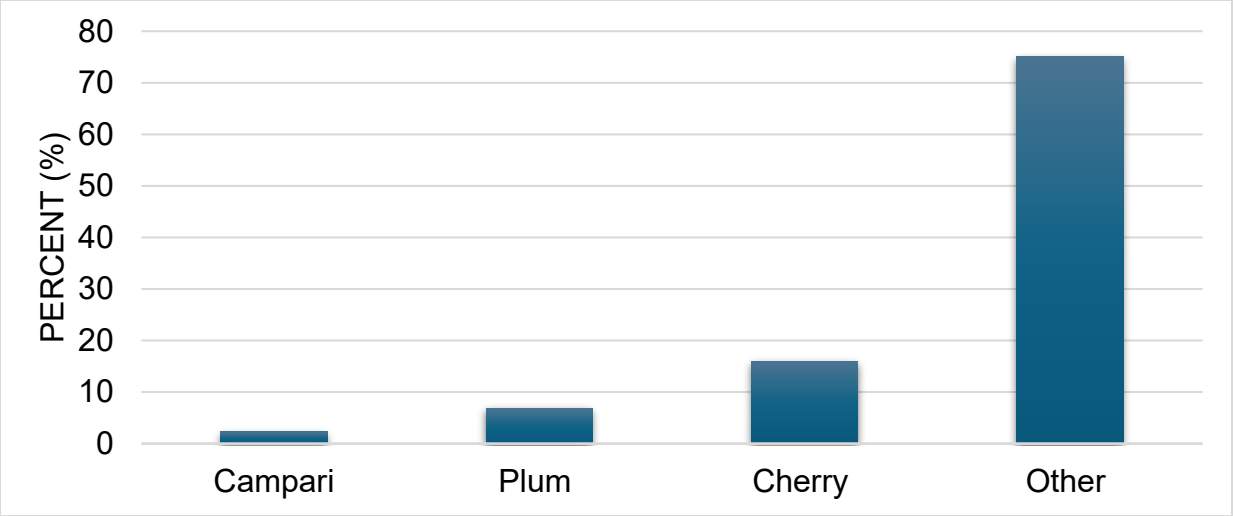

Figure 15: Perceived market demand and consumer preference of tomato cultivars in South Africa
Source: NAMC survey data

4.3. Challenges facing sustainable tomato production

Figure 16 shows the key challenges tomato farmers experience while using sustainable farming practices. According to the data, the major challenge faced by tomato producers is the high expense (36.36%) of implementing sustainable production practices, followed by the lack of or limited access to extension support (13.64%), and the lack of information relating to the practices (9.09%). Other hurdles accounting for 40.91% include limited access to markets and environmental considerations.

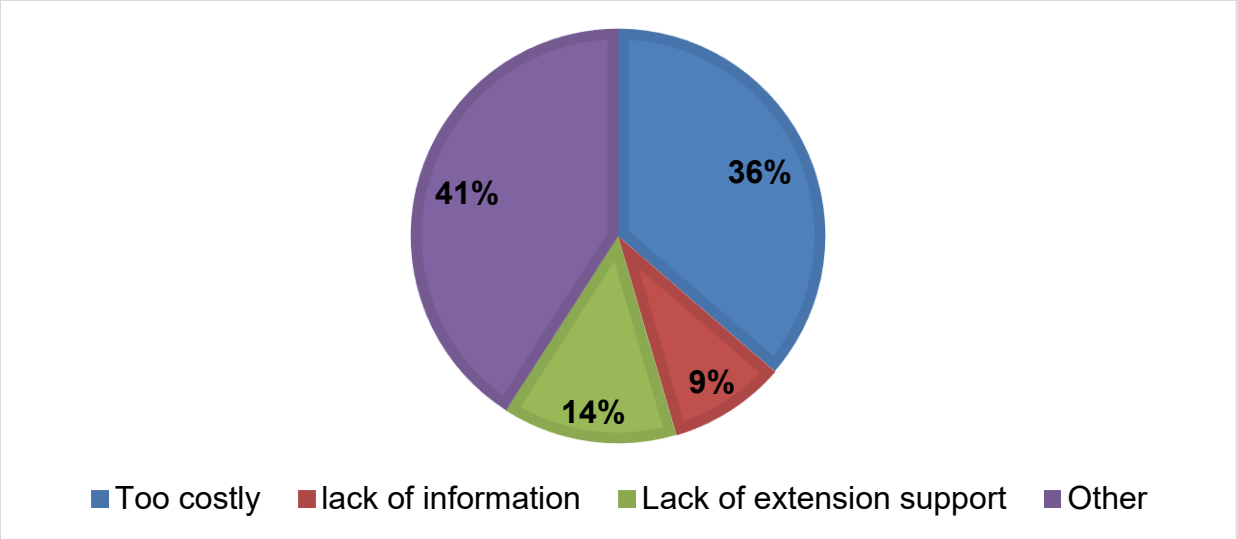

Figure 16: Challenges encountered by tomato farmers in implementing sustainable farming practices
Source: NAMC survey data

Figure 17 displays farmers' responses to how the challenges raised in Figure 12 can be handled. Notably, most of the farmers (64%) reported that there is a need to enhance support towards their use of sustainable tomato production practices, followed by increasing awareness campaigns (16%), and other interventions, which accounted for 18% of all responses from the surveyed tomato producers. Other interventions mentioned include the provision of subsidies to farmers using sustainable production systems.

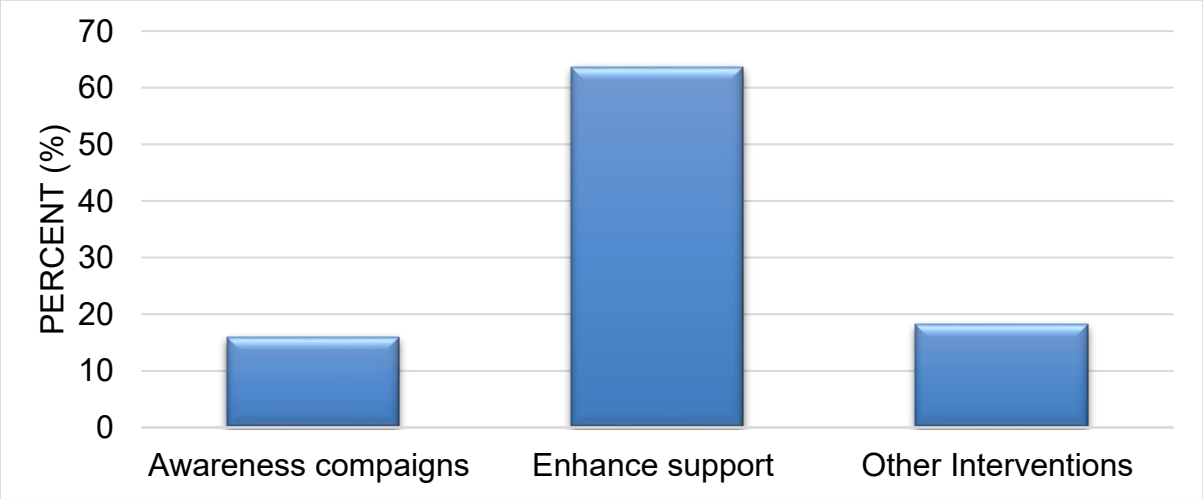

Figure 17: Responses on how to address the challenges encountered by farmers
Source: NAMC survey data

Table 1 displays data on the most common environment-related challenges affecting tomato production. Pests and diseases are the most common environment-related challenges affecting tomato production, accounting for nearly 50%, followed by water shortage (18%) and drought (7%). Floods (2.27%) were reported to be less common. Other environmental-related issues, including fluctuating climatic conditions, accounted for (22.73%).

Table 1: Environment-related challenges encountered by farmers

Environmental challenge	Percent (%)
Pests and Diseases	50.00
Water Scarcity	18.18
Drought	6.82
Floods	2.27
Other	22.73

Source: NAMC survey data

Figure 18 shows the principal pests affecting tomato production as reported by tomato farmers. The most common pest identified by farmers is the whitefly, accounting for 25% of responses provided, followed by aphids with 18.8%. Other pests affecting tomato production collectively accounted for 56.82% of the responses and some of the mentioned pests include Tuta absoluta (a leafminer moth), cutworms, and a variety of insects and mites.

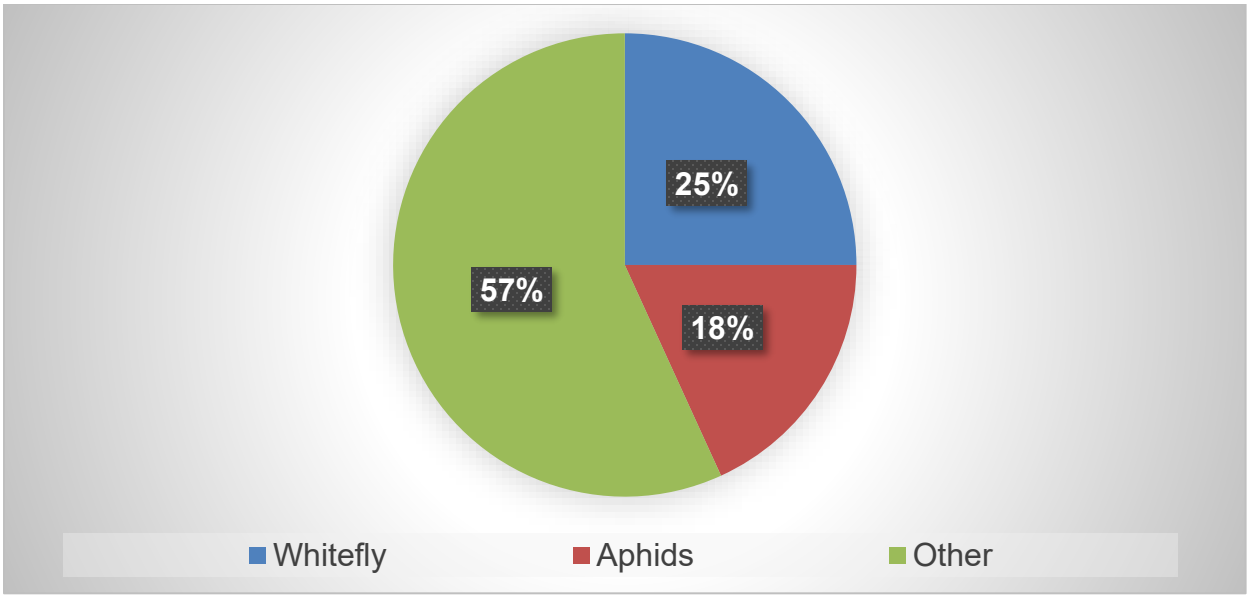

Figure 18: Major pests identified by tomato farmers
Source: NAMC survey data

Figure 19 depicts the main diseases influencing tomato production in various areas as reported by farmers. The most common disease mentioned by farmers was powdery mildew (34%), followed by Septoria leaf spot (21%) caused by a fungus, Septoria lycopersici. Powdery mildew is a fungal disease caused by Oidium neolycopersici and manifests as white, powdery lesions on leaves, stems, and petioles, potentially leading to leaf yellowing, premature senescence, and reduced fruit quality.

Other diseases collectively accounted for 46% of the responses and leaf spot was among the few mentioned diseases. Tomato farmers reckoned that all diseases substantially impact tomato production and the effect is compounded in the presence of the blossom end rot and sunscald. It is worthwhile to note that blossom-end rot is not a disease but rather a physiological disorder due to calcium deficiency. It strongly manifests itself as a brown, leathery rot at the blossom end of the fruit in instances when there is inconsistent watering and high nitrogen levels in the soil (Abdelkader, *et al.,* 2024; Srivastava *et al*., 2022). On the other hand, sunscald appears as a pale yellow to white spot on the side of the fruit facing the sun and it's common in hot weather (Kumar *et al.,* 2021).

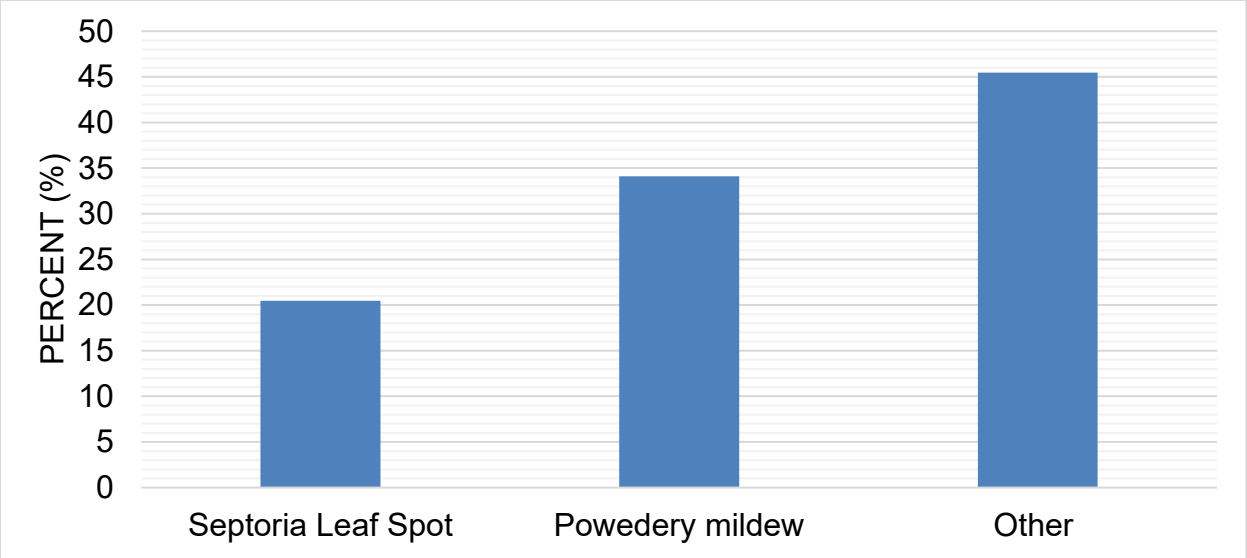

Figure 19: Major Diseases identified by farmers
Source: NAMC survey data

Table 2 presents the economic challenges tomato farmers face. The major economic barrier reported by tomato growers is the high input costs, accounting for 61.36% of the responses. The high cost of inputs limits farmers' ability to invest in production and sustainable production systems. The existence of market entrance barriers (18.18%) and the lack of access to credit (13.64%) were also reported as major economic hurdles encountered by tomato farmers. Collectively, "other" economic challenges accounted for 6.82% of the responses and included the poor infrastructure network, especially in the rural communities.

Table 2 : Economic challenges reported by farmers

Economic challenge	Percent (%)
High input expenses	61.36
Market entry barrier	18.18
Access to credit	13.64
Other	6.82

Figure 20 depicts statistics on how the availability and cost of agricultural inputs affect profitable, sustainable tomato production. Responses reveal that about 59% of tomato producers believe that the availability and cost of agricultural inputs significantly affect sustainable tomato production. However, 29% of farmers expressed that the effect is moderate, while 7% and 5% reported that the effect is mild and no effect at all, respectively.

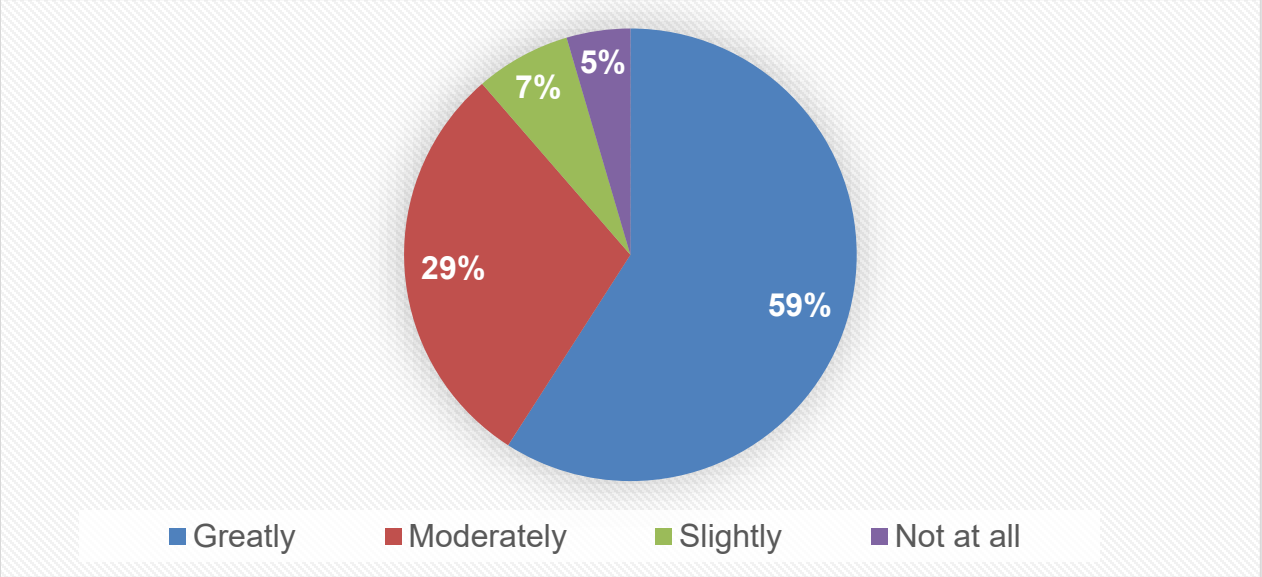

Figure 20: Perceived effect of agricultural inputs on tomato production
Source: NAMC survey data

4.4. Smallholder market access estimates for the top 10 traded vegetables in 2024

This section presents the 2024 aggregated smallholder market access estimates (SMAE) for the top ten traded vegetables in the top ten fresh produce markets, ranked based on revenue and volume. The SMAE estimate is based on the recommendation that approximately 30% of fresh produce at National Fresh Produce Markets (NFPMs) is supplied by smallholder farmers (NAMC, 2025). **Table 3** provides the aggregated SMAE of the total volume supplied at different NFPMs in 2024. The average SMAE for the top ten selected vegetables is 610,000 tons, presented in percentages to illustrate the market share distribution per commodity among the top traded products and sales channels. The

results indicate that potatoes are the most significant vegetable, contributing 46.9% of the total volume, followed by onions (18.0%), tomatoes (10.7%), and carrots (6.1%). In terms of total traded volume, tomatoes rank third among the top ten fresh produce markets, highlighting their importance to smallholder farmers.

Table 3 : Aggregated 2024 Smallholder Market Access Estimates for Vegetables (%Tons)

Commodity	Top ten fresh produce markets (2024)[3]										
	JHB	TSH	CPT	DBN	SPR	BLM	EL	KDP	WLK	PMB	Total
Potatoes	20.4	9.2	4.0	4.4	2.6	1.3	1.4	1.3	1.2	1.0	46.9
Onions	9.5	3.4	1.2	2.0	0.5	0.3	0.5	0.2	0.2	0.3	18.0
Carrots	3.0	1.2	0.5	0.7	0.1	0.1	0.3	0.1	0.1	0.0	6.1
Beetroot	1.2	0.5	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	2.2
Lettuce	0.5	2.1	0.3	0.5	0.3	0.4	0.1	0.2	0.2	0.0	4.7
Butternut Squashes	1.9	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.5
Cabbage	3.2	0.8	0.5	0.2	0.0	0.0	0.1	0.0	0.0	0.0	4.9
Tomatoes	5.3	1.7	1.5	0.8	0.4	0.3	0.2	0.3	0.2	0.1	10.7
Peppers	1.6	0.8	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	3.1
English Cucumbers	0.5	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Grand Total	**47.2**	**20.2**	**8.7**	**9.2**	**4.1**	**2.5**	**2.6**	**2.2**	**1.8**	**1.5**	**100**

Table 4 presents smallholder market access estimates for the top ten vegetables across different markets in Rand terms. The values show the percentage of SMAE revenue for each selected fresh produce market in 2024. The aggregated SMAE revenue for the top ten traded vegetables amounts to R4.4 billion. The analysis further examines market share distribution per commodity and market. The results reveal that in revenue terms,

[3] JHB= Johannesburg, TSH = Tshwane, CPT = Cape Town, SPR = Spring, BLM = Mangaung (*formerly Bloemfontein),* EL = East London, KDP = Matlosana (*formerly Klerksdorp*), WLK = Matjhabeng (*formerly Welkom*), PMB = Pietermaritzburg,

potatoes rank first, contributing 45.5%, followed by tomatoes (17.0%) and onions (15.7%). This suggests that smallholder tomato farmers have a strong market presence and significant income opportunities in the fresh produce sector.

Table 4 : Aggregated 2024 Smallholder Market Access Estimates for Vegetables (% Rands)

Commodity	Top ten fresh produce markets (2024)										
	JHB	TSH	CPT	DBN	SPR	BLM	EL	KDP	WLK	PMB	Total
Potatoes	19.6	8.9	4.2	4.3	2.4	1.3	1.4	1.2	1.1	1.0	45.4
Onions	8.1	2.8	1.2	1.9	0.3	0.3	0.5	0.2	0.2	0.2	15.7
Carrots	2.2	0.9	0.4	0.6	0.1	0.1	0.3	0.1	0.0	0.0	4.8
Beetroot	0.9	0.4	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1.6
Lettuce	0.9	0.7	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.0	2.8
Butternut Squashes	1.1	0.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Cabbage	1.5	0.4	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0	2.5
Tomatoes	8.3	2.8	2.4	1.3	0.5	0.5	0.3	0.4	0.4	0.1	17.0
Peppers	3.4	1.2	0.9	0.5	0.1	0.1	0.1	0.1	0.0	0.0	6.4
English Cucumbers	1.1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Grand Total	**47.1**	**18.9**	**10.2**	**9.3**	**3.7**	**2.6**	**2.7**	**2.1**	**1.9**	**1.4**	**100**

4.5. Sustainable farming techniques

Table 5 depicts statistics on the sustainable farming practices that tomato farmers use. According to the data, 59 of the surveyed tomato producers employ crop rotation, a key sustainable strategy fostering soil health and pest management. On the other hand, 23 of tomato growers embraced organic farming, demonstrating their dedication to reducing chemical input use. A smaller proportion of farmers (2.27% for each practice) use integrated pest management and cover crops, while about 5% employ resistant varieties

to manage pests and diseases. Other sustainable practices account for around 9.09%, respectively.

Table 5 : Farming practices used by tomato farmers

Farming practice used	Percent (%)
Organic farming	22.73
Integrated pest management	2.27
Cover crops	2.27
Crop rotation	59.09
Resistant varieties	4.55
Other	9.09

Source: NAMC survey data

Figure 21 depicts statistics on what farmers believe are the benefits of employing sustainable tomato production practices. According to farmer responses, the main benefits of using sustainable farming practices in tomato production are high yields (46%), low pest incidences (21%), other unlisted benefits (18%), and the ability to avoid crop failure (16%).

Figure 21: Advantages of using sustainable farming methods
Source: NAMC survey data

4.6. Discussion

4.6.1. Current challenges facing sustainable tomato production

Sustainable tomato production faces numerous challenges in South Africa. Key issues include high input costs, pests and diseases, postharvest losses, and marketing difficulties (Gatahi, 2020, Buthelezi et al., 2023). This is supported by responses from key informant interviews, which revealed that "*Tutor absoluta is one of the major challenges farmers are battling with. Another hurdle noted was pests – especially aphids and whiteflies which transmit viruses that affect tomatoes, e.g. the tomato yellow leaf curl virus"*. Buthelezi et al. (2023 2021) further elaborate those harsh environmental conditions such as extremely high and low temperatures, and pest and disease infestation exacerbate farmers' challenges. The above-mentioned factors delay the maturity of tomatoes and cause uneven ripening, fruit abrasion, as well as blemishes, which consequently result in poor fruit quality and reduced shelf life. These effects collectively compromise the marketability of tomatoes.

In Africa, post-harvest challenges such as improper harvesting, poor transportation, and lack of storage facilities significantly impact profitability (Arah *et al*., 2015). Climate change-induced stresses and limited breeding initiatives further hinder production in sub-Saharan Africa (Ddamulira & Maphosa, 2020; Buthelezi et al., 2023). However,

opportunities exist to address these challenges. Implementing plant diversity strategies can mitigate biotic and abiotic stresses, with companion crops like Vicia villosa, Coriandrum sativum, and Allium cepa showing promise (Cruz-López et al., 2024). Other potential solutions include adopting organic production methods, improving value-addition processes (Gatahi, 2020), utilizing low-cost intermediate technologies (Arah *et al.*, 2015), and embracing modern breeding techniques like CRISPR and gene sequencing (Ddamulira & Maphosa, 2020). Desneux *et al.* (2022) also commend the use of integrated pest management initiatives. All the above-mentioned approaches potentially enhance the sustainability and profitability of tomato production. DNA Smallholders' demand for funds to invest in machinery and equipment as well as permanent improvements continues to be a major obstacle to loan availability. Economics (2025) reckons that due to their lack of freehold ownership of the land they farm, many are unable to obtain the required funds. Before granting loans for such farmers, the majority of banking institutions still need property ownership as collateral. Although some lenders might provide financing for movable assets, they usually only do so in exchange for the asset's worth and do not take other types of collateral.

4.6.2. Sustainable farming practices

Sustainable tomato farming in South Africa faces challenges due to yield gaps and economic pressures (Malherbe & Marais, 2015). Smallholder farmers show lower technical efficiency compared to commercial farmers, highlighting the need for improved resource management (Gwebu & Matthews, 2018). To optimize water and fertilizer use, research suggests that fertilization scheduling significantly affects tomato yields, while irrigation scheduling has a minor role (Albasha *et al*., 2020). Implementing innovative technologies and improved management practices can increase water productivity and yield. A study in Giyani demonstrated that drip irrigation outperformed traditional furrow irrigation, and introducing better soil nutrient management and mulching practices led to substantial increases in tomato yield from 26.5 t/ha to 120.9 t/ha and water productivity from 4.61 kg/m-3 to 17.69 kg/m-3 (Pienaar, 2014). These findings emphasize the

importance of adopting sustainable farming methods to enhance productivity and resource efficiency in South African tomato production.

Whereas sustainable farming practices such as integrated pest management, organic farming, and the use of resistant varieties have been documented to be beneficial, especially when complemented with irrigation and/or fertigation, they are also associated with high input costs and environmental concerns. Environmental issues are eminent in instances where synthetic agro-inputs are used. Another nonchemical proven practice in fruit production is the use of preharvest bags (Liu *et al*., 2015; Sharma and Sanikommu, 2018). In economic terms, the use of preharvest bags in tomatoes is noted to reduce the average production costs by approximately 41% per hectare when compared with the use of agrochemicals (Filgueiras *et al*., 2017). Similar benefits emanating from the use of preharvest bags are documented for other fruits –e.g. mangoes (Islam *et al*., 2017; Afsar and Sultana, 2019).

However, Buthelezi *et al.* (2021) reckon that whereas the preharvest bagging technology is very beneficial and safe to use, it might be challenging to implement in expansive commercial production. Therefore, it is commendable for small- to medium-scale tomato production. The effectiveness of the preharvest bagging technique lies in the ability to enhance a suitable microclimate while physically deterring pests and disease-transmitting organisms from getting in direct contact with the fruit. The technique is also documented to improve upon other quality attributes, including uniform ripening, dry matter content, fruit appearance, and fruit size (Buthelezi et al (2022). All these attributes directly foster the marketability of the produce.

5. Conclusion

Despite the importance of tomatoes in South Africa, the tomato industry is currently experiencing many difficulties potentially rendering it unsustainable. Thus, this study aimed to scrutinize the challenges affecting tomato production as well as the sustainable farming practices used by farmers. The study used a structured question to survey farmers from Limpopo and Gauteng Provinces. Basic descriptive analysis was used to

understand the intricacies faced by farmers. This study established that there are several challenges affecting the sustainable production of tomatoes in South Africa. The challenges encountered are broadly categorized into two, namely environmental and economic challenges. Environment-related challenges are both biotic and abiotic. Biotic challenges entail pests and diseases, including Tutor absoluta, aphids, and the whitefly, among others. Manifestation of biotic challenges is exacerbated by abiotic challenges such as drought, and water shortages.

On the other hand, more than 60% reckoned that the high cost of inputs was the major economic challenge factor, followed by barriers to market entry. In a bid to sustain tomato production, farmers use various practices, including integrated pest management, organic farming, crop rotation, and cover cropping. A majority of the farmers (59.09%) who participated in the study use crop rotation, followed by organic farming practices. A small proportion of the farmers use integrated pest management and cover crop practices.

6. Recommendations

Based on the current study's findings and recent work by Buthelezi *et al*. (2021; 2022) and Afsar and Sultana (2019), among others, it is recommended that smallholder farmers explore the use of preharvest bagging. The technology not only significantly reduces production costs coupled with the associated environmental attributes; it is documented to improve the quality of tomatoes. Preharvest bagging enhances a microclimate suitable for uniform ripening, increased dry matter content, no sunburns and blemishes, while accelerating maturity, among other quality aspects (Antolinos et al. 2020; Casals et al. 2019). Preharvest bagging is very important since in most cases smallholder farmers' fruits hardly meet the high market quality standards, thereby being discriminated out of the formal market structure (Ndlovu & Masuku, 2021; Tilburg & van Schalkwyk, 2012).

Following Lu *et al.* (2009), we further recommend the use of biodegradable starch-based polymers since their development might be an alternative solution for reducing the use of plastics and environmental problems. Biodegradable bags completely decompose within

a reasonably short period (up to 5 years). Buthelezi et al (2021) articulate that using a combination of cassava starch and polybutylene succinate provides a biodegradable material. With the emerging cassava industry in South Africa, this further presents agro-processing opportunities since cassava starch is noted to be relatively more affordable.

Therefore, in light of the identified challenges, including pests and diseases, harsh climatic conditions as well as market access entry barriers, the documented evidence, as seen in other fruits and vegetables affirms that the biodegradable preharvest bags are a very suitable option for addressing the challenges. For sustainable production practices, it is commendable that small-scale tomato producers explore the use of crop rotation given its numerous advantages.

To minimize the high competition faced by local producers against imported tomato products, DNA Economics (2025) contends that tomato farmers with prospects to process (or those already running small processing units) should be supported to produce differentiated products by value addition. Therefore, research and development (R&D), incentive-driven innovations customized for the benefit of small-scale tomato farmers involved in value addition activities should be prioritized. This will also reduce the overreliance on contracts dictated by large-scale processors. Additionally, government support (e.g., through small-scale farmer-tailored access to concessional finance) should be provided to small-scale tomato producers that exhibit economically viable operations. Most importantly, their scale of operation should be rated at the same level as the commercial producers.

Within the Agriculture and Agro-Processing Master Plan (AAMP) framework, it is commendable to action the following interventions to generally boost tomato production among small-scale tomato producers in South Africa.

***Table 6:* Summary of AAMP interventions for the horticulture value chains**

Intervention	Description
Resolving Policy Ambiguities and Creating an Investment-Friendly Environment	• Energy Access: Improve access to alternative energy sources such as solar and wind to support sustainable agricultural practices. • Legislative Monitoring: Oversee the progression of key bills (e.g., APAC Amendment Bill) to ensure alignment with sector goals. • Public-Private Partnerships (PPPs): Collaborate with strategic agricultural input suppliers to enhance capacity and reduce the backlog in applications for Act 36 amendments. • Institutional Review: Conduct reviews of land reform programs (e.g., CPAs and Trusts) to resolve institutional challenges affecting fruit industry participants.
Creating Enabling Infrastructure	• Water Infrastructure: Expand and maintain irrigation infrastructure. • Transport: Revise and implement the Road to Rail strategy to increase the share of fruit transported by rail, aiming for efficiency in port operations and equipment modernization. • Comprehensive Support: Provide holistic support including affordable credit, land, water, and training for commercial and emerging farmers.
Farmer Support, Development Finance, and Extension Services	• Blended Financing: Explore blended finance models, customized to benefit small-scale producers to enable them to cover high production costs. • Extension Services: Partner with commodity organizations to provide technical assistance through secondment programs for extension officers. • Disaster Support: Develop an effective insurance scheme and disaster management strategy to address droughts and natural calamities.
Improving Food Security and Employment	• Production Growth: Target increases in production and employment, • Land Reform: Revitalize PLAS farms suitable for horticulture and transfer title deeds to successful producers for better financing access.
Localized Food and Import Replacement	• Import Protection: Implement measures to protect local producers from cheap, dumped, or illicit products,

Adapted from DNA Economics (2025).

7. Proposed implementation plan

Based on the AAMP pillars, **Table 7** presents a breakdown of the proposed implementation plan through which smallholder producers might be supported further to sustain tomato production in South Africa.

Table 7: Proposed implementation plan to sustain tomato production among smallholder farmers

AAMP pillar	Research questions	Research focus areas	Recommendations	Activities	Output	Responsibilities
Pillar-3 Providing comprehensive farmer support, development finance, R&D, and extension services	To identify factors influencing farmers' choice of tomato cultivars to grow in South Africa.	**Decision-making drivers on the choice of cultivar** -Potential yield -Drought tolerant -Disease resistance -Quality of the product and price -Input production costs levels.	Capacity building of smallholder farmers on the potential of various tomato cultivars. Strengthen the interface between smallholder farmers and various research institutions such as the Agricultural Research Council (ARC) and academia.	Training of smallholder farmers. Provide coaching and mentorship to smallholder farmers.	Increased productivity by smallholder farmers on the suitability and potential of each cultivar	DoA, PDA, ARC, Industry associations, Seed companies
	To comprehensively understand the challenges faced by small-scale tomato farmers in South Africa.	**Challenges faced by smallholder tomato farmers** -High production costs -Limited availability of adequate and effective extension services -Lack of access to information -Lack of access to finance.	Establish a smallholder farmers' commodity association. Interface smallholder farmers with extension officers. Embark on awareness campaigns to explain available funding instruments to farmers. Disseminate information required by smallholder farmers through the commodity association.	Facilitate the formation of commodity association(s) amongst smallholder farmers. Link smallholder farmers with the extension service Package and distribute information to farmers	Improved productivity Better awareness of channels to address challenges faced by farmers.	DoA, PDA, ARC, Industry associations, Local municipalities.
	To identify the different sustainable farming techniques used in tomato production among small-	**Sustainable farming practices** -Environmental Biotic: pest and disease Abiotic: drought, excessive rainfall etc -Economic and financial	Organic farming. Integrated pest management. Crop rotation. Resistant cultivar varieties.	Interface farmers to adequate and efficient extension service program(s). Training of smallholder farmers.	Appreciation of the potential and benefits of sustainable tomato farming practices.	DoA, PDA, ARC, Industry associations, Seed companies

	scale farmers in South Africa.		Access to financial and non-financial support.	Provide coaching and mentorship to smallholder farmers.		
Pillar-5 Enabling markets expansion, improving market access and trade facilitation	To describe smallholder market access estimates for the top-traded vegetables in 2024.	The potential of tomatoes when compared to other top-traded vegetables	The main channel to the market for smallholder farmers is the fresh produce market and informal channels. Conduct a demand and supply estimate of the market for smallholder farmers.	Implement agricultural marketing skills programmes. Implement the AAMP.	Reduced postharvest losses by smallholder farmers. Increased market access among smallholder farmers	DoA, PDA, ARC, Industry associations, Local municipalities, NAMC.

8. Study limitations and areas for further research

Farmers' response rate was very low, rendering profitability analysis of the various sustainable farming practices impossible. Thus, there is a need for future research to assess the profitability of the various farming practices used by both smallholder and commercial farmers.

9. Reference

Abdelkader, M., Elkhawaga, F. A., Suliman, A. A., Puchkov, M., Kuranova, K. N., Mahmoud, M. H., & Abdelkader, M. F. (2024). Understanding the Regular Biological Mechanism of Susceptibility of Tomato Plants to Low Incidences of Blossom-End Rot. *Horticulturae*, *10*(6), 648.

ADAMA (2024). Tomato farming in South Africa. Available at: https://www.adama.com/south-africa/en/tomato-farming/tomato-farming-south-africa

Afsar, M., & Sultana, N. (2019). Effects of different bagging materials on mango production: Assessment of profitability and fruit quality. *J. Agr. Rural Res*, 4(1), 11.

Agbiz (2018). The Current State of Fruit & Vegetable Agro-Processing in South Africa. Available at: https://agbiz.co.za/uploads/AgbizNews19/190215_Current-state-of-agro-processing-in%20SA.pdf

Agricultural Research Council, (*n.d*). The tomato, a versatile, popular and vulnerable crop, Summer Vegetables 012. Available at: https://arc.agric.za/Agricultural%20Sector%20News/The%20tomato%20-%20a%20versatile,%20popular%20and%20vulnerable%20crop.pdf (accessed on 09 May 2024).

Akimowicz, M., Vyn, R.J., Cummings, H. and Landman, K. (2018). An introduction to mixed methods research in agricultural economics: The example of farm investment in Ontario's Greenbelt, Canada. *Journal of Rural Studies*, 61, pp.162-174.

Albasha, R., Jovanovic, N., Cheviron, B., De Clercq, W., & Mailhol, J. C. (2020). Optimizing tomato water and fertilizer uses in smallholder farms in South Africa using the Piloten model. *Irrigation and Drainage*, 69, 100-116.

Antolinos, V., Sánchez-Martínez, M. J., Maestre-Valero, J. F., López-Gómez, A., & Martínez-Hernández, G. B. (2020). Effects of irrigation with desalinated seawater and hydroponic system on tomato quality. *Water*, *12*(2), 518.

Arah, I. K., Kumah, E. K., Anku, E. K., & Amaglo, H. (2015). An overview of post-harvest losses in tomato production in Africa: causes and possible prevention strategies. *Journal of Biology, Agriculture and Healthcare*, *5*(16), 78-88.

Ashraf, L., Saher, L., Rashid, S., Shakeel, A., Ghous, H. F., & Asghar, A. (2024). Assessment of Genetic Variability in Solanum lycopersicum L. Genotypes for Yield and Yield Attributing Traits. *Trends in Biotechnology and Plans Science.* DOI: https://doi.org/10.62460/TBPS/2025.069

Baliyan, S. P., & Rao, M. S. (2013). Evaluation of tomato varieties for pest and disease adaptation and productivity in Botswana. *International Journal of Agricultural and Food Research*, *2*(3), 20-29.

Bayat, A., Louw, W. and Rena, R. (2014). The impact of socio-economic factors on the performance of selected high school learners in the Western Cape Province, South Africa. *Journal of Human Ecology*, Vol. 45 No. 3, pp. 183- 196.

Bosch, S. E., Louw, A. J., & Aucamp, E. (1985). 'Rodade' bacterial wilt resistant tomato.

Bozo, T. T., Mpambani, B., Mbenga, A., & Mhlontlo, S. (2019). Comparative Studies on yield and quality response of soil and soilless grown tomatoes: the case study of Masiphathisane community project and Bathurst Experimental Farm. *South African Journal of Agricultural Extension, 47*(4), 75-85. https://doi.org/10.17159/2413-3221/2019/v47n4a527

Brévault, T., Sylla, S., Diatte, M., Bernadas, G., & Diarra, K. (2014). Tuta absoluta Meyrick (Lepidoptera: Gelechiidae): A New Threat to Tomato Production in Sub-Saharan Africa.

Buthelezi, N. M. D., Olowoyo, J. O., & Mafeo, T. P. (2023). Influence of Preharvest Bagging on Maturity Indices and Postharvest Quality of Cherry Tomato (Solanum lycopersicum var. cerasiforme). *HortScience*, *58*(1), 95-104. https://doi.org/10.21273/HORTSCI16844-22

Buthelezi, N. M. D., Mafeo, T. P., & Mathaba, N. (2021). Preharvest Bagging as an Alternative Technique for Enhancing Fruit Quality: A Review. *HortTechnology hortte*, *31*(1), 4-13. https://doi.org/10.21273/HORTTECH04658-20

Casals, J., Rivera, A., Sabaté, J., Romero del Castillo, R., & Simó, J. (2019). Cherry and Fresh Market Tomatoes: Differences in Chemical, Morphological, and Sensory Traits and Their Implications for Consumer Acceptance. *Agronomy*, *9*(1), 9. https://doi.org/10.3390/agronomy9010009

Cuartero, J., Bolarin, M.C., Asins, M.J. and Moreno, V., 2006. Increasing salt tolerance in the tomato. Journal of experimental botany, 57(5), pp.1045-1058.

Dam, B.V., Goffau, M.D., Lidth de Jeude, J.V. and Naika, S., 2005. Cultivation of tomato: Production, processing and marketing. Agromisa.

DALRRD (2020). A profile of the South African tomato market value chain. Available at: https://www.dalrrd.gov.za/images/Branches/Economica%20Development%20Tra

de%20and%20Marketing/marketing/annual-publications/vegetables/tomato-market-value-chain-profile-2020.pdf

DALRRD (2024). A profile of the South African Tomato Market Value Chain. Available at: https://www.dalrrd.gov.za/images/Branches/Economica%20Development%20Trade%20and%20Marketing/marketing/annual-publications/vegetables/tomato-market-value-chain-profile-2020.pdf

Ddamulira, G., & Maphosa, M. (2020). Tomato breeding in sub-Saharan Africa - challenges and opportunities: a review.

Department of Agriculture, Forestry and Fisheries (DAFF), 2019, A Profile of South African Tomato Market Value Chain.

Desneux, N., Han, P., Mansour, R. *et al.* (2022). Integrated pest management of *Tuta absoluta*: practical implementations across different world regions. *J Pest Sci.,* 95, 17–39. https://doi.org/10.1007/s10340-021-01442-8

DNA Economics (2025). In-Depth Research Analysis of The Tomato Paste Value Chain in South Africa. Value Chain Analysis, Prioritization & Options Analysis Report.

Directorate: Statistics (2021). Trends in the agriculture sector. Available at: https://www.dalrrd.gov.za/phocadownloadpap/Statistics_and_Economic_Analysis/Statistical_Information/Trends%20in%20the%20Agricultural%20Sector%202021.pdf.

Dube, J., Ddamulira, G. and Maphosa, M., 2020. Tomato breeding in sub-Saharan Africa-Challenges and opportunities: A review. African Crop Science Journal, 28(1), pp.131-140.

Erhenhi, A.H., Lemy, E.E., Vwioko, D.E. and Imene, O., 2019. Growth of tomato (Solanum llycopersicum L.) under waterlogging condition. *European Journal of Scientific Research*, 152(4), pp.509-515.

Fetters, M.D. and Freshwater, D. (2015). Publishing a methodological mixed methods research article. Journal of Mixed Methods Research, 9(3), pp.203-213.

Filgueiras, R. M. C., Pastori, P. L., Pereira, F. F., Coutinho, C. R., Kassab, S. O., & Bezerra, L. C. M. (2017). Agronomical indicators and incidence of insect borers of tomato fruits protected with non-woven fabric bags. *Ciência Rural*, 47, e20160278.

Food and Agriculture Organization of the United Nations (2022). Compare data, FAOSTAT, Available at: (accessed on 09 May 2024).

Food and Agriculture Organization of the United Nations, (2022). Crops and livestock products, FAOSTAT. Available at: https://www.fao.org/faostat/en/#data/QCL (accessed on 09 May 2024).

Fufa, F., Hanson, P., Dagnoko, S. and Dhaliwal, M. (2009). AVRDC-The World Vegetable Center tomato breeding in sub-Saharan Africa: Lessons from the past, present work, and future prospects. In I All Africa Horticultural Congress 911 (pp. 87-98).

Gardening (2025). Tomato Floradade Seeds – Heat-Tolerant and High-Yielding. Available at: https://gardening.co.za/products/tomato-floradade#:~:text=Tomato%20Floradade%20is%20a%20determinate,while%20still%20producing%20high%20yields.

Gatahi, D.M. (2020). Challenges and Opportunities in Tomato Production Chain and Sustainable Standards. *Journal of Horticultural Science*, 7, 235-262.

Gobu, R., Shiv, A., Kumar, C.A., Basavaraj, P.S., Harish, D., Adhikari, S., Vinita, R., Umesh, H. and Sujatha, M., 2020. Accelerated crop breeding towards development of climate resilient varieties. Climate change and Indian Agriculture: Challenges and Adaptation Strategies

Goldfield farm supplies (2025). Floradade Tomato (100% Heirloom/Non-Hybrid/Non-GMO). Available at: https://www.farmsupplies.co.za/tomato-floradade-1kg?srsltid=AfmBOopkjQnR2tHG-RbpQlnTqsIHEFOodkwOHFMkRi7_1rIyBK7qu0MW

Gwebu, J.Z., & Matthews, N. (2018). Meta frontier analysis of commercial and smallholder tomato production: A South African case. *South African Journal of Science, 114*(7-8), 55-62.

Harika, R., Faber, M., Samuel, F., Kimiywe, J., Mulugeta, A. and Eilander, A., 2017. Micronutrient status and dietary intake of iron, vitamin A, iodine, folate and zinc in women of reproductive age and pregnant women in Ethiopia, Kenya,Nigeria and South Africa: a systematic review of data from 2005 to 2015. *Nutrients*, 9(10), p.1096.

Harwell, M. (2012). Multisite Studies and Scaling up in Educational Research, Educational Research Quarterly. Document available online: https://eric.ed.gov/?id=EJ1061944 [Accessed 16 August 2024].

Hellin, J. and Meijer, M. (2006). Guidelines for value chain analysis. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Islam, M. T., Rahman, M. S., Shamsuzzoha, M., Chowdhury, A. K. M. M. B., & Alom, R. (2017). Influence of pre-harvest bagging on fruit quality of Mango (Mangifera indica L.) cv. Mishribhog. *International Journal of Biosciences*, *11*(3), 59-68.

Kellogg Garden Products (2021). Determinate Tomatoes vs. Indeterminate Tomatoes. Available at: https://kellogggarden.com/blog/gardening/determinate-tomatoes-vs-indeterminate-

tomatoes/#:~:text=Indeterminate%20tomatoes%20are%20those%20that,tall%20tomato%20trellises%20and%20cages.

Koza, W. (2022). Effects of climate variability on small-scale production of tomatoes (solarium lycopersicum) in Mopani District of Limpopo Province, South Africa (Doctoral dissertation).

Kumar, A., Kumar, V., Gull, A. and Nayik, G.A. (2020). Tomato (Solanum Lycopersicon). Antioxidants in vegetables and nuts-Properties and health benefits, pp.191-207.

Kumar, A., Kanwar, M. S., Gupta, V., Narayan, S., Lamo, K., Malik, A. A., & Singh, P. K. (2021). Abiotic Anomalies and Their Management in Solanaceous Vegetables. *Agriculture Practices*, 66.

KZNDard (*nd*). Tomato. Available at: https://www.kzndard.gov.za/images/Documents/Horticulture/Veg_prod/tomato.pdf

Lawal, M. K., Ayanlola, P. S., Raji, I. A., Owoade, R. A., Adeoje, E. A., Oladapo, O. O., ... & Isola, G. A. (2022). Influence of Pre-Planting and Post-Harvest X-ray irradiation on the Morphological Traits, Shelf-Life, Microbial Load, and Proximate Contents of Tomato (Solanum Lycopersicum). *Shelf-Life, Microbial Load, and Proximate Contents of Tomato (Solanum Lycopersicum)*. http://dx.doi.org/10.2139/ssrn.4215158

Liu, T., Song, S., Yuan, Y., Wu, D., Chen, M., Sun, Q., ... & Chen, K. (2015). Improved peach peel color development by fruit bagging. Enhanced expression of anthocyanin biosynthetic and regulatory genes using white non-woven polypropylene as replacement for yellow paper. *Scientia Horticulturae*, *184*, 142-148.

Louw, A. (2013). Sustainable policy support for smallholder agriculture in South Africa: Key issues and options for consideration. Smallholder and agro-food value chains in South Africa: Emerging practices, emerging challenges. Cape Town: Institute of Poverty, Land and Agrarian Studies (PLAAS).

Lu, D. R., Xiao, C. M., & Xu, S. J. (2009). Starch-based completely biodegradable polymer materials. *Express polymer letters*, *3*(6), 366-375.

Maboko M.M., du Plooy, C.P., Bertling, I. (2009). Comparative performance of tomato on soilless vs in-soil production systems. *Acta Horticulturae,* 843, 319-326.

Maboko, M.M. (2013). Yield and quality parameters of tomato cultivars as affected by different soilless production systems and beneficial micro-organisms.

Malherbe, S. (2016). The interactions between biotic and abiotic factors that influence the sustainability of tomato production in South Africa. University of Pretoria (South Africa).

Malherbe, S., and Marais, D. (2015). Economics, Yield and Ecology: A Case Study from the South African Tomato Industry. *Outlook on Agriculture*, 44(1), 37-47. https://doi.org/10.5367/oa.2015.0195

Malhi, G.S., Kaur, M. and Kaushik, P., 2021. Impact of climate change on agriculture and its mitigation strategies: A review. *Sustainability*, 13(3), p.1318.

Massel, K., Lam, Y., Wong, A.C., Hickey, L.T., Borrell, A.K. and Godwin, I.D., 2021. Hotter, drier, CRISPR: the latest edit on climate change. *Theoretical and Applied Genetics*, 134(6), pp.1691-1709.

Mbunge, E. (2020). Effects of COVID-19 in South African health system and society: An explanatory study. Diabetes and Metabolic Syndrome. *Clinical Research and Reviews*. Vol. 14 No. 6, pp. 1809-1814.

Mohan, A., Krishnan, R., Arshinder, K., Vandore, J. and Ramanathan, U., 2023. Management of postharvest losses and wastages in the Indian tomato supply chain—a temperature-controlled storage perspective. Sustainability, 15(2), p.1331.

Naika S, Juede J, Goffau M, Hilmi M, Dam V (2005). "Cultivation of Tomato". Production, processing and marketing, Agromisa/ CTA. Revised edition, 2005 Agrodokseries No 17.

NAMC (2025). Smallholder market Access Estimates quarter 3. Available online: https://www.namc.co.za/wp-content/uploads/2025/02/SMALLHOLDER-MARKET-ACCESS-ESTIMATES-QUARTER-3.pdf

Ndlovu, C., & Masuku, M. (2021). Small-scale Farming and Access to Market: Challenges and Opportunities in South Africa. *Journal La Sociale*, *2*(5), 50-63. https://doi.org/10.37899/journal-la-sociale.v2i5.491

Olowe, O.M., Nicola, L., Asemoloye, M.D., Akanmu, A.O. and Babalola, O.O. (2022). Trichoderma: Potential bio-resource for the management of tomato root rot diseases in Africa. *Microbiological Research*, 257, p.126978.

Perez, K.W., Froikin-Gordon, J.S., Abdourhamane, I.K., Levasseur, V., Alfari, A.A., Mensah, A.C., Bonsu, O., Habsatou, B., Assogba-komlan, F., Mbaye, A.A., Noussourou, M., Otoidobiga, L.C., Ouédraogo, L., Kon, T., Rojas, M.R., Gamby, K.T., Shotkoski, F.A., Gilbertson, R.L., & Jahn, M.M. (2017). Connecting smallholder tomato producers to improved seed in West Africa. Agriculture & Food Security, 6.

Pienaar, C. J. (2014). Increased Water Productivity in irrigated Tomato production in the smallholder farming community of Giyani (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Post Harvest Innovation, nd. Tomatoes. Available online: https://postharvestinnovation.org.za/commodities/tomatoes/. [Accessed 20 June 2024]

ReportLinker (2025). South Africa Tomato Industry Outlook 2022 – 2026. Available at: https://www.reportlinker.com/clp/country/484797/726333

Sanganza, H. (2021). A competitive advantage analysis of South African vegetable sector: tomatoes, carrots and onions (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Shikwambana, S., Malaza, N. and Ncube, B. (2022). Enhancing the resilience and adaptive capacity of smallholder farmers to drought in the Limpopo Province, South Africa. *Conservation*, 2(3).

Sibomana, M.S., Workneh, T.S. and Audain, K.J.F.S. (2016). A review of postharvest handling and losses in the fresh tomato supply chain: a focus on Sub-Saharan Africa. *Food Security*, 8, pp.389-404.

Simelane, T., Mutanga, S.S., Hongoro, C., *et al.* (2023). National Food and Nutrition Security Survey: National Report: HSRC: Pretoria.

Surni, S., Saediman, H., Wulandari, F., Zani, M., Yunus, L., & Taridala, S. A. A. (2020). Profitability and constraints of small-scale tomato production in Baubau municipality of Southeast Sulawesi. *WSEAS Transactions on Environment and Development*, 16, 219-225.

Srivastava, S., Singh, L., Debnath, B., Shukla, M., Kumar, S., Rana, M., & Meshram, S. (2022). Blossom end-rot (BER): an abiotic devastating disorder of tomato. *Climate Change and Environmental Sustainability*, *10*(1), 15-22.

Sharma, R. R., & Sanikommu, V. R. (2018). Preharvest fruit bagging for better protection and postharvest quality of horticultural produce. In *Preharvest modulation of postharvest fruit and vegetable quality* (pp. 455-489). Academic Press.

South African Cities Network (SACN), 2015. Rural-Urban Linkages: Agro-food value chain. Available online: https://www.sacities.net/publication/rural-urban-linkages-agro-food-value-chain/ [Accessed 20 June 2024].

Starke Ayres (2019). Growing tomatoes. Available at: https://www.starkeayresgc.co.za/wp-content/uploads/2022/04/SAGC-growing-tomatoes.pdf?utm_source=Website&utm_medium=download

Stats SA (2025). Quarterly Labour Force Survey. Available online at: https://www.statssa.gov.za/publications/P0211/P02114thQuarter2024.pdf

Taylor, S. and Yu, D. (2009), "The importance of socio-economic status in determining educational achievement in South Africa". Unpublished working paper (Economics). Stellenbosch: Stellenbosch University, pp. 33-47.

TIPS (2024). Horticulture value chain. Available at: https://www.tips.org.za/manufacturing-data/manufacturing-sectors/item/download/2586_3d5b63be63192b0e1019c9f17b5b36c4

Trade Map (2024), Bilateral trade between South Africa and World Product: 0702 Tomatoes, fresh or chilled Available at:

https://www.trademap.org/Bilateral_TS.aspx?nvpm=1%7c710%7c%7c000%7c%7c0702%7c%7c%7c4%7c1%7c1%7c2%7c2%7c1%7c1%7c1%7c%7c1 (accessed on 09 May 2024)

Tomato News (2024). The processing tomato market in Africa. Available at: https://www.tomatonews.com/en/the-processing-tomato-market-in-africa_2_2256.html

Udoka, O., Kalu, C. M., Kanu, S. A., & Ntushelo, K. (2021). Growth stimulation and yield enhancement of the tomato cultivar Heinz 1370 by Bacillus subtilis (strain BD233) under glasshouse conditions. *Academia Letters*, 2.

van Tilburg, A., & van Schalkwyk, H. D. (2012). Strategies to improve smallholders' market access. *Unlocking markets to smallholders: Lessons from South Africa*, 35-58.

World Health Organization, 2004. Vitamin and mineral requirements in human nutrition. World Health Organization.