TRADE & INDUSTRIAL POLICY STRATEGIES

INDUSTRY STUDY

Technological Change in the Horticulture Industry

May 2025

TIPS industry studies aim to provide a comprehensive overview of key trends in leading industries in South Africa. For each industry covered, working papers will be published on basic economic trends, including value added, employment, investment and market structure; trade by major product and country; impact on the environment as well as threats and opportunities arising from the climate crisis; and the implications of emerging technologies. The studies aim to provide background for policymakers and researchers, and to strengthen our understanding of current challenges and opportunities in each industry as a basis for a more strategic response.

This industry study examines technology advancements in horticulture, drivers for adoption, and impact on firms. It highlights local and international technological changes and constraints to adoption and absorption, and explores domestic support incentives from the government, academia, and private business.

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CONTENTS

TABLES

ABBREVIATIONS

AgriSETA	Agricultural Sector Education Training Authority
AI	Artificial Intelligence
AISI	Aerospace Industry Support Initiative
ARC	Agricultural Research Council
BMS	Breeding Management System
CAP	Common Agricultural Policy
CGA	Citrus Growers Association
CSIR	Council for Scientific and Industrial Research
CRI	Citrus Research International
DALRRD	Department of Agriculture, Land Reform and Rural Development
DSI	Department of Science and Innovation
EU	European Union
FAO	Food and Agriculture Organization
FPEF	Fresh Produce Exporters' Forum
GIS	Geographic Information System
IoT	Internet of Things
LATS	Limpopo Agro-food Technology Station
MAP	Modified Atmosphere Packaging
PC4IR	Presidential Commission on the Fourth Industrial Revolution
PCMs	Phase Change Materials
PHI	Post-Harvest Innovation (Programme)
R4A	Rain for Africa
RFID	Radio Frequency Identification
SMEs	Small and Medium-sized Enterprises
US	United States

INTRODUCTION

Horticulture is an essential component of agriculture, manufacturing and, in some cases, tourism. It contributes significantly to various industries through the supply of fresh and dried fruits and vegetables for retail. In addition, it supports other industries in the production of non-alcoholic beverages, confectionery, dairy products, baked goods, baby food, and cosmetics. Exports of edible fruit and nuts account for 3.94% to total exports of South Africa, growing from R2.7 billion in 2004 to R80 billion constant rands in 2023. As such, technological shifts in transforming production, preservation, processing, packing, and logistics have become integral for the continued growth of a sustainable, efficient, and competitive subsector in the “industrialisation of freshness”.

The drive towards technological change supports the implementation of sustainable agricultural systems, which enhance scale production and operational efficiencies. These new technologies also address climate concerns through efficient water and energy-saving mechanisms and meet ever-changing requirements in trade agreements, consumer preferences, and requirements by financial institutions. COVID-19 disrupted supply chains of essential goods, bolstering the need for increased technology collaboration, cohesion, and coordination among all role players. For example, through the Internet of Things (IoT) to conduct remote conformity assessment procedures, such as remote inspections of agricultural and food processing facilities.

This study analyses technological advancements in the subsector, focusing on four key areas:

- Digital applications such as artificial intelligence (AI), IoT, blockchain, coding systems, and big data.
- Advanced technological equipment such as drones, robotics, automated packhouses, and sophisticated cold chains.
- Advanced science such as biotechnology.
- Processes such as vertical farming.

The study examines technology advancements in horticulture, drivers for adoption, and impact on firms. It also highlights local and international technological changes and constraints to adoption and absorption. Finally, it explores domestic support incentives from the government, academia, and private business.

Horticulture is mainly comprised of products such as the growing and processing of fruit, vegetables, nuts, spice crops, coffee, and tea. Due to the large nature of horticulture, this paper builds on the previous horticulture subsector report, Industry Study: Horticulture Value Chain 2024, looking at the top three traded products HS 8, 7 and 20, “Edible fruit and nuts”, “Edible vegetables”, and “Preparations of vegetables, fruit, nuts”.

Drivers for technologies in horticulture

Adoption of innovative technology in horticulture, as well as the broader agricultural sector, is driven by several key factors. These include mitigating the impacts of climate change, promoting environmental sustainability, and enhancing productivity through higher yields with fewer resources. Additionally, biotechnology is leveraged to meet the escalating global demand. Technology advancements are also influenced by evolving consumer preferences that now demand greater transparency, traceability, and accountability throughout the entire fruit supply chain (Singh et al. 2022). For export-driven industrialisation, there is also the need to comply with dynamic health, safety, and phytosanitary standards, alongside increasingly complex trade regulations.

For example, digitalisation, such as blockchain, has emerged as a key enabler, significantly improving decision-making processes and contributing to essential aspects of food safety, particularly through traceability systems. Blockchain consolidates crucial information such as tracking size, thickness of fruits, specifications, and fertiliser used, among others.

Technological equipment and systems, such as advanced cold chain logistics, have become essential. Temperature fluctuations significantly impact the quality and shelf life of fresh produce after harvest, particularly for citrus. The integration of such technology expands opportunities for broader market access across continents and facilitates deep-sea trade, enhancing global supply chain efficiency and market reach. Advancements such as automation in packhouses, robotics that clean, sanitise, wax, grade by colour, size, and pack for different export market requirements create operational efficiencies and faster lead times. Currently, requirements and regulations of export markets in Asia, Europe, and the United States (US) all differ, and hence technology in packhouses needs to ensure the needed throughput to push the volumes required within a specific period (Habiyaremye et al. 2024).

From a finance perspective, crop insurance underwriters now mandate IoT deployments, promoting precision agriculture and enhancing risk assessment in the agricultural sector. This has seen horticulture, among other crops and livestock production businesses, investing in technological change.

From an environmental perspective, there are both the tremendous impacts of agriculture on the climate and of climate change on agriculture. Globally, the drive for sustainable agriculture, regenerative agriculture, food security, and the water-energy-food nexus has become key in policy development.

Many countries have implemented policies aimed at setting new targets to reduce the environmental impact of agricultural activities through incentives for innovation and technology. The increasing competition for water resources between industrial, agricultural, and domestic use is pressing.

Advancements in AI and IoT, such as sensors that collect and control temperature, soil moisture, and humidity, or advanced solutions such as smart irrigation systems, vertical farming, and deep learning algorithms, optimise crop growth and resource management. These technologies represent critical pathways for reducing agricultural water consumption and fostering climate-resilient agricultural practices.

The integration of biotechnology has been crucial to enabling the development of resilient and high-yield crops. Techniques like delayed ripening, gene editing, and the use of drones for early disease detection in orchids are crucial for boosting production and improving post-harvest preservation. These advancements help minimise crop loss and enhance overall efficiency in both cultivation and supply chain management.

1. TECHNOLOGICAL CHANGE IN HORTICULTURE AND IMPACT ON FIRMS

Table 1 illustrates some examples of technology advancements in horticulture, such as:

- Digital applications such as AI, IoT, blockchain, e-extension officers, coding systems, and big data.
- Advanced technological equipment such as drones, robotics, automated packhouses, sophisticated cold chains, and phase change materials (PCM).
- Advanced science such as biotechnology – delayed ripening, new, tasty, and disease-resistant fruit varieties.
- Advanced processes such as vertical farming.

The impact of advanced technology in horticulture is numerous. Digital applications offer opportunities to enhance, optimise, and improve productivity, such as crop yield, water utilisation, and decision-making. With real-time information, farmers can instantly address problems such as disease detection in orchards. Other applications, such as blockchain, enhance traceability and improve supply chain networks across multiple actors, reducing manual documentation, emails, and loss of paperwork in transit. E-extension officers alleviate information asymmetry and transport costs for farmers. Advanced equipment, such as drones, offers solutions for accessing remote, difficult terrains or surveying large areas in less time and detecting pests, plant diseases, and malnutrition of fruits. Automated pack houses, for example, can clean, sanitise, wax, grade by colour and size into grading systems for local and export markets or different consumer needs conveniently. Advanced cold chain systems help preserve fruit and vegetables, improve health standards, reduce utility costs, and offer market expansion opportunities.

Table 1: Emerging technologies in digitalisation

DIGITALISATION		IMPACT ON FARMERS	ADOPTION REQUIREMENTS
IoT	Devices such as soil sensors, smart irrigation, etc, connected to the internet, collecting data such as: • soil moisture, temperature, humidity • photosynthetic radiation, soil water potential and soil oxygen, nutrients, levels, etc.	• Can enhance, optimise, and improve productivity and crop yield • Can contribute to efficient water and energy-saving mechanisms • Can allow access to remote and real-time information instantly and address problems • May reduce operational expenses, i.e. manual costs	• IT skills • Reliable and fast internet • Subscription to applications • Smart gadgets, i.e, phones or tablets
Digital Twins	These are virtual replicas of physical systems, processes and products, and can use real-time data received from sensors to mirror the actual physical counterpart. In horticulture, virtual recreations of orchards allow for simulation, interrogation, design, prescription, and control of the structure and performance of perennial horticultural food systems.	• Can enhance, optimise, and improve productivity and crop yield. • Adapt designs or new, effective designs	• IT skills • Reliable and fast internet • Subscription to applications • Smart gadgets, i.e. phones or tablets
AI	AI reproduces human intelligence through machines. AI technologies range from machine learning, deep learning, and natural language processing that perform tasks such as identifying patterns, using different variations and algorithms, and features in systems. In horticulture, for example, disease detection, quality assessment, i.e bruising, ripeness, decay, and grading through UV-A light. Smart irrigation mapping before installing systems.	• Can enhance, optimise, and improve productivity and crop yield • Can contribute to efficient water and energy-saving mechanisms • Allows access to remote and real-time information • Improve decisions before installing equipment	• IT skills • Reliable and fast internet • Subscription to applications • Smart gadgets, i.e. phones or tablets

Big Data analytics	Customised weather and agriculture advisory services, e-agriculture marketplace information, disaster alerts, virtual extension officer.	• Can enhance, optimise, and improve productivity or crop yield • Improve decision-making and access to centralised and vast information	• Reliable and fast internet • Subscription to applications
Cloud Computing	Cloud computing in agriculture supports smart farming by leveraging cloud-based data and IoT to make informed decisions about products. It enables real-time monitoring, precise crop management, and enhances precision farming techniques.	• Can enhance, optimise, and improve productivity, crop yield	• Reliable and fast internet • Subscriptions • Smart gadgets, i.e, phones or tablets
Blockchain	Blockchain is a decentralised digital ledger that securely stores, records data across a network of computers, ensuring transparency, immutability, and resistance to tampering. In horticulture, blockchain can be applied to enhance traceability, ensure transparency, enable fair payments, and build consumer trust. It facilitates real-time monitoring of activities throughout the supply chain and optimises logistics, addressing key challenges in the industry.	• Can enhance traceability and improve the supply chain network for efficiency • Enables multiple actors, farmers, processors, and distributors to track the movement of goods • Reduce physical paperwork and storage	• IT skills • Reliable and fast internet • Subscriptions • Smart gadgets, i.e. phones or tablets
Coding QR, RFID	Digital solutions to enhance transparency, track product movement, and help identify potential issues in real-time. Firms can use barcodes or QR codes on product packaging to store essential information such as origin, production date, and batch number. Radio frequency identification (RFID) tags can store more information than barcodes and can be read from a distance.	• Can enhance traceability and improve the supply chain network for efficiency • Can reduce physical paperwork and storage	• IT skills • Reliable and fast internet • Subscriptions • Smart gadgets, i.e, phones, tablets, or tags

Source: Compiled from Chigumira 2018; AgUnity 2024; FAO 2019; Singh et al. 2022; Habiyaremye et al. 2024; Dube and Das Nair 2020; International Fresh Produce Association 2025.

Table 2: Technologies in advanced equipment or machinery

	ADVANCED EQUIPMENT	IMPACT ON FARMERS	ADOPTION REQUIREMENTS
Drones and GIS (Geographic Information System)	Drones can be used in activities such as crop monitoring and precision agriculture. Computer vision in agriculture involves the use of AI algorithms and machine learning techniques to analyse and process images and videos that are captured by	• Accessing remote, difficult terrain or large areas in real-time • Enhance, optimise, and improve crop yield productivity	• Finance and access to equipment • IT skills and interpretation of data

	cameras or sensors. In horticulture robotics with vision for the detection in orchards of pests, plant diseases, malnutrition of fruits, ripeness, etc.	• Detect and address diseases in orchards	• Reliable and fast internet
Robotics	Equipped with several robotic manipulators, agribots can be used in packhouses for picking fruit. Analyse fruit ripeness and transport via a conveyor system to a packaging area. Automated tractors for planting, harvesting, or other farming tasks. They are equipped with sensors for automatic navigation and obstacle avoidance.	• Efficiency in operating and monitoring remotely • Efficiency in packhouses	• Finance and access to equipment • Maintenance and software updates • Access to IT engineering skills
Automated Packhouses	Automated pack houses that clean, sanitise, wax, grade by colour and size into grading systems for local and export markets, or different consumer needs.	• Enhanced efficiency. • Optimised supply chains	• Finance and access to equipment • Access to IT engineering skills
Advanced Cold Chain	A set of procedures and equipment with adaptable modular and atmospheric temperature-controlled systems for the storage, transportation, and distribution of perishable goods. It can be equipped to be energy efficient, reduce carbon emissions, use lightweight and expandable smart materials for different fruits and vegetables, and provide remote access.	• Quality preservation: helps retain original colour, texture, flavour, and nutritional content. • Reduced food waste • Market reach expansion through longer shelf life. • Food safety: helps prevent the growth of harmful bacteria • Meet various trade regulations	• Finance and access to equipment • Skills and interpretation of data • Reliable and fast internet

Source: Compiled from Chigumira 2018; AgUnity 2024; FAO 2019; Singh et al. 2022; Habiyaremye et al. 2024; Dube and Das Nair 2020; International Fresh Produce Association 2025.

Table 3: Technologies in food science

	ADVANCED FOOD SCIENCES	IMPACT ON FARMERS	ADOPTION REQUIREMENTS
Biotechnology	Advancements include gene editing, which is used for plant breeding to grow varieties that are adaptable, and Delayed Ripening physiological and molecular strategies to delay ethylene-mediated ripening in climacteric fruits and their impact on shelf life, postharvest quality, sensory attributes, and volatile compounds.	• Reduced food waste • Market reach expansion: longer shelf life • Quality preservation	• Access to food and agricultural scientists

Source: Compiled from Chigumira 2018; AgUnity 2024; FAO 2019, Singh et al. 2022; Habiyaremye et al. 2024; Dube And Das Nair 2020; International Fresh Produce Association 2025.

Table 4: Technologies in processes

	ADVANCED PROCESSES IN SMART FARMING	IMPACT ON FARMERS	ADOPTION REQUIREMENTS
Hydroponics	Produce differently using new/better technologies and innovations. Hydroponics refers to growing plants without soil. Since the water carrying nutrients to the growing plants can be reused, hydroponic systems require 70% to 90% less water. Only a select variety of agricultural products can be grown, mainly leafy greens.	• Water efficient. • Space optimisation. • Enhanced efficiency	• Finance and access to equipment
Automated Vertical farming	Method of growing crops in vertically stacked layers and uses controlled-environment agriculture technology to regulate environmental factors such as light and temperature. Some systems are automated, some with automatic SMS text messaging for any faults.	• Water efficient. • Space optimisation. • Enhanced efficiency	• Access to warehouses or greenhouses • Access to automated systems

Source: Compiled from Chigumira 2018; AgUnity 2024; FAO 2019; Singh et al. 2022; Habiyaremye et al. 2024; Dube and Das Nair 2020; International Fresh Produce Association 2025.

2. USAGE ACROSS OTHER SECTORS

Technologies utilised in horticulture cut across other agricultural subsectors, manufacturing, mining, and aviation. Developments in those sectors have led to modifications for agricultural usage and, in some cases, specific to horticulture.

Digitalisation apps across multiple sectors can be modified for the agricultural sector, for crops, or livestock management, and even within horticulture for different fruits.

Blockchain technology, for example, is versatile among many industries and emanates from Distributed Ledger Technology (DLT) in the financial sector, but can be applied in the manufacturing, utilities, health, and energy sectors. With some companies, blockchain systems can be verified by scanning a QR code. Across agriculture, blockchain is used in fisheries to track and deter illegal, unreported, and unregulated fishing (FAO 2019).

Drone technology, for example, has been adapted from aviation in defence systems to mining, agriculture, and water and sanitation to survey orchards or spray crops. Cold chain technology cuts across pharmaceuticals in the storage of vaccines, in manufacturing-sensitive electrical or specialised machinery, and preservation in almost all agricultural products, such as meat or dairy.

Processes such as aquaponics have been adapted and modified with hydroponics to leverage nutrients from fish for growing vegetables for circular systems.

3. INTERNATIONAL TECHNOLOGICAL TRENDS IN THE SECTOR

Support for agriculture through research, innovation, and the use of new technologies varies in countries and regions. In some cases, multinationals such as Nestle, tech companies such as IBM, as well as global organisations such as the Food and Agriculture Organization (FAO), have played a role in driving research and adoption of technologies. The Common Agricultural Policy (CAP) is a key

European Union (EU) policy that supports farmers and technology adoption. One of the key 2023-27 objectives was to enhance market orientation and increase farm competitiveness both in the short and long term, including a greater focus on research, technology, and digitalisation. CAP tools for digitalisation include:

- Investments, for instance, for broadband or the installation of digital technologies in agriculture, forestry, and rural areas, such as investments in precision farming, smart villages, rural businesses, and information and communications technology infrastructures like broadband.
- Eco-schemes and agro-environment-climate commitments to support precision farming technologies, optimising input use.
- Sectoral interventions to purchase digital technologies at any stage of the supply chain, including knowledge exchange or monitoring of product quality.
- Knowledge exchange and information: support training for digital skills, increase awareness and knowledge on digital technologies, and promote exchange of experiences with digital technologies (e.g., demonstration farms).

Overall, more than 274 000 farms are to be supported by digital farming technology to better adapt to new technical developments (EU 2023).

Kumar and Karthikeyan (2019) identified an estimated 101 Agricultural Technology applications in the Apple App Store and 83 applications in the Google Play Store. One of the leading apps is called Rivulis. Rivulis helps farmers plan irrigation systems by calculating total installation costs in advance. The mobile app lets farmers design and plan their irrigation systems easily. The app provides access to an extensive product database, enabling farmers to receive customised quotes before initiating the installation.

Other common apps by large agri-tech giants include Cropwise AI, created by Syngenta, a Swiss company. This app uses machine learning to optimise crop management practices and improve sustainability. From the US are apps such as AGMRI developed by Intelinair, which uses AI-driven analytics and high-resolution imagery to deliver insights into crop health and yield-limiting issues. FarmLogs provides detailed insights into crop health, weather, and soil data, enabling informed decision-making for farmers. Others include FieldMargin, a United Kingdom firm, which helps farmers map fields, track tasks, and manage operations efficiently.

Recent global agri-tech developments include New Zealand's T&G, which has invested US$100 million in a Packhouse in Hawke's Bay. This advanced facility is one of the largest in the Southern Hemisphere, covering 1.7 hectares and capable of packing over 125 million kilograms of apples each season. It incorporates innovative automation and technology throughout. The automation allows for defect sorting, soft fruit handling, and has robotic fruit packers and palletisers, enhancing efficiency and precision (T&G 2023). One of Abu Dhabi's leading food, agriculture, and technology companies, Silal, launched one of the largest automated packhouses in 2024. The world-class facility encompasses an automated system for packing locally grown produce in less than 60 seconds. The automation process calculates the weight, dimension, and condition of fruits and vegetables and adjusts packing accordingly to ensure flawless results (Silal, 2025). Wyma, an Australian company, offers world-leading handling, weighing, packaging, and palletising equipment for fruit processing and packaging, including automated warehouses with robotic bin handling systems, while providing high traceability on data records such as grower ID, quality grade, and harvest date (Wyma Solutions 2025).

Globally, some leading cold chain technologies include PCMs. They encompass the integration of thermal energy storage in cold units to facilitate amounts of cold energy with minimal temperature fluctuations and high energy storage densities (Li, Sha and Zhang 2024). PCMs play a role in refrigeration, temperature control, heat insulation, and energy saving. The integration of PCMs in thermal energy storage units, within air conditioning systems, facilitates the storage of substantial amounts of cold energy and reduces carbon emissions during transportation.

Some global leaders in PCMs are American firms. For example, Honeywell International is known for its innovative PCM solutions that enhance energy efficiency in cold chain applications. DuPont de Nemours provides advanced materials used in perishables, pharmaceuticals, and horticulture. One such innovation is the Tyvek-Cargo Covers, which are covers thrown over cargo that are specifically engineered to address the threat of cold chain breaks during air transit (Du Point 2025). Both DuPont de Nemours and Honeywell International have subsidiaries in South Africa. The firm Cold Chain Technologies leads in reusable and single-use thermal packaging solutions for the shipment of temperature-sensitive products, principally serving the life sciences supply chain. Sasol Chemicals also plays a pivotal role in the latent heat storage industry through the production of essential building blocks for PCMs. This includes the PARAFOL single cut paraffins for latent heat storage applications used in cold chain logistics, functional textiles, and construction (Sasol n.d.).

Recent technology in cold chain sensors has emerged from an Australian firm, PostHarvest Technologies, and its innovative “Environmental Sensor”. The firm manufactures a system of mounted sensors or cloud-based software, designed to monitor environmental conditions like temperature, humidity, ethylene, and carbon dioxide in storage facilities. It provides real-time tracking of these factors without human intervention, ensuring the continuous monitoring of fresh produce (PostHarvest Technologies 2025)

Maersk’s Captain Peter is part of Maersk’s Remote Container Management system. The company has invested in advanced technology and hardware that enables the remote transmission of data from reefer containers. This system tracks various conditions, including in-transit temperature, humidity, and atmospheric levels, ensuring real-time monitoring of container environments (Maersk n.d.).

Blockchain technology in the broader agriculture sector is led by giant tech companies operating across several countries, leading in agricultural production such as the US, EU, China, India, and Australia. These companies include but are not limited to AgriDigital (Australian) and IBM Food Trust (US). IBM Food Trust is used by several major food companies, including Walmart, Nestle, and Unilever. Ambrosus in Switzerland is used by several major food companies, including Nestle and Swiss Food Research. GrainChain (US) is used by several major food companies, including Walmart, Kellogg's, and Cargill (Opeyemi 2024).

4. SOUTH AFRICA TECHNOLOGICAL TRENDS IN THE SECTOR

A variety of technologies are being used and adopted to drive advancements in agriculture and improve the sustainability of agribusiness and food processing in South Africa (Hector 2024).

In digitisation, various farming apps are available for all types of agricultural needs, including planning and management, financial management, farm surveying, soil, water, fertiliser monitoring, and disease surveillance, among others. Most of these are available free or require a subscription on platforms such as the Google Play Store and the Apple Store. Some examples are the Farmers Friend app, developed by IQ Logistica, which aids farm management through mobile devices. It offers tools for field mapping, contract management, weather updates, soil moisture monitoring, and harvest reporting. Macrocomm's Smart Fresh Produce Monitoring System iGrow is another product that has been designed with the specific needs of the citrus market and other horticulture products. It offers monitoring of water systems, temperature and humidity, soil health, animal health, surveillance, and logistics (Macrocomm 2025).

PhytClean was launched a decade ago, with recent updated versions, to replace many of the manual paper-based systems with online or electronic data sharing alternatives. Initially, it was primarily focused on the Citrus Black Spot, a persistent problem blocking local exports to the EU. The system offers an electronic alternative for tracking and verifying all prerequisite steps in the phytosanitary certification process of citrus and stone fruit. This digital system ensures transparency and accessibility for all stakeholders in the fruit value chain, including importing authorities, streamlining compliance, and enhancing efficiency in agricultural exports. This initiative is currently run by the Department of Agriculture, Land Reform and Rural Development (DALRRD) in collaboration with the Department of Science and Innovation (DSI), Fruit SA, Citrus Growers Association (CGA), Hortgro, Fresh Produce Exporters' Forum (FPEF), and Citrus Research International (CRI) (Hardman 2017).

A farm management software, FarmNode, was founded in 2018 by Citrii Software in Stellenbosch. This software includes various modules, such as irrigation monitoring, pest management, and fertiliser management, to enhance farm efficiency and productivity. FarmNode is integrated with packhouses, which provides a better estimate of crop production and adjustment for packing. This software, however, still requires human interaction to investigate the accuracy of information and monitor it. Some advanced technologies have made significant changes in citrus, including Bluetooth calipers and hydraulic pruning shears. Bluetooth calipers measure fruit size and automatically record the data in a spreadsheet, making the process faster and more efficient than manual measurement. Hydraulic pruning shears have replaced manual pruning, allowing workers on farms in South Africa to prune up to 200 trees a day, compared to 100 trees with traditional methods, significantly improving productivity and efficiency in orchard management (Habiyaremye et al. 2024).

Milestones have been achieved locally in drone technology and remote sensing, with some companies offering plant and orchard monitoring services. Local leaders and affiliates of international giants include Aerobotics, AeroVision, Agri-Sense, DRONESIX, FarmPin, FruitLook, Terracam, and SkyFarmers (GreenCape 2019). SkyFarmers is a certified dealer and trainer of agricultural drones for various uses (SkyFarmers n.d.). Aerobotics is a South African agritech company using smart pest management platforms through satellite, drone, and in-field scouting, with a smart scouting platform to identify pests and diseases in tree crops, especially citrus. Agrihawk, founded in 2015, is a fully licensed drone operator in South Africa and provides services in horticulture, among other crops.

In combating the latest trade barrier to the EU on the false codling moth, Cybicom Atlas Defence, in partnership with Pretoria-based Bronberg Dynamics, developed a Remotely Piloted Aircraft System designed for pest control in citrus. This initiative was supported by the Aerospace Industry Support Initiative (AISI), a programme of the Department of Trade, Industry, and Competition (the dtic), managed by the Council for Scientific and Industrial Research (CSIR) (AISI 2024).

PACSys Ltd is a farmer-owned organisation established in 2016 to research, develop, and distribute economical precision agricultural technologies (both hardware and software), tailored to increase farming efficiencies (Chigumira 2018). PACSys is Africa's largest accredited distributor of DJI Agriculture's innovative precision agricultural drones and technologies. It specialises, among other services, in drone spraying and advanced training for agricultural drone pilots.

In terms of automated packhouses, Tru-Cape Fruit Marketing, one of South Africa's largest apple and pear marketers, has implemented advanced automation in its packhouses. The company installed a 10-lane sorting system capable of processing eight fruits per second per lane. This technology integrates iFA light technology for detecting internal irregularities and features high-precision camera-scanning equipment to enhance quality control (Dube and Das Nair 2020).

According to the CRI, the coddling moth regulations passed by the EU to South Africa require that all oranges shipped to the EU must be pre-cooled to below 2°celcius and then maintained for 20 days, rendering technological advancements crucial (CRI 2025). In cold chain systems, significant milestones have been made through public-private partnerships. The Post-Harvest Innovation (PHI) Programme is a public-private collaboration between government and business in research and development of a variety of technological solutions related to integrated packing solutions, such as modified smart expandable packaging, traceability solutions, controlled atmosphere cold chain technologies, cooling efficiencies, and energy consumption (PHIP n.d.). The partnership includes the DSI, Hortgro Science, Citrus Research International, the Subtropical Growers' Association, the Pomegranate Association, Cape Flora SA, the Kiwi Fruit Association, South African Berries Producers Association, and the Tomato Producers' Organisation.

There are various leaders in the cold chain system, such as Southern African Fruit Terminals, which provides cold storage facilities for fruit and other perishable industries; DHL Supply Chain South Africa, including temperature-controlled storage and transportation for fruits and other perishables; and Imperial Logistics. Some notable milestones have included leaders such as InspiraFarms from Kenya with operations in South Africa. It has developed cost-effective, solar-powered cold storage and post-harvest handling facilities with cloud-based remote monitoring. The technology addresses cold chain challenges in first-mile distribution, especially near production sites. InspiraFarms has shifted its focus to fruit and vegetable supply chains, providing on-farm cooling and handling solutions to help farmers and agribusinesses meet quality standards and reduce post-harvest losses (Inspira Farms n.d.)

Delta Trak is a leading innovator of cold chain management and temperature monitoring solutions. In the Western Cape, new packaging strategies, such as Modified Atmosphere Packaging (MAP), have been developed to extend the shelf life of fresh produce during transport. MAP works by adjusting the surrounding atmosphere to slow down spoilage, using either gas flushing (oxygen, carbon dioxide, and nitrogen) or specialised packaging materials (Delta Trak 2025).

In terms of biotechnology, such as delayed ripening, Delta Trak produces Ethylene Adsorption Packaging. These polyethene pallet covers contain an additive that removes ethylene, slowing ripening and decay. The breathable material ensures proper gas exchange while preventing bacterial growth, enhancing produce quality, appearance, and shelf life (Delta Trak 2025). Advancements in biotechnology have enabled the development of new crop varieties. In South Africa, the citrus industry exemplifies this progress with the creation of local mandarin varieties like ClemenGold and Tango. ClemenGold has been successfully introduced to global markets, and the Tango variety received Plant Breeders' Rights in South Africa in March 2016, establishing it as a distinct variety (Dube and Das Nair 2020).

Over 50 companies in South Africa are involved in hydroponics that offer consulting, training, installation, and sales of equipment, parts, or whole systems. There are also around 20 private and public training and research institutions offering courses in hydroponics and management systems. Agricultural products that are currently being grown encompass vegetables such as peppers, cucumbers, lettuce, spinach, tomatoes, and celery (Chigumira 2018).

5. HOW DIFFICULT IS IT TO ABSORB THESE TECHNOLOGIES?

In a recent study*, The Use of Advanced Technology in South African Agriculture: Insights from Selected Sub-Sectors,* by Habiyaremye et al. (2024), absorbing technology is dependent on socio-demographic factors and characteristics of potential adopters. Other factors include the agricultural enterprise size, extension services provided and market access, as well as financial resources, costs of technology and the perceived benefits of the technology.

Some highly skill-intensive technologies depend on specialised digital infrastructure for effective use. As such, their adoption has been slow and uneven, particularly in developing countries, despite their potential benefits (Habiyaremye et al. 2024). Although drone technology is widely available in South Africa, these technologies have been reported as costly. In terms of digitisation, i.e. IoT and blockchains, access to efficient connectivity, digital and ICT skills, computers, and smartphones are essential. These are available but can be costly for small-scale farmers. Absorption of technology is also dependent on scale, where large-scale farmers can utilise farm systems such as FarmNode, but small-scale farmers find it costly to implement and manage it for small-scale harvests. Other constraints in absorption are some IoT devices that operate on limited battery power; there is a critical need for energy-efficient communication systems that support long-range transmission (Singh et al. 2022).

The high cost of technology has discouraged the use of automated packhouses. For example, it is expensive to maintain or install equipment with limited functions or functions that cannot be utilised across other farm operations. Although maintenance is usually the responsibility of the supplier, software upgrades can be expensive to the farmer. The CGA has reported that about 25% of small-scale Black farmers affiliated with the Grower Development Company are actively adopting precision agriculture technologies. This indicates a strong willingness among farmers to learn and adopt new practices. However, financial constraints remain a significant barrier to the widespread adoption of these technologies (Habiyaremye et al. 2024).

In South Africa, geographic challenges hinder the adoption of certain technologies, particularly in remote citrus farms and plantations located in valleys. Limited network coverage and digital data transmission pose significant barriers. In addition, unreliable electricity supply and inadequate backup systems further restrict the effective implementation of advanced agricultural technologies. Investments are also often eroded by expensive transport, costs of fuel, utilities, and delays at the port.

6. SUPPORT INSTITUTIONS

6.1. Government support

Several government departments play a role in supporting and driving the adoption of technologies in horticulture.

The DALRRD and its various institutions have been at the forefront in response to the 2020 Presidential Commission on the Fourth Industrial Revolution (PC4IR). The Agricultural Research Council (ARC) in its 2024-2025 Performance Plan, highlights that the department has now embedded technological change in its strategy, in addition to implementing technologies in projects such as Precision Farming, big data analytics, satellite imagery, and IoT. The ARC has invested in research and development applications such as Rain for Africa (R4A), the Breeding Management System (BMS), and climate change-related tools. The BMS, an integrated software package by the Integrated Breeding Platform, facilitates plant breeding logistics, data management, analysis, and decision support. It includes a robust database collecting and integrating data from plant breeding activities. To tackle climate change challenges, the ARC ICT has created applications such as a drought early warning system and the Farm Assessment Toolkit (ARC 2024). In addition, the exploration of blockchain technology for traceability in collaboration with DALRRD is underway.

As reported, DSI houses the PHI Programme, a public-private partnership with other associations such as FPEF, with FPEF serving as the implementing partner. Launched in 2007, the programme focuses on developing innovative post-harvest technologies to enhance and sustain the global competitiveness of South Africa's fresh fruit industry.

The Agricultural Sector Education Training Authority (AgriSETA) publishes yearly skills plans on horticulture, with new technology at the forefront. Driven by COVID-19 and the need to accelerate digital processes, the AgriSETA has prioritised training for members on the latest technology skills as part of its action plans (AgriSETA 2024).

Under the Advanced Agriculture and Food Cluster, the CSIR has a 'precision agriculture programme'. It seeks to 'leverage multidisciplinary expertise, including climate modelling, remote sensing, geographic information systems, drone technologies, digitisation, big data analytics, artificial intelligence and machine learning' (CSIR 2025). Currently, the CSIR has developed an advanced, cost-effective robotic system to inspect and monitor horticultural crops, enhancing production, harvesting, and processing efficiency. There have been robotic field trials in vineyards in collaboration with Stellenbosch University's Department of Viticulture and Oenology and the Institute for Wine Biotechnology. Equipped with sensors to estimate grape yield and assess plant health, the robot provides early detection of anomalies, helping farmers prevent significant yield losses. Designed to withstand South Africa's harsh climate, the robot was built with durability, advanced weight capacity, and energy efficiency. This innovation is part of a broader initiative to integrate robotics and automation into South Africa's horticulture sector, improving its global competitiveness.

In the wake of the changing technological landscape, the dtic established the Future Industrial Production and Technologies Chief Directorate in 2017, to understand emergent technologies, the effects of these technologies, and to prepare for the future. Further, horticulture forms part of the 12 downstream subsectors supported by the dtic. As such, the Agro-Processing Support Scheme supports investments in modernising machinery and equipment (the dtic n.d.).

6.2. Universities

Several universities across the country support various initiatives in technology adoption and research and development. These include universities such as the Limpopo Agro-food Technology Station (LATS). LATS, among other initiatives, helps reduce barriers to access to expensive high-end skills and equipment for agro-processing innovators and facilitates the development and improvement of agro-processing technology innovation. For horticulture, LATS provides various technical services, including juice processing, and drying of indigenous and exotic fruits. They also offer extensive technical training for small and medium-sized enterprises (SMEs) and services covering areas like: Advising on pre- and post-harvest practices and treatments; conducting quality control checks; monitoring production; analysing shelf-life; and developing new products, particularly fruit drying with various preservatives like sulfur dioxide (University of Limpopo n.d.).

The Agrifood Technology Station, located at Cape Peninsula University of Technology, assists companies in improving their use of technology. At Stellenbosch, in the Department of Horticultural Science is the Post-Harvest Physiology Research Chair in Deciduous Fruit, which focuses on research to eliminate various physiological disorders which occur when apples and pears are stored or ripened after picking (University of Stellenbosch n.d).

6.3.Industry and private sector

Several associations in the South African horticulture industry play a crucial role in supporting the adoption, research, and awareness of technologies in horticulture. Citrus Research International has a programme focused on evaluating the effects of different growing conditions and new orchard technologies, such as plant growth regulators and shade netting, on rind quality. Another programme examines innovative post-harvest technologies and practices aimed at preventing or reducing disease. This includes managing temperature, selecting appropriate wax types and their application, as well as developing strategies to categorise fruit in the packline according to their sensitivity to minimise postharvest disorders (CRI 2021).

Hortgro Science has Farming Technology Research as one of its themes. It focuses on orchard mechanisation and technology drivers such as big data, remote sensing, robotics, and GIS that will all contribute to sustainable orchards (Hortgro n.d.). Winetech is a non-profit company with the mission to prioritise, commission and transfer relevant Research, Development, and Innovation projects that deliver value to the South African wine industry.

Several banks have agribusiness units that have begun to provide financing for technology in the sector. Nedbank advocates for regenerative agriculture – a practice that involves building soil health, improving water management, and using practices that reduce irrigation demands. It has partnered with Agrico, a leading manufacturer in South Africa that offers enhanced financing options for new centre-pivot irrigation systems (Hudson 2024). Standard Bank recently financed a citrus producer that uses robotics in its packhouse to improve the speed of packing (Standard Bank n.d.). Absa and Avenews-GT, a Kenyan-based firm, rolled out the Avenews App in South Africa. The app supports agribusiness firms in making payments, recording finances and cash flow and inventory, among other functions. In addition, digitisation has enabled financial institutions to offer tailored financing solutions by leveraging reliable and accurate data, enhancing support for farmers and agribusinesses (Maeko 2021).

7. CONCLUSION

Globally, multiple countries and agri-tech companies are driving innovation and technology in horticulture and the broader agriculture sector. These include digital innovations such as AI, IoT, blockchain, coding systems, and big data; advanced equipment like drones, robotics, automated packhouses, and sophisticated cold storage; as well as scientific advancements in biotechnology and modern farming techniques like vertical farming.

Since South Africa is a significant player in global horticultural trade, with edible fruit and nut exports contributing 3.94% to total exports. As such, technological shifts in transforming production, preservation, processing, packing, and logistics have become integral for the continued growth and sustainability of the industry. The country has made progress in integrating advanced technologies, some of which are locally developed, to maintain its competitive edge. In South Africa, digital tools are providing farmers with valuable resources. The country has also made strides in drone technology and remote sensing, with multiple companies leading advancements in plant and orchard monitoring. Cold storage innovations, including smart expandable packaging, traceability solutions, and controlled atmosphere cold chain technologies, have also been developed for use in South Africa.

South African government initiatives, industry associations, and financial institutions are actively supporting the adoption of Agri-tech solutions in horticulture. The Agricultural Research Council is implementing AI, big data, and IoT in precision farming and climate resilience projects, while the CSIR is developing robotics for crop monitoring. Universities and industry bodies continue to drive innovation through research, training, and post-harvest advancements. Financial institutions like Absa and Nedbank are expanding access to funding for Agri-tech investments.

With ongoing advancements in technologies, South Africa's horticulture sector is poised for sustained growth, increased efficiency, and strengthened global competitiveness.

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