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Measuring regional innovation systems in the Western Cape: Agriculture and Agri Processing

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December 2022

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List of Abbreviations

AfCFTA	African Continental Free Trade Area
AfDB	African Development Bank
API	Agri Processing Index
ARC	Agricultural Research Centre
CASIDRA	Cape Agency for Sustainable Integrated Development in Rural Areas
CEA	Controlled Environment Agriculture
CHEC	Cape Higher Education Consortium
CPUT	Cape Peninsula University of Technology
CRI	Citrus Research International
DALRRD	Department of Agriculture, Land Reform and Rural Development
DEDAT	Western Cape Department of Economic Development & Tourism
DFFE	Department of Forestry, Fisheries and the Environment
DSBD	Department of Small Business Development
DTIC	Department of Trade, Industry and Competition
EU	European Union
FBO	Faith-Based Organisation
FSD	Farmer Support and Development
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GVA	Gross Value Add
HEI	Higher Education Institution
ICT	Information and Communication Technology
IS	Innovation System
IDC	Industrial Development Corporation
MIGA	World Bank Group's Multilateral Investment Guarantee Agency
NGO	Non-Governmental Organisation
NPO	Not for Profit Organisation
NMMU	Nelson Mandela Metropolitan University
NRF	National Research Foundation
R&D	Research and Development
RIS	Regional Innovation Systems
SA	South Africa

SARETEC	South African Renewable Energy Technology Centre
SCB-UK	Standard Chartered Bank of the United Kingdom
SEDA	Small Enterprise Development Agency
SME	Small Medium Enterprise
STI	Science, Technology, and Innovation
SU	Stellenbosch University
UCT	University of Cape Town
US	University of Stellenbosch
UWC	University of the Western Cape
WC	Western Cape
WCDoA	Western Cape Department of Agriculture
WCG	Western Cape Government

1 INTRODUCTION

The Cape Higher Education Consortium (CHEC) is currently coordinating a project with the Western Cape Government (WCG) on Regional Innovation Systems (RIS). The joint task team comprises partners from the University of the Western Cape (UWC), Stellenbosch University (US), WCG and CHEC.

A key driver for the project is the importance of innovative systems in addressing developmental priorities within the WC region, as identified in the WCG's COVID-19 pandemic Provincial Recovery Plan. At the core of the RIS approach is an emphasis on economic and social interactions between agents, spanning the public and private sectors, to engender and diffuse innovation within regions embedded in wider national and global systems. The project focuses on various economic sectors, of which Agriculture and Agri Processing are the focus of this particular report.

Agriculture/Agri Processing is a central tenet of the WC economy (Wesgro, 2022b); and in line with national objectives, has been identified in the Western Cape Strategic Plan as one of the key potential drivers for economic growth and job creation in the province (WCG, 2019a).

This report starts by providing the sectoral background and main characteristics inherent in the agricultural sector in the province. This is followed by an overview of the policies and regulations that guide the sector. The maturity of the RIS is then determined through an established framework that informs recommendations on future activities, research and government support for the improvement of the RIS's maturity level.

2 AIMS AND OBJECTIVES

The broad aim of this research is the development and study of Agriculture and Agri Processing RIS in the WC to provide an overview of the sector.

The objectives are:

- To identify existing networks and role-players in the WC agricultural sector.
- To identify factors that influence regional innovation in the sector.
- To determine a rating and level of maturity of the RIS.
- To recommend future activities, research and government support in order to improve the RIS's rating and maturity level.

3 METHODOLOGY

The following methodological steps were undertaken for this research:

1. Review of existing literature to identify role-players/stakeholders, policy and regulatory frameworks, challenges and enabling factors in the Agriculture and Agri Processing sector within the provincial boundaries of the WC province.
2. Engagement with key stakeholders (including public sector officials) where possible to gain more in-depth knowledge and understanding of innovation in the sector.
3. Gathering of relevant quantitative and qualitative data points from sources including open datasets, StatsSA, Western Cape Department of Agriculture (WCDoA) reports, relevant policies ad regulations, scientific publications, research reports (e.g. WESGRO, Green Cape), etc.
4. Collection and analysis of data according to an established measurement framework and relevant indicators (see section 4 and Appendix B). A minimum of one indicator per function was identified according to data availability.
5. Determination of the level of maturity of the sector (see section 4 and Appendix C) in terms of the 7 functions of the measurement framework (Appendix B).
6. Visualisation of the findings through the Environmental System Research Institute (ESRI) Geographic Information System (GIS).

4 FRAMEWORK

As per step 4 of the methodological approach discussed above, a RIS framework developed by Macaskill (2022) was utilised for the easy inspection and maturity rating of Agricultural and Agri processing innovation within the boundaries of the WC (see Appendix B). The framework looks at how structural aspects (actors, institutions, interactions and infrastructure) interact according to seven different functions: Entrepreneurial activity, Knowledge development, Knowledge diffusion, Guidance of search, Market formation, Resource mobilisation, and Creation of legitimacy. Each function focuses on a different aspect of the RIS and explains how they play a role in the operations of a RIS. To determine if each function is present, the use of indicators and diagnostic questions are used. Appendix B outlines the developed RIS framework utilised in this project.

A maturity model was utilised alongside the framework as per step 5 of the methodological process. The model is based on four stages of the innovation system's life cycle, namely: birth, growth, maturity, and decline (Mackaskill, 2022). The tool is used to determine the maturity of the WC's Agricultural Sector and is outlined in Appendix C. A further numerical expression of the maturity model allows for the quantification of the maturity of the sector and is outlined in Table 1.

Table 1 Assigned life cycle stage values corresponding to the maturity (Mackaskill, 2022)

Life cycle stage	Assigned value
Birth	1
Growth	2
Mature	3
Decline	4

5 DEFINITIONS: FRAME OF REFERENCE

The following section provides insights into the sectoral background and context as well as the main characteristics and inherent dynamics in the WC Agri processing sector. The review provides definitions, background and insights into the main actors and role-players, and opportunities and challenges in the Agri processing sector. This review provides a basis for the analysis of subsequent outputs of the overall research project. The review is not meant to be an exhaustive list, but rather a summary of the characteristics of the province.

5.1 Sectoral background and context

Agri processing is defined as the process of transforming raw materials and intermediate products that originate from agriculture, forestry and fisheries (WCG, 2019a; Wesgro, 2022a). Importantly, primary agriculture and secondary industries are not viewed as separate sectors due to both contributing to development (Partridge & Pienaar, 2015b).

Globally, the agriculture, forestry and fishing sector contributed 4.33% to GDP in 2021 (see Figure 2) and the sector is considered a critical tool in attaining the United Nations Sustainable Development Goal of Zero Hunger (Wesgro, 2022b). However, the sector has succumbed to extreme weather conditions, geopolitical pressures and conflicts and the COVID-19 pandemic, which has negatively affected productivity, the nutritional value of crops, and ultimately, food security and livelihoods (Wesgro, 2022b). Nevertheless, despite these challenging global conditions, rising input costs and local challenges such as ongoing load shedding, the South African government recognises Agriculture and Agri processing as a priority area for economic growth, employment, and a platform to increase exports through various strategic governmental plans (Wesgro, 2022b).

The WC province of South Africa has a globally competitive agribusiness sector that significantly contributes to the regional and national economy (Wesgro, 2022b). According to WCG (2022e) and Wesgro (2022b), the WC is the second-largest agricultural area in Africa and is home to many businesses that operate at various points along the agricultural supply chain. The sector makes up 10% of the WC's economy and accounts for 25.7% of total provincial exports (Partridge & Pienaar, 2020). Figure 1 provides an overview of the market size of the sector over the past decade (Gross Value Add – GVA and employment), where GVA has increased year on year since 2019. Figure 2 shows that agriculture has a 4% share of the province's total GVA.

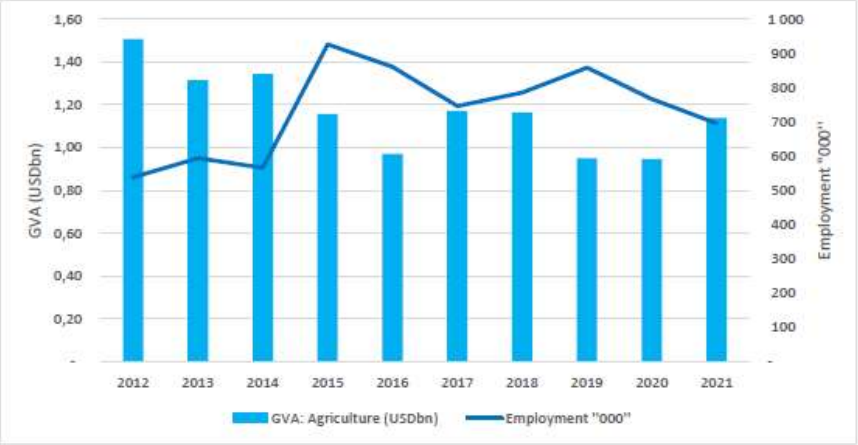

Figure 1 WC's Agriculture and Agri Processing Market Size (GVA and employment), 2012-2021 (Wesgro, 2022b)

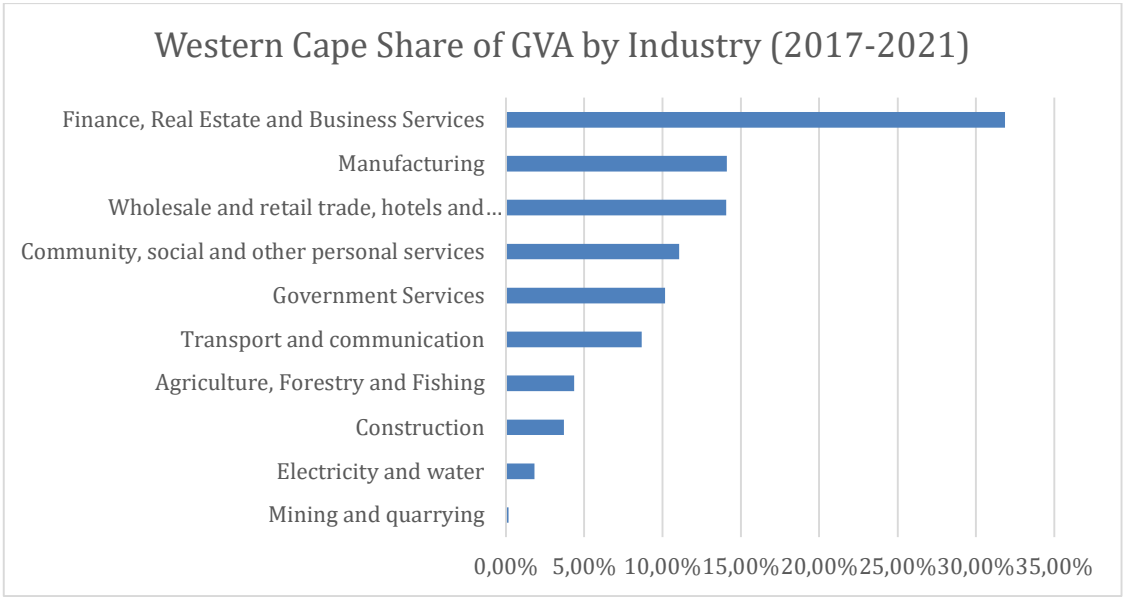

Figure 2 Western Cape: Share of GVA by industry 2017-2021 (Wesgro, 2022b)

In 2021, orange exports accounted for the largest share of the total value of exported agricultural products, followed by table grapes, apples and wine of fresh grapes in containers (Maseko, 2022). Value-added services that have emerged in recent years include slaughtering, processing, and preserving of meat; processing and preserving of fruit and vegetables; dairy products; grain mill products; crushing of oilseeds; prepared animal feeds; sugar refining; and cocoa, chocolate, and sugar confectionery (Wesgro, 2022b).

5.2 Main characteristics in the sector

5.2.1 Actors and Role-players

The various actors and role-players that operate within the Agri processing RIS that convert knowledge, networks and markets to create and use business opportunities are listed in Appendix A. These actors and role-players fall into six broad categories namely: research and academia (Higher Education Institutions (HEIs), research organisations), the public sector (local

municipalities, National and Provincial government, state-owned enterprises, Non-Governmental Organisations (NGOs), farmers/producers, input/technology suppliers, industry associations (Enterprises, Industry, Financial Organisations (Banks, Venture capitalists), and Support organisations (incubation hubs/accelerators), informal businesses, Not for Profit Organisations (NPOs), labour organisations).

Further to this, the WC has substantial agricultural production and agri processing infrastructure which is easily accessible and provides a significant opportunity for the growth of Agri processing in the province (Maseko, 2022). Of all the districts in the province, the Cape Winelands District has the largest proportion of agricultural production infrastructure including chicken batteries, homesteads, nurseries, piggeries and tunnels (Partridge *et al.*, 2020). The Cape Winelands District also has the largest share of processing infrastructure (pack-houses, distilleries, fruit packers, cool chain facilities, olive cellars and wine cellars) (Partridge *et al.*, 2020).

Financial resources including funding, investments and loans are available from various public, private and blended institutions as outlined in Table 16. Access to this funding can be evidenced in the following:

- The monthly flow of tractor and combine harvester sales indicate an upward trend since 2020, currently peaking at 800 tractor units and 50 combine harvesters (WCG, 2022g).
- WCG (2022d) shows that in 2022, the WC had the highest Gross Value of agricultural transactions (R14 198 525 928) as well as the number of transactions (805) in SA. The number of transactions is in line with the general upward trend of agricultural land indicated by Partridge *et al.* (2020) in the years 2016-2019.
- For January 2003 to July 2022, there were 27 capital projects invested in the agribusiness sector in the province from 25 companies, reaching a total Capex of USD816,70m, which

created 1,523 jobs (Wesgro, 2022a). Investment in WC agriculture has, however, continued on a declining trend since 2016 as evidenced in Figure 3.

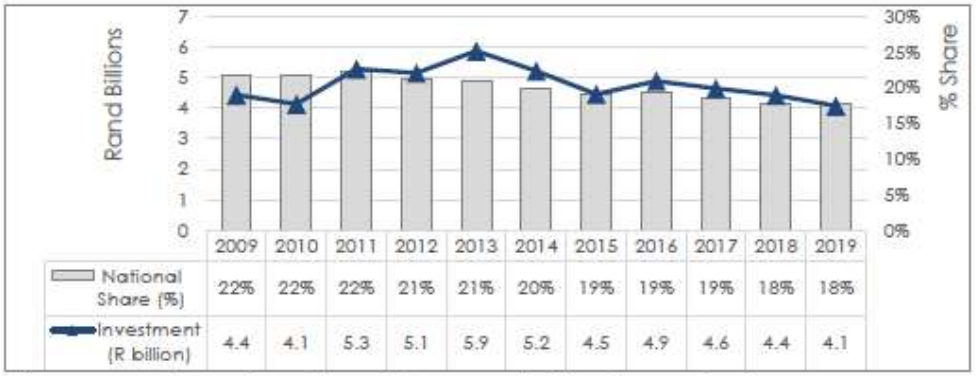

Figure 7.1: Real Investment (GFCF) in WC Agriculture (2019 prices), 2009-2019
Source: (Quantec, 2020)

Figure 3 Real investment in WC Agriculture 2009-2019 (WCG, 2020)

- While NACI (2020) provides national data on venture capital investments, it may provide insight into the WC scenario. While venture capital investments have increased rapidly since 2012, the agricultural sector has attracted a relatively small portion. The food and beverage and energy, in contrast, have attracted a large proportion of funding.

5.2.2 Agri processing: opportunities and challenges

Given that many Agri processing industries tend to be labor-intensive, a key potential of the sector lies in employment creation (Chitonge, 2021). Challenges in realising this potential, however, include increasing production costs, declining or stagnating investment, natural resource scarcity, climate change, mindset and awareness, lack of knowledge and data, policies and regulatory environment, market pressures and changing consumer pressures, loadshedding and limited capacity of the ports to process high volumes of export agricultural products (Chitonge, 2021; Kuschke, 2020; Maseko,2022; Ungerer *et al*., 2018; WWF, 2018). These challenges are, however, in turn also drivers of innovation. Key opportunities in the province as listed by Maseko (2022) include:

- Energy efficiency and renewable energy sources.
    - Particular opportunities exist in packhouses and cold stores, especially given decreasing technology costs and opportunities for grid feed-in.
- Regenerative agricultural practices/Conservation Agriculture.
    - Opportunities for the manufacture of specialist machinery (e.g. no-till machinery) are significant.
- Controlled environment agriculture (CEA).
    - CEA is the use of technology to control the growth of animals or crops (e.g. netting cover, tunnels, hydroponics, aquaculture). Opportunities for local manufacture of CEA components and systems exist.
- Smart farming/precision agriculture.
    - Precision farming optimises farming inputs (e.g. water use efficiency through drip irrigation)
- Electric equipment.

The technologies that support these opportunities, that are emerging in the province and could potentially transform Agri processing in the WC as listed by Ungerer *et al.* (2018) include the following:

- Smart Water (water management and related technologies).
- Information and communication technologies (ICT).
- Internet of Things and low-cost sensors.
- Remote sensing technologies.
- Precision agriculture and smart farming.
- Artificial intelligence and machine learning.
- Bioinformatics.
- Nanotechnology.
- Protein transition.
- Unmanned aerial vehicle technology.

- Robotics.
- Food preservation technology.
- Synthetic biology.
- Transport technology.
- Vertical Agriculture.
- Food design.
- 3D and 4D printing.
- Genetics.
- Biorefinery and biofuels.

There is evidence of effort being undertaken within the province for innovation to exist. This includes the commissioning of a study by the WCDoA to develop a view on agriculture in the province in the context of the fourth industrial revolution (4IR). There is also the Agrifood Technology Station at CPUT which serves as one of the technology stations in the country that supports agricultural innovation in the region.

In terms of the availability of an appropriately skilled workforce, The Department of Home Affairs (DHA) list agricultural scientists and food and beverage scientists as scarce skills in South Africa in 2022 (DHA, 2022). The most notable required skills that are not readily available to the agricultural labour force are in areas such as ICT, electrical engineering, civil engineering, mechanical engineering and chemistry (Kuschke and Shai, 2021; DHA, 2022).

In terms of Doctoral graduates in 2018, the natural and agricultural sciences are at the top of the list with this discipline producing 1 051 doctorates in 2018 and engineering is at the bottom of the list, producing 229 doctoral graduates in 2018.

5.2.3 Knowledge and Learning

Article publication and filed patents are indicative of how much knowledge is being generated within a region. Table 2 shows the number of highly cited papers with South African authorship for the period 1 January 2010 to 29 February 2020 (filtered for agriculturally relevant research fields). While WC-specific data in this regard is lacking, it is deemed to be a reasonable representation given the concentration of HEIs in the WC province as well as the agricultural sector's large contribution to the regional economy.

Table 2 South African highly cited papers per research field relevant to the agricultural sector (2010-2020) (NACI, 2020)

Ranking (out of 22)	Research Field	Web of science documents	Citations	Citations per paper	Highly cited papers
15	Agricultural sciences	4 158	33 946	8.16	33
4.	Plant & animal science	13 397	127 363	9.51	164
5.	Environment/ecology	9 115	131 511	14.43	163
7.	Engineering	6 641	60 765	9.15	98

An analysis of agricultural publications from the various academic and research actors in the WC revealed that SU contributed the most to knowledge production within the innovation system over the past five years (see Table 3).

Table 3 Number of Agricultural Science Publications in the past five years at Western Cape Research and Academic Institutes (Web of Science, 2022)

Institution	Number of Agricultural Science Publications (past five years)
Stellenbosch University (SU)	228
University of Cape Town (UCT)	104
Cape Peninsula University of Technology (CPUT)	32
University of the Western Cape (UWC)	41
Agricultural Research Council (ARC)	96

Over and above academia, the public sector also produces and diffuses knowledge in the IS. The WCDoA Research and Technology Development Services Programme provides expert and needs-based agricultural research, development, technology transfer services and research infrastructure support services. Output indicators and actual achievements of the programme for the 2021/2022 Financial Year as showcased in Table 4 provide evidence of knowledge development and diffusion within the Department.

Table 4 WCDoA Research and Technology Development Services Programme – Achievements for 2021/2022 Financial Year (WCG, 2022f)

Output Indicator	Achievements in 2021/22
Number of research projects implemented to improve agricultural production	100
Number of scientific papers published	28
Number of research presentations made at peer-reviewed events	59
Number of research presentations made at technology transfer events	151
Number of new technologies developed for smallholder producers	2
Number of articles and radio broadcasts in popular media.	100

World patents per million population in South Africa have been on the decline over the decade 2009–2018 (NACI, 2020).

In terms of financial backing for research and development (R&D), the National Research Fund (NRF) is one of the main actors in this regard. Between 2017 to 2019, however, the NRF's funding of research and other grants declined from R1.7 billion to R1.5 billion. Agricultural sciences received 5.5% of NRF grants between 2016 and 2019 and the ARC received 1.42% (NACI, 2020).

Since the inception of the *Horizon2020* Programme in 2014, South African Science Technology and Innovation (STI) organisations acquired more than €33.273 million in funding from the European Union (EU). In the WC province, UCT, SU, UWC and ARC were among the top South African organisations in terms of the value of EU support in the *Horizon2020* programme. For Small and Medium-sized Enterprises (SMEs), CRI Pty Ltd received €101.73 k in support from Horizon2020.

Various agricultural shows and conferences occur within the sector and serve as a medium through which knowledge is shared.

Table 5 Agricultural shows and conference in the Western Cape (2022/2023)

Knowledge Sharing Medium	Number	Year	Comment	Source
Agricultural shows	29	2022	Includes shows, seminars and awards evenings. The majority are in the wine industry.	Agriexpo (2022)
Agricultural Conferences	37	2023		Conferenceindex (2022)
Agricultural engineering conferences	7	2023		Conferenceindex (2022)

There are some collaborations between the WCDoA and academic institutes as evidenced by the following:

- Research farms are maintained to serve as “field” research hubs for WCDoA internal research, for trials in collaboration with external research partners and postgraduate students of various tertiary institutions (WCG, 2022f).
- Collaboration with the University of Stellenbosch is fostered through the engagement of WCDoA staff members in various committees (e.g. Academic Planning Committee, Staff Development Committee) (WCG, 2022f).
- Ungerer et al. (2018) is a collaborative report by the WCDoA together with the University of Stellenbosch Business School (USB).
- Agreements on plant pathology research collaboration between the WCDoA and Curtin University in Western Australia, as well as the University of Melbourne, were concluded and signed in 2022 (WCG, 2022f).
- International collaboration on remote sensing machine learning project between WCDoA, the Radiant Earth Foundation in the USA, US and Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) (WCG, 2022f).

6 POLICY/GOVERNMENT SUPPORT-CURRENT POLICIES

The agricultural sector in South Africa and the WC has an extensive range of policies and regulations that govern it as outlined in this section.

6.1 National Legislative Framework

On a national level, the Department of Agriculture, Land Reform and Rural Development (DALRRD) and the Department of Environmental, Forestry and Fisheries (DEFF) are the entities responsible for overseeing and supporting the development of the agricultural sector in South Africa. Key policies and legislation as listed below aim to create an enabling environment for a sustainable agricultural sector that addresses agricultural policy distortions of the past (Kuschke, 2020):

- The National Development Plan 2030 (NDP 2012)
- The Strategic Plan for the Department of Agriculture, Forestry, and Fisheries (DAFF 2013)
- The Agriculture Integrated Growth and Development Plan (IGDP 2012)
- The Agricultural Policy Action Plan (APAP 2014)
- The National Environmental Management Act 107 of 1998 (NEMA 1998)
- Integrated Resources Plan (IRP) 2019

6.2 Western Cape Strategic Alignment

The WCDoA has determined seven departmental strategic goals that are aligned with the provincial strategic goals and overall planning (Strategic Plan 2015 – 2021), as well as to the NDP and APAP through its detailed programmes and sub-programmes as outlined in Table 6.

So too, the Western Cape Agriculture and Agro Processing Masterplan centres around 6 pillars

which also mirror the national legislative framework:

- Resolving policy ambiguities and creating an investment-friendly climate.
- Market expansion and improved market access.
- Comprehensive Farmer Support, Research and Development and extension services.
- Enhance food security, production output and employment creation.
- Creating production, marketing and trade infrastructure and trade facilitation.
- Localised food, import replacement and expand Agri processing.

These pillars were echoed in a strategic session held by the WCDoA for the development of a full Theory of Change, where key topics identified included market access, private sector investment, resource availability, food security, transformation, agricultural skills and rural safety and security (Troskie, 2020a).

The following table is a synopsis of various key reports from the WCDoA which showcase these identified focus areas.

Table 6 WCDoA Focus Areas

Western Cape Department of Agriculture: Focus Areas
Food Security Programme
To boost food production and security in the province, The WCG encourages and supports community farming projects through funding. The Food Security Programme promotes agricultural production among vulnerable households and emerging farmers. An evaluation of the programme in 2015 revealed that despite certain challenges that a large share of community, household and school gardens were productive and beneficial to the beneficiaries (WCG, 2015). In total 54 community food production projects were evaluated (40 community and 14 schools). A total of 625 household gardens were evaluated (561 beneficiaries and 64 non-beneficiaries). It was found that the assistance provided an improvement in the ability to meet beneficiaries' food needs.
The Farmer Support and Development (FSD) Programme
The Farmer Support and Development (FSD) Programme provides extension, support and facilitation of training to emerging farmers, implementation of land reform programmes and agricultural rural development projects. The sub-programmes towards achieving these goals include: • Farmer settlement. • Farmer support services. • Food security. • Farmworker development. • Cape Agency for Sustainable Integrated Development in Rural Areas (CASIDRA).

Farmer Needs
To guide the allocation of support needs (e.g. infrastructure, economic, financial, marketing, etc.) of various farmer categories in the WC Province, the WCDoA designed an evaluation framework (Louw, 2014). Key recommendations from an evaluation undertaken in 2014 include the following (Louw, 2014): • To strengthen the FSD programme in support of subsistence farmers. • To concentrate efforts through extension services on market readiness and market access in public-private partnerships for Smallholder Lifestyle farmers and smallholder farmers with commercial aspirations: • Acquiring resources and attending to market issues for Small commercial farmers: • Medium and large commercial farmers: To facilitate and support commercial agriculture in negotiations with provincial and national government and the development of a formal protocol by organised agriculture and commodity organisations on methods, procedures and the allocation of responsibilities with the involvement of the WCDoA. • Partnerships for the funding of research between commodity organisations and commodity groups; and the funding of research and other basic services for small or alternative industries with the potential to create job opportunities.
Land Reform
To secure democratic stability, access to and the redistribution of land is an important development goal in South Africa and is reflected in the Western Cape Strategic Plan (WCG, 2019a). The actual success of land reformed projects as opposed to the number of farms/hectares transferred is an important indicator of the development goal (WCG, 2019c). An evaluation was therefore undertaken in 2019 which revealed that 72% of the agricultural land reform projects in the province were successful in terms of economic performance and poverty alleviation (WCG,

2019c). Aspects for improved performance as identified in the report include (WCG, 2019c): support formalisation, exit strategies for the cessation of support, skills development, encouraging diverse income streams, etc.

Smart Agri Plan

The Western Cape Climate Change Response Framework and Implementation Plan for the Agricultural Sector (Smart Agri plan) was launched in 2016 as a "roadmap" for a climate-resilient agricultural sector (WCG, 2020). An evaluation of the plan was commissioned to assess its relevance and design; its success thus far and how the plan and its implementation can be strengthened. Key findings from the report, out of which 7 recommendations emerged, including the fact that the plan is highly relevant, innovative, scientifically grounded and relevant for climate change resilience but with a shortcoming in the mechanism required to facilitate its adoption (WCG, 2020). Additional findings included: a lack of knowledge of the plan and its details among key stakeholders in the sector, the absence of an appropriately resourced operational structure for overseeing and coordinating the implementation of the plan and areas of greater and lesser progress (WCG, 2020).

Arid Areas

Given that the arid agricultural areas of the WC and globally are particularly vulnerable to stressors such as climate change, emerging technologies, socioeconomic shifts, etc., the WCDoA commissioned an evaluation to define strategic focus areas to achieve an aspirational future state of farming (WCG, 2021).

The three strategic focus areas are (WCG, 2021):

- Underpinning and enhancing innovation and social innovation processes
- Broad-scale adoption of ecosystem function management approaches and practices.
- Harnessing of existing and new economic opportunities.

Post Covid Response 2020

In 2020, the WCDoA commissioned a strategic foresight project to explore the post-Covid-19 future of the Agriculture and Agri processing sector in the WC (Hichert, 2020). The aim of the project was to address research questions around innovation trends, “Black Elephants”, possible futures and plausible interventions to achieve a preferred future. The following main interventions were identified: democratising the 4th industrial revolution technology, making ‘climate smart’ agriculture possible and successfully conducting agricultural education and knowledge transfer (Hichert, 2020).
Evaluation of the Covid 19 Pandemic Response
The WCDoA commissioned a diagnostic, implementation, impact and design evaluation of its COVID-19 response to showcase the learnings and to improve future readiness for future disruptive risk events (Troskie, 2022b). It was found that the Department performed well and responded effectively and efficiently to the pandemic and used it as an opportunity for learning (Troskie, 2022b). Lessons learnt (including the need for good data, flexibility, early detection, etc.) were incorporated into a “Risk and Resilience Framework” which sets out a holistic risk and resilience management process. 5 key interventions are listed for the implementation of the framework (Troskie,2022b).
Impact of Covid 19 on agriculture and food
A working paper was commissioned by the WCDoA to investigate the immediate and long-term impact of Covid-19 on the WC Agricultural Sector and food supply systems (WCG,2022b). The introduction provided an overview of the main components of food security whilst the second section highlighted some key characteristics of the South African Agricultural Sector as well as food demand in the country. Through an analysis of the trends observed as a result of Covid-19, seven key impacts were identified (WCG,2022b): • Short-term shortage of goods on the domestic market • Long-term shortage of goods on the domestic market • Food insecurity

- Wasting of fresh produce
- Loss of market share abroad
- Shortage of farming inputs
- Failing farms

A further finding was that the change in consumer patterns may result in a higher demand for fresh fruit and vegetables; as well as opportunities abroad.

Agri Processing Index

Given the complexity of Agri processing in that it spans different industries and levels of technology, Partridge & Pienaar (2015,2020) devised an Agri Processing Index (API) to allow for prioritisation of the agri processed products and thereby a knowledge tool for building a strategy for the sector. The API is a multivariate index that draws on various data sets and a number of weighted relevant factors (Pienaar & Partridge, 2015). The top ten product APIs are:

- Cherries
- Macadamia Nuts
- Blueberries and cranberries
- Raspberries, blackberries, mulberries and loganberries
- Fruit jams, marmalade, chutney and frozen fruit
- Honey
- Lemons and limes

- Guavas and mangoes
- Grapes (fresh)
- Dried grapes

The top ten industry APIs are:

- Processed Meat
- Processed fruit and vegetables
- Animal oils and fat
- Dairy products
- Grain mill and starch
- Processed animal feeds
- Bakery Products
- Sugar and cocoa products
- Macaroni and other food
- Beverages

Overall primary processing activities tended to perform better, largely driven by greater employment potential (Partridge & Pienaar, 2020). The API also affirmed great potential for berry production in the province.

Flyover Project

The “Flyover project” was commissioned by the WCDoA to gain insight into land-use changes and trends over time through an aerial census of all agricultural fields in the WC. Tracking data from 2013 to 2017 gave insights into the changes in the use of agricultural land (Pienaar, 2018).

A marginal decline in total area under orchard and a shift into higher values crops (e.g., blueberries) and high water demand crops (e.g. soft citrus)

A decline in wine grape farming

Increase in nets and tunnel structures for more efficient water use

A decline in vegetable production

Marginal increase in field crop area (e.g. wheat) and a marginal decline in fodder crops

A marked increase in fallow land.

The ‘agri renaissance’ is identified by Ungerer *et al.* (2018) as a desired end state for the agricultural sector in the WC whereby smart technologies emerging in the 4IR are harnessed to optimise yields, costs, etc. There is, however, a misalignment with WCDoA’s strategic positioning as the department’s vision does not reflect this end state.

In terms of targets/goals, the WCDoA measures the performance of eight programmes (Administration, Sustainable Resource Use and Management, Agricultural Producer Support and Development, Veterinary Services, Research and Technology Development Services, Agricultural Economics Services, Agricultural Education and Training, Rural Development) and their relevant targets are measured annually (WCG, 2022a).

Several master plans as relevant to the agricultural sector have been developed with the primary objective to set out an agreed-upon set of measurable actions to encourage sector growth, investment, job creation and competitiveness. (Maseko, 2022). These include:

- The South African Poultry Sector Master Plan
- South African Sugar Value Chain Master Plan 2030
- Master Plan for the Commercial Forestry sector in SA
- Masterplan for the South African Furniture Industry
- South African Retail-Clothing, Textile, Footwear and Leather (R-CTFL) Value Chain Master Plan to 2030

In addition to the policies introduced above, Table 7 outlines relevant legislation that impacts the agricultural sector either by being an enabler or a barrier.

Table 7 Impeding or enabling existing/new legislation (Maseko, 2022)

Policies/Legislation	Enabler/Barrier
Amendments to cannabis legislation now allow for the commercial cultivation of cannabis for medicinal use and manufacturing is permitted with a license.	Enabler
The Climate Change Bill was tabled in Parliament in October 2021 to develop a response to climate change and its impacts and therefore support the long-term adaptation of the agricultural sector to climate change.	Enabler
Amendments to Schedule 2 of the Electricity Regulation Act 4 of 2006 allow businesses to increase their energy capacity to meet their energy needs or to utilise electricity generated by other parties.	Enabler
African Continental Free Trade Area (AfCFTA) implementation	Enabler
The Land Reform Bill was submitted to parliament in December 2021. Several outstanding issues around Land Donations, Beneficiary Selection and Land Allocation policy, and the Restitution of Land Rights currently act as a barrier to the agricultural sector.	Current barrier
The second phase of the South African Carbon Tax Act (No 15 of 2019) is due to commence in 2023 and farmers will no longer be exempt from carbon tax.	Current Barrier
The regulatory landscape of the water sector in recent years has been predominantly influenced by the prolonged drought experienced across the country. The policy updates were characterised by the need for agricultural water users to reduce their water consumption, monitor their water usage, and comply with metering installation enforcement and reporting requirements.	Current Barrier
EU Farm to Fork Strategy (agricultural sector to address several challenges to maintain access to EU markets)	Current Barrier

The enabling policies as listed in Table 7 provide incentives for innovation in the agricultural market. It should be noted, however, that several of the policies listed as barriers are also drivers of innovation over time. For instance, Phase II of the Carbon Tax Act where farmers are to pay direct and indirect tax is expected to be a key driver in the uptake of technologies and practices that increase resource efficiency and decrease dependence on synthetic fertiliser on farms (e.g. precision agriculture technologies and regenerative agriculture practices) (Kuschke, 2020).

In terms of policies or incentives for the market, South Africa and the WC drive a range of funding solutions and tax incentives for green technology manufacturers and service companies, as well as those who use or procure such goods and services (Maseko, 2022). Government funding and incentives cover local manufacturing, critical infrastructure grants, small enterprise development and a diverse set of sector-specific incentives such as the Aquaculture Development and Enhancement Programme (Maseko, 2022).

7 ASSESSMENT OF THE WESTERN CAPE AGRICULTURAL AND AGRI PROCESSING SECTOR- RIS FRAMEWORK

This sectoral analysis provides a systematic look at the entire Agriculture and Agri Processing sector in the WC RIS, by applying the indicator maturity matrix (see Appendix C) where the maturity of relevant indicators is mapped. The analysis allows for the identification of the sector's current state, opportunities and challenges by creating an overarching picture through the level of maturity. As previously stated, at least one indicator from the framework by Mackaskill (2022) per function is utilised for analysis dependent on data availability. The rankings range from 1 to 4, each being associated with a lifecycle stage, as per Table 1. While the full numerical results used to calculate Function averages can be seen in Appendix D, Table 8 provides a summary of the maturity of the Agricultural and Agri processing sector in the WC. Data sources are indicated and include additional input from Dr. Dirk Troskie (WCDoA Director: Business Planning and Strategy) with whom a meeting was held on 6 September 2022.

Table 8 Capturing data points per function on the RIS Framework: Agricultural Sector

Indicator	Maturity Level	Comments and Description	Data Source & Cross Reference
Function 1: Entrepreneurial Activity			
Private vs public sector enterprises	MATURE: The sector is majorly made up of private enterprises but works in synergy with the public enterprises present.	There are a large number of private enterprises including farmers/producers, input/technology suppliers, industry associations, financial organisations and support organisations. These outweigh the public sector enterprises including provincial government and state-owned enterprises. The WCDoA offers various programmes and subprogrammes in support of private enterprises, particularly farmers and producers.	WC Fly Over Data' (2018) supplied by WCDoA. Food Garden Data (WCG, 2015) Green Cape Finance Data Statistics provided in WCDoA annual report (WCG, 2022f) Ungerer *et al.* (2018) (see Appendix A, Table 6; Section 5.2.2, Section 6.2)
Number of entrepreneurs/enterprises	GROWTH: An increased number of enterprises. Few established innovation focus enterprises.	While there are a large number of enterprises in the sector, the majority (e.g. emerging farmers, etc.) do not focus on innovation which would then translate to a mature level of maturity.	

Function 2: Knowledge Development			
Sources and intensity of knowledge development	GROWTH Continuous increase of knowledge created. An academic institution in the sector's region has an increasing amount of knowledge production. A small number of enterprises are involved in producing R&D contributions.	Knowledge relevant to the agricultural sector mainly originates from the various HEIs and research organisation, led by SU. Additional knowledge is being produced by the WCDoA. Relative to global knowledge generation, the WC is still in the Growth phase and falls short of producing large volumes of multi-topic articles and patents. The WCDoA developed 2 new technologies for smallholder producers.	Paper citations provided in NACI (2020) Publication analysis (Web of Science, 2022) Statistics in WCDoA annual report (WCG, 2022f) (See Section 5.2.3, Table 2 Table 4, Table 3)
Who finances the knowledge development?	BIRTH: There is minimal or no funding for knowledge development.	While various sources of Agri processing finance are evident as per Appendix A, there appears to be minimal funding for knowledge development in particular as it is not clear what the sources are for financial backing. NRF funding has declined in recent years.	Statistics provided in NACI (2020) Green Cape Finance Data (See Appendix A and Section 5.2.3)
Who leads research and development?	GROWTH: There is an increasing number of prominent leaders	The prominent leaders in terms of knowledge production in the WC are the HEIs and research institutions (led by SU) followed by the WCDoA. The	Publication analysis (Web of Science, 2022)

	in research and development.	private sector appears to contribute to knowledge production to a lesser extent.	Statistics in WCDoA annual report (WCG, 2022f) (See Table 3, Table 4)
FUNCTION 3: Knowledge Diffusion			
Are there partnerships or collaborations?	GROWTH: There are some collaborations among enterprises and between academic institutes.	There is evidence of collaboration between the WCDoA and local (particularly SU) and international HEIs. There is no clear collaboration between HEIs.	Statistics provided in WCDoA Annual report (WCG, 2022f) (See Section 5.2.3)
How is knowledge shared?	GROWTH: Knowledge is mostly shared unintentionally, intentional knowledge events, and sharing are increasing in the sector.	There is evidence of knowledge sharing through events such as technology transfer events, awards ceremonies, conferences, radio broadcasts and articles in popular media	Listings provided in Conferenceindex (2022) and Agriexpo (2022) (See Table 5, Table 4)

FUNCTION 4: GUIDANCE OF SEARCH			
Do clear targets/goals exist?	GROWTH: Innovation-orientated sector-focused targets and goals are being set and achieved.	There is evidence of defined innovation-orientated targets and goals being set and achieved (e.g. WCDoA Smart Agri Plan)	Various WCDoA reports (e.g. Ungerer *et al.* (2018) WCG (2020)) -see summary in Table 6 Green Cape Report (Hichert (2020)) (See Section 6.2)
Do the goals cause government involvement?	MATURE: The government is steadily involved with goal setting or contributing to achieving sector-focused goals.	It is evident that the innovation agenda is being pushed by the WCDoA and therefore the government is present and steadily involved.	
Does existing or new legislation/ regulation act as a barrier or an enabler?	GROWTH: Impeding legislation is relaxed and/ or new legislation is introduced to aid innovation in the IS.	Both enabling and impeding policies exist in the sector. It should be noted, however, that several of the policies listed as barriers may also be drivers of innovation over time.	Relevant legislation as applicable to the agricultural sector (see Table 7 for full list)

FUNCTION 5: MARKET FORMATION			
Are their policies, or incentives for the market?	MATURE: Policies or incentives to support innovation are introduced and utilised by various entities.	SA and WC drive a range of funding solutions and tax incentives for green technology manufacturers and service companies, as well as those who use or procure such goods and services.	Green Cape Data-government incentives (available at: www.green-cape.co.za) Analysis by Maseko (2022) (See Section 6.2)
The market size of a specific sector	MATURE: The sector's market is growing rapidly and receiving increasing growth.	The sector's GVA has increased year on year since 2019.	Statistics provided in Wesgro (2022b) (See Figure 1)
Who are the sector's market leaders?	MATURE: Clear sector leader(s) emerge and can be easily identified. There is still space in the market for new entrants.	There are clear market leaders in the sector as evidenced by the Agri Processing Index (API) devised by Partridge and Pienaar (2020).	Agri Processing Index Data (Partridge and Pienaar (2020)) (See Table 6)

FUNCTION 6: RESOURCE MOBILISATION			
Nature of financial resources	MATURE: There is a large variety of types of funding resources or mechanisms available.	Various sources of Agri processing finance (public, private and blended) are available from government (local and international), development finance institutions, commercial and others.	Green Cape Finance Data (See Appendix A)
Accessibility of financial resources	GROWTH: Financial resource access is increasingly easier, and investors are showing increased interest.	While access to financial resources is evidenced through tractor and combine harvester sales and agricultural land transactions in the province, the declining trend in investment in WC agriculture translates to the growth phase.	Tractor and combine harvester sales data (WCG, 2022g) Agricultural land Transactions (WCG, 2022d) Investment statistics provided in WCG (2020) and Wesgro (2022b) (See Section 5.2.1 and Figure 3)

Accessibility of seed and venture capital (VC)	BIRTH: Seed and venture capital are not available or are difficult to obtain.	While venture capital investments have increased rapidly since 2012, the agricultural sector has attracted a relatively small portion (NACI, 2020).	Statistics provided in (NACI,2020) (See Section 5.2.1)
Availability of a high-skill workforce	BIRTH: There are minimal or no high skilled workers available.	Agricultural scientists and food and beverage scientists are listed as scarce skills in SA. Further skills to aid innovation in the sector in areas such as ICT, electrical engineering, civil engineering, mechanical engineering and chemistry are not readily available.	Scarce Skills list (DHA (2022)) (see Section 5.2.2) Ungerer *et al.* (2018)
FUNCTION 7: Creation of Legitimacy			
Is there recognised actor support?	GROWTH: Large enterprises are starting to support and fund innovation activities and actors within an area	There is evidence that the WCDoA, HEIs, as well as private enterprises, are showing interest and investing in innovation (e.g. 4IR study, Agrifood Technology Station at CPUT, Atlantis Special Economic Zone).	Various reports including WCG (2022f), Ungerer, *et al.* (2018), Maseko (2022) (See Section 5.2.2)

8 FINDINGS

The findings from the maturity ranking of the Agricultural and Agri processing sector are discussed in this section per function. Function 5: *Market Formation* was ranked as mature, while four of the seven functions were ranked in the "growth" phase of the maturity lifecycle while the remainder ranked in the "birth" phase.

8.1 Function 1: Entrepreneurial Activity

Entrepreneurial activity in the RIS was ranked in the "growth" maturity phase indicating that the conversion of knowledge, networks, and markets for the creation of business opportunities is not quite mature. The RIS is fairly populated with a large number of enterprises (see Appendix A), but the majority of them do not explicitly focus on innovation (see Section 5.2.2) which would then translate to a higher level of maturity. Given the large number of private enterprises including farmers/producers, input/technology suppliers, industry associations, financial organisations and support organisations (See Appendix A), the private sector has a large influence on the sector. Public sector enterprises, particularly the WCDoA, offer synergy through various programmes and subprogrammes in support of private enterprises.

Table 9 Function 1 (Entrepreneurial activity) Maturity ranking, opportunities and challenges

Maturity: GROWTH (2.5)	
Opportunities/Promoters	**Challenges/Barriers**
Populated-a large number of entrepreneurs. Many private enterprises working in synergy with the WCDoA.	Lack of innovation focussed enterprises

8.2 Function 2: Knowledge Development

Knowledge development in the RIS was ranked in the "Birth" lifecycle stage in terms of maturity. Knowledge originates mainly from HEIs and research organisations with SU the leader in terms of agricultural publications (see Section 5.2.3). The WC, however, falls short of producing large volumes of multi-topic articles and patents; and private Research and Development (R&D) is not clearly evident. While various sources of Agri processing finance are evident (see Appendix A), financial backing for knowledge development, in particular, is not clear and NRF funding has declined in recent years.

Table 10 Function 2 (Knowledge Development) Maturity ranking, opportunities and challenges

Maturity: BIRTH (1.66)	
Opportunities/Promoters	**Challenges/Barriers**
HEIs and research organisations publishing agriculturally relevant studies	Number of patents is on the decline. Financial backing for knowledge development Private R&D not evident Collaboration for knowledge development

8.3 Function 3: Knowledge Diffusion

Knowledge Diffusion ranked in the "growth'' phase of the maturity lifecycle. There is evidence of the exchange of information and ideas in the IS through technology transfer events, awards ceremonies, conferences, radio broadcasts and articles in popular media (see Table 5 and Table 4). The wine industry features particularly prominently in terms of awards ceremonies, shows and conferences. There are some collaborations among enterprises such as partnerships between the WCDoA and local (particularly SU) and international HEIs (see Section 5.2.3). Collaborations between the various academic and research role-players and public and private partnerships are, however, not clear.

Table 11 Function 3 (Knowledge Diffusion) Maturity ranking, opportunities and challenges

Maturity: GROWTH (2.0)	
Opportunities/Promoters	**Challenges/Barriers**
Agricultural shows and conferences are regular annual events. The wine sector is particularly prominent. Collaboration between WCDoA and local and international HEIs.	No clear leaders or collaboration for knowledge diffusion between HEIs

8.4 Function 4: Guidance of Search

Guidance of Search was ranked in the "growth" phase of the maturity lifecycle. This function helps create goals and targets to direct knowledge creation. Defined innovation-orientated targets and goals are emerging and being achieved particularly by the WCDoA (e.g. WCDoA Smart Agri Plan: WCG (2020), Ungerer *et al.* (2018), Hichert (2020) – See Table 6). The 'agri renaissance' is identified by Ungerer *et al.* (2018) as a desired end state for the agricultural sector in the WC whereby smart technologies emerging in the 4IR are harnessed to optimise yields, costs, etc. There is, however, a misalignment with WCDoA's strategic positioning as the department's vision does not reflect this end state. The innovation agenda being pushed by the WCDoA is nonetheless apparent, and the government is present and steadily involved. Both enabling and impeding policies exist in the sector (Table 7). While the enabling policies listed provide incentives for innovation in the agricultural sector, it should be noted that several of the policies listed as barriers may also be drivers of innovation over time (see section 6.2).

Table 12 Function 4 (Guidance of Search) Maturity ranking, opportunities and challenges

Maturity: GROWTH (2.33)	
Opportunities/Promoters	**Challenges/Barriers**
WCDoA is strongly involved in innovation focussed goal setting. Impeding legislation is mild	WCDoA's vision is not in alignment with the 'agri renaissance' end state. Some impeding legislation.

8.5 Function 5: Market Formation

The *Market Formation* function is ranked in the ''mature'' phase of the maturity lifecycle. There are appropriate policies, tax incentives and a range of funding solutions that are shaping the market and stimulating demand, particularly around green technology manufacturing and service companies as well as those who use or procure such goods and services (Maseko, 2022) (see Section 6.2). The size of the agricultural sector's market has increased year on year since 2019 providing the foundation for increased innovation (see Figure 1). The clear market leaders in the sector are evidenced by the API devised by Partridge and Pienaar (2020) constituting private actors (see Table 6). There is still space in the market for new entrants.

Table 13 Function 5 (Market Formation) Maturity ranking, opportunities and challenges

Maturity: GROWTH (3.00)	
Opportunities/Promoters	**Challenges/Barriers**
The sector's market is growing. Policies/incentivesto support innovationare prominent and utilised by various entities. Market leaders emerging.	Market not yet self-sufficient: Unutilised capacity in agri-processing, service exports, and manufacturing

8.6 Function 6: Resource Mobilisation

The *Resource Mobilisation* function is ranked in the ''birth'' phase of the maturity lifecycle. Various sources of Agri processing finance (public, private and blended) are available from the government (local and international), development finance institutions, commercial and others (see Appendix A). While access to these financial resources is evidenced through tractor and combine harvester sales and agricultural land transactions in the province, there is a declining trend in investment in WC agriculture (see Section 5.2.1 and Figure 3). Given that seed and venture capital are synonymous with innovation, the relatively small portion of venture capital investments in the agricultural sector affects the performance of innovation within the IS (NACI, 2020). There are certain scarce skills in the workforce qualified in high-skill education (e.g., agricultural scientists and food and beverage scientists and broader skills to support technology such as ICT, civil engineering, etc.) (Section 5.2.2; DHA, 2022). Given that human capital is a crucial foundation for an IS, this skills shortage affects innovation performance.

Table 14 Function 6 (Resource Mobilisation) Maturity ranking, opportunities and challenges

Maturity: BIRTH (1.75)	
Opportunities/Promoters	**Challenges/Barriers**
A large number of financial institutions	Access to venture capital Scarce skills (e.g. agricultural scientist) and skills to support technology (e.g. engineering, ICT). Investment declining.

8.7 Function 7: Creation of legitimacy

The Creation of Legitimacy function is ranked in the ''growth'' phase of the maturity lifecycle. Prominent actors (WCDoA, HEIs and private enterprises) are showing an interest and/or investing in innovation. For instance, the 4IR study by Ungerer *et al.* (2018), the Agrifood Technology Station at CPUT and the Atlantis Special Economic Zone for green technologies).

Table 15 Function 7 (Creation of legitimacy) Maturity ranking, opportunities and challenges

Maturity: GROWTH (2.00)	
Opportunities/Promoters	**Challenges/Barriers**
Prominent actors showing interest and investing in innovation.	

9 CONCLUDING REMARKS AND RECOMMENDATIONS

9.1 Conclusions

As stated in Section 5, the WC province has a globally competitive agribusiness sector that significantly contributes to the regional and national economy, has seen year-on-year GVA growth since 2019 and is home to many businesses that operate at various points along the agricultural supply chain. So despite various challenges such as extreme weather conditions and rising input costs, Agriculture and Agri processing are recognised as a priority area for economic growth, employment, and a platform to increase exports in the province.

Key opportunities in the sector for a preferred future state centre around energy efficiency and renewable energy sources, regenerative agricultural practices, controlled environment agriculture, smart farming and electrical equipment; and the technologies that underpin these.

The WCDoA plays a key role in supporting a large number of private enterprises in the sector (including farmers/producers, input/technology suppliers, industry associations, financial organisations and support organisations) through various programmes and subprogrammes. There is also evidence of defined innovation-orientated targets and goals being set and achieved by the WCDoA (e.g. Smart Agri Plan).

An assessment of the sector using the RIS framework (see Sections 7 and 8) revealed The findings from the maturity ranking of the Agricultural and Agri processing sector are discussed in this section per function. Function 5: *Market Formation* was ranked as mature, while four of the seven functions were ranked in the “growth” phase of the maturity lifecycle while the remainder ranked in the “birth” phase.

This study has provided an initial overview of the WC agricultural sector and its maturity and provides a foundation for future activities and research. Field visits and questionnaires can provide additional insight into the sector while drilling down into specific sub-sectors, district/local municipalities in the province and specific case studies is possible using this study as a starting point.

9.2 Recommendations (Government Support)

In order to build on the significant opportunities for growth of the agriculture and agri processing sector in the WC, to address the challenges identified in Section 8, and ultimately to increase the maturity of the sector, the following is recommended in terms of government support:

Function 1: Entrepreneurial Activity

Given the large number of private enterprises and therefore the fact that the private sector has a large influence on the sector, the public sector must continue to work in synergy providing support through its various programmes. The lack of an explicit focus on innovation by many of the actors in the RIS requires that the WCDoA has appropriately resourced operational structures for overseeing, coordinating and implementing more innovation-focused support.

Function 2: Knowledge Development and Function 3: Knowledge Diffusion

In order to increase the creation of knowledge, existing Research Institutes need to be cultivated and supported as valuable collaborative platforms (particularly between HEIs) and drivers of research and to broaden the range of topics in the agricultural research space.

Under- and postgraduate studies in the scarce skills fields (e.g., agricultural science) need to be attracted and/or retained through, for example, tax incentives (UNESDOC, 2008). It is important to note the shift in required skills in light of the 4IR and amend training offerings to better prepare and train agricultural graduates. Investment in agricultural research in recognition of the fact that a lack of consistent funding is a key barrier to the uptake of agricultural studies needs to be

increased. Options such as public/private funding models, consulting work, and scholarship funding through “sandwich programs” (WorldBank, 2014) should be explored, drawing on the success of the Millennium Science Initiative in increasing Ugandan researchers and Master’s students in science (WorldBank, 2014).

Collaborative programmes with the private sector, landowners, interest groups, forums, HEIs etc. should be fostered and built upon. A greater representation of HEIs or public research institutions on certain agricultural statutory or unitary and professional bodies could facilitate collaboration and knowledge transfer. The expansion and improvement of databases for the dissemination of information through knowledge-sharing platforms will further leverage collaboration and partnerships. Other tools such as competitions, ideas fairs etc. should also be considered to stimulate the diffusion of knowledge.

Function 4: Guidance of Search

While it is evident that the innovation agenda is being pushed by the WCDoA, and there is evidence of defined innovation-orientated targets and goals being set and achieved, the department’s strategic vision should be repositioned to reflect the ‘Agri Renaissance’ as the desired end state (Ungerer *et al*., 2018). The department’s vision should reflect this scenario with strategic initiatives to accelerate growth in agri-economic outputs.

Function 5: Market Formation

The market formation function is ranked as mature. Stimulating demand and encouraging new entrants through, for instance, appropriate policies, tax incentives and funding solutions should be continued. The WCDoA should also provide support to role-players for the diversification and specialisation of the production of their goods and services so that they can compete in export markets and against imports (WCG, 2022e).

Function 6: Resource Mobilisation

In order to attract investment in the sector, which is on the decline, quantifiable investment business cases need to be developed by the department. In collaboration with industry role-players and HEIs, the WCDoA needs to create a strategy/ recognisable brand to attract skills and investment in the sector and to encourage innovation.

Function 7: Creation of legitimacy

Prominent actors in the sector are showing an interest and/or investing in innovation (e.g. 4IR study by Ungerer *et al.* (2018) and CPUT Agrifood Technology Station). This effort needs to be nurtured and expanded which would also allow for the showcasing of innovation to improve its appeal.

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11 APPENDIX A: WESTERN CAPE AGRI PROCESSING ACTORS AND ROLE-PLAYERS

Table 16 Western Cape Agri processing Actors and Role-players (Maseko,2022; (Green Cape Finance Data; WCG, 2022c; Wesgro, 2022b)

Actors/Role-players	Names	Comment/Description/Quantification
Research/Academia	Higher Education Institutions (HEIs): • University of Cape Town (UCT) • Stellenbosch University (SU) • University of the Western Cape (UWC) • Cape Peninsula University of Technology (CPUT) • Nelson Mandela Metropolitan University (NMMU) George Campus Research Organisations: • The Agricultural Research Centre (ARC) (Stellenbosch premises)	Agri processing research and development capacity.

	• Citrus Research International (CRI) Pty Ltd (Stellenbosch premises) • the Institute of Poverty, Land and Agrarian Studies at UWC. • Elsenberg Agricultural Training Institute (the WCDoA provides support on a broad range of agri processing services through the Agro-Processing Support sub-program).	
Input/Technology Suppliers	Input Suppliers (e.g. Kynoch (fertiliser suppliers), Henchem (pesticide suppliers, Dynatrade tunnel production). Technology Suppliers (e.g. Cape Cold Storage, Aerobotics Remote Sensing).	Input and technology suppliers produce inputs such as fertiliser, seeds, pesticides, packaging, machinery, green technology (e.g. solar PV manufacturers), production, harvesting processing, logistics and waste processing.
Public Sector	National Government: • The Department of Agriculture, Land Reform and Rural Development (DALRRD) • the Department of Forestry, Fisheries and the Environment (DFFE). Regional Government	DALRRD and DFFE are the primary National Government entities responsible for SA's agriculture sector and activities therein. They support the development of sustainable agriculture, in a manner that addresses historical inequities and drives inclusive job creation.

	• the Western Cape Department of Economic Development & Tourism (DEDAT) • Western Cape Department of Agriculture (WCDoA)	The DEDAT provides support to Agri processing businesses boosting private sector investment, promoting exports and enterprise development. The WCDoA provides development, research and support services in the WC agricultural community.
Industry Associations	Government Financial Institutions: • WCDoA • Department of Small Business Development (DSBD) • Department of Trade and Industry and Competition (DTIC) • Department of National Treasury Development Finance Institutions • Ithala Development Finance Corporation Ltd • Land and Agricultural Development Bank of South Africa • Industrial Development Corporation (IDC) • African Development Bank (AfDB)	Various sources of Agri processing finance (public, private and blended) are available from government (local and international), development finance institutions, commercial and others.

	• World Bank Group's Multilateral Investment Guarantee Agency (MIGA) • Standard Chartered Bank of the United Kingdom (SCB-UK) Commercial Banks • Absa Bank • Standard Bank • Nedbank • First National Bank Agricultural Agencies • Kaap Agri (Pty) Ltd • Capital Harvest (Pty) Ltd • Unigro Farmer Lending • Hortfin • BKB Agrifin Development Agencies • National Youth Development Agency • Small Enterprise Finance Agency	

	• Masisizane Fund • Small Enterprise Development Agency (SEDA) • Enablis Accelaration Fund • National Empowerment Fund • Identity Development Fund (IDF) Other • Anela Capital (Pty) Ltd • Acorn Private Equity • UFF African Agri Investments • Arise • GreenTec Capital Partners • Old Mutual Industry (e.g. Fresh Harvest, Afoodable, Oceana, Alpen Food Company, Parmalat, Assegaay Bosch Ranch (Pty) Ltd, Pick n Pay, BOS, Pioneer Fishing (Pty) Ltd, Bowler Metcalf Limited, Pioneer Foods, Cape Thai Restaurant Holdings (Simply Asia), Premier Fishing SA (Pty) Ltd,	

	Cape Vintages (Pty) Ltd, Ceres Fruit Juices, Real Foods, Coca Cola, Rembrandt, Deli, Remgro Limited, Dewcrisp Western Cape (Pty) Ltd, Rhodes Food Group, Distell, Robertson Winery, Excellent Meat Market, Sea Harvest, Simonsberg Cheese, South African Dried Fruits, Irvin & Johnson Limited (I&J), Spur, Jack Black Brewing Co., Systemfarmer (Pty) Ltd, Klein Karoo Saad Bemarking (Pty) Ltd, The Coca-Cola Company, Konstanz Properties (Pty) Ltd, Tiger Brands (Beacon), KWV Holdings, Twizza, Langeberg & Ashton Foods, W En E Ohlhoff Boerdery CC, Lindt, Willendorf Rustica CC, Lodestone Brands (Pty) Ltd, Wj Van Niekerk (Pty) Ltd, Monis ACG Fruit formerly known as Afrifresh.)	
Support Organisations	NGOs, Faith Based Organisations (FBO), and Community-Based Organisations (CBO): • Women on Farms Project (WFP) • Abalimi Bezekhaya • South African Urban Food and Farming Trust	Support organisations provide financial and social support for employees in the agricultural sector. There is a wide range of organisations generally dependent on donor money for advocacy activities, the promotion of food security and addressing challenges faced by people living on farms.

	Organisations representing smallholder farmers in the WC: • National African Farmers Association (NAFU) • African Farmers Association of South Africa (AFASA). • Black Farmers Association of South Africa (BFASA) • United South African Agricultural Association (USAAA). Support services for Agri processing Businesses and investors: • InvestSA One Stop Shop • City of Cape Town Enterprise and Investment • GreenCape • Wesgro • SAREBI • SARETEC (South African Renewable Energy Technology Centre) (Maseko, 2022).	The majority of commercial farmers belong to a farmer association and/or one or more industry organisations that jointly form Agri West Cape and eventually Agri South Africa.

Producers/Farmers **Agri processing companies**	Commercial Farmers (e.g. Du Toit Group, Rainbow, Daybreak Farms, Karan Beef, AFGRI, Mega Merinos, Milk Pro, Nipypy Brand Branding Iron, Organic Green, Ratho Farms, Fresh Harvest, Montic Dairies and Sonnendal dairies, Assegaay Bosch Ranch (Pty) Ltd, Robertson Winery, Zorgfontein Boerdery (Pty) Ltd. Small-scale/emerging/smallholder farms (e.g. Community gardens, School Gardens, Household Gardens, subsistence farms)	Producers/farmers (commercial and emerging/small scale) produce commodities and in most cases do their own harvesting, storage, and transport. Commercial agricultural farmers supply the majority of the WC's food while small-scale/emerging/smallholder farms subsistence/smallholder farmers farm primarily for their own consumption. Fly over data supplied by WCDoA indicates 269744 in the Western Cape.

12 APPENDIX B: MEASUREMENT FRAMEWORK & SELECTED INDICATORS

The following framework as utilised in this project presents RIS according to seven functions (Macaskill, 2022) Each function focuses on a different aspect of a RIS where indicators and diagnostic questions give input into each function.

Table 17 System functions and indicators for regional innovation systems (RIS) in Western Cape (WC)

	Function	Definition	Probing questions for RIS	Indicator	Description
F1	Entrepreneurial activity	Entrepreneurs are needed in any innovation system. They convert knowledge, networks, and markets to create and use business opportunities.	• Who promotes entrepreneurial activity in the RIS? • Who utilises innovation more? i.e., Emerging firms and developed firms. Includes social and	Number of new entrepreneurs/ entrants	The influx of new entrepreneursin the form of SMEs or start-ups shows growth in the system. An increase in new entrants shows the system is attractive to new participants.
				Private vs public sector enterprises	Comparing the private and public sectors shows the degreeof privatisation within the system. This helps determine which sector has more influence in the system.

			traditional entrepreneurs.	Number of entrepreneurs/enterprises	The number of entrepreneurs or enterprises indicates how populated the system is.
				The churn rate of entrepreneurs	The churn rate of entrepreneurs represents the rate at which entrepreneurs leave the system,either by not being supported enough or not being able to succeed.
				The intensity ofte competition	Entrepreneurs generally compete against each other to stay ahead. This indicator looksat how intense entrepreneurs innovate to compete against each other.
F2	Knowledge development	An important aspect of innovation is the knowledge creation process. This includes	• How is knowledge created in the region?	Sources and intensityof knowledge development	The source and intensity of knowledge are crucial to understanding where knowledge is originating from and how much knowledge is being generated, this is commonly measured by the

		learning by searching and learning by doing.	• Knowledge needs to be created to enable innovation. • Decide on the types of knowledge and the sources of knowledge. • Can measure with patents, R&D projects, and R&D investments.		number of patents filed and articles published. Main knowledge development sources are education institutes and private R&D.
				Who finances the knowledge development?	For knowledge to be generated there needs to be some form of financial backing. Financial contributions can come from the private sector, self-funded byeducation institutes or governmental grants/incentives.
				Who leads research and development?	Which source contributes the most to knowledge production within the innovation system? Does the private sector, education institutes, or research institutes produce the majority of the knowledge for the IS?
				Relevance of knowledge produced	Is the knowledge produced relevant to themain sectors within the innovation

					system? Six types to consider are scientific, technological, production, market, logistics, and design.
				Who collaborates to produce published knowledge?	Identifying collaborations determines which actors are working together to produce published knowledge (knowledge measured through bibilometrics). This indicates interactions among the actors and can show a more developed IS.
				Who collaborates to produce knowledge from R&D?	Identifying collaborations determines which actors are working together to produce knowledge from research and development. This indicates interactions among the actors and can show a more developed IS.
F3	Knowledge diffusion	Support the diffusion of ideas and		Are there partnerships or collaborations?	Partnerships or collaborations are evidence of interactions among actors.

		innovations through supply and demand-side support mechanisms/diffusion. The exchange of information is important, namely in a research and development environment. Activity can be seen through 'learning by interacting' or 'learning by using'	• How do you share the knowledge that had been created? • Look at networks that exist. Can be measured by several workshops or conferences hosted, the size of these events also plays a factor. • The market of knowledge plays a role here: measure by the number of publications and their citations.	How is knowledgeshared?	The medium through which knowledge isshared is crucial to inform decisions and policymakers effectively. Knowledge canbe shared in various ways. Some ways to share knowledge are through events suchas workshops, seminars, conferences or private meetings among actors.
				Is the knowledge diffused relevant tothe IS?	Similar to the "relevance of knowledge produced" indicator for knowledge development, the knowledge diffused in the IS needs to be relevant and usable. Determining the relevance is based on the IS's sectoral focus.
				Who shares more knowledge?	To develop appropriate insight into knowledge diffusion in the IS it is important to identify who the primary drivers are. Knowing if the primary

					drivers belong to the private or public sector can aid policymakers when developing incentives or supporting policies to improve knowledge sharing in the IS.
				Absorptive capacityof the IS's actors	How much knowledge is absorbed by theactors within the IS. Through which knowledge diffusion medium is more knowledge absorbed?
F4	Guidance of search	Guidance towards correct investment in technologies and developments This function helps create goals and targets to direct knowledge creation	• Is there a clear goal to improve innovation? • Is the innovation agenda pushed by different actors?	Do clear targets/goalsexist?	Have actors set properly defined targets or goals that aim to improve the IS?
				Do the goals cause government involvement?	This indicator determines if the government is present and what role they play in the IS.
				Does existing or new legislation/ regulation act as a barrier or an enabler?	Structural elements still need to adhere tolaws that exist within the IS's boundary. Laws that exist or are going

		and diffusion. It shows that change does not happen by itself. A catalyst is needed to activate it.			to be introduced can affect innovation performance negatively or positively.
				Articulation of interest by leading customers	The demand from the users using the outputs of the IS provides a direction for the IS to move towards.
F5	Market formation	As new technologies are not optimised on release. An environment must be created to help increase the diffusion rate of new technologies.	• Are the appropriate policies implemented? i.e., financial incentives, forms of money injection, demand-side policies. • Is there a market developed for innovation to exist?	Are their policies, or incentives for the market?	The implementation of policies that shapethe market helps improve innovation growth and stimulates demand. An incentive can be used to provide directionto actors. Tax breaks/regimes and conditional grants are examples of some incentives.
				Market size of aspecific sector	The market size indicator helps determine the presence of existing markets for an innovation to enter. It also aims to identifythe presence of niche markets created to assist innovations.

				Who are the sector'smarket leaders?	It is important to understand which participants influence the market development to facilitate innovation growth. Determining if these are private or public actors provides insights into theIS.
				What lifecycle stageis the market in?	The market phase helps characterise already existing markets that have been identified. They can be characterised as nursing, bridging, and mature. A nursing market, also a niche market, has limited structural elements and growth potential.A bridging market has space to welcomemore structural elements. A mature market is seen as a large and well-established market.
F6	Resource mobilisation	It refers to the activities involved in		Nature of financial resources	Financial resources refer to any form of access to funding, investments or loans.

		the mobilisation and alignment of resources in the innovation system. Financial and human capital is crucial as a foundation for any innovation system. They are also required for knowledge creation to begin.	• Are resources easily available for the actors involved in the innovation? • Are there programs to improve resource availability?		The presence of fiscal resources is crucialto be determined as money drives the economy of an IS, the more financial resources available the more opportunity for entrepreneurial activity, knowledge development and diffusion.
				Accessibility of financial resources	Having financial resources is one side of the coin, the other is access to the resource. Is it easy to obtain funding or investors or is it difficult? Limiting financial resources could hinder innovation's performance.
				Accessibility of seed and venturecapital (VC)	Seed and venture capital are synonymouswith innovation, the presence and availability of seed and VC are crucial tothe performance of innovation within an IS.

				Accessibility of infrastructure to provide basic needs (business-facing as well)	The basic needs refer to water, food, security, health care, shelter, and education. The indicator refers to adjustedbasic needs as access to the internet is included as multiple countries have added the internet as a basic need.
				Availability of appropriately skilledworkforce	The population of an educated workforceis important to note as without a workforce the other functions will not be fulfilled. This indicator specifically refersto the portion of the workforce that has completed some form of further studies, tertiary or at alternative education institutes.
				Availability of a high-skill workforce	It has been observed that the innovation performance in an IS is better with an increased presence of a workforce

					qualified in high-skill education. A high-skill worker refers to any individual witha qualification in mathematics, science or engineering.
F7	Creation of legitimacy	When a new technology is introduced, it needs to enter the market or create its own. Various partnerships, such as putting new technology on the agenda (F4), lobbying for resources (F6) and favourable tax regimes (F5). These types of actions create a new	• How is the innovation promoted to the public? Is it marketed well; are discussions held? • Can be measured by How much effort is done for innovation to exist within the area? • Look at the increase of various interest groups and	Strength of resistanceto change for a specific sector?	Resistance to change is the reluctance to accept changes in circumstances and processes. The evidence of past cases of how elements in the IS have reacted to innovations can indicate their resistance tochange. Resistance to change may vary between communities.
				Is there recognised actor support?	Actor support is intended to create a claim to legitimacy by showing that prominent actors are showing interest and/or investing in the innovation. These prominent actors can be in the form of government departments or large enterprises.

		technologies legitimacy.	their collective effort.	Are there mechanisms to engage with the community?	The community plays a large role in the acceptance of an innovation. An innovation needs group backing or buy-into be successful. A community that buys into innovation easier will greatly improve the IS's innovation performance.Is the sector socially acceptable?
				Do actors lobby for sector support? Are there resources or formal structures to empower lobbying for actor support?	Lobbying is often used by decision-makers in an IS to make a change or provide what other elements require. Resources are often popular topics for lobbyists.
				Are the benefits of innovation marketed effectively?	Innovation needs to be effectively showcased to the market to improve its appeal and demand. The more exposure innovation receives, and the community isinformed the more likely

					the IS elements'reaction to innovation changes.

13 APPENDIX C: MATURITY MATRIX

The maturity matrix forms a crucial part of the measurement framework (Appendix B) in terms of the measurement of an innovation system. The following maturity matrix was utilised in this project (Mackaskill, 2022) where four stages (birth, growth, mature and decline) of a system's lifecycle are indicated. The corresponding numerical expression for each stage is indicated in Table 1.

Table 18 Maturity matrix for RIS in Western Cape Region

		Indicator	**Birth**	**Growth**	**Maturity**	**Decline**
F1		Number of new entrepreneurs/ entrants	A low number of new enterprises. Enterprises are not innovation-focused.	A rapid increase of new enterprises. Few established innovation-focused enterprises.	Continuous introduction of newenterprises. Most enterprises are innovation-focused.	It is difficult for newer enterprises to compete due to too many large corporations. Enterprises do not focus on innovation.

	Entrepreneurial activity	Private vs public sector enterprises	The sector is made up of a small number of private enterprises andis majorly made up of public enterprises.	The sector has a growing number of private enterprises that hold healthy relationships with public enterprises.	The sector is majorly made up of private enterprises but works in synergy with the public enterprises present.	The relationship between private and public enterprises deteriorates. A large number of enterprisesleave the system in a shake-out event.
		Number of entrepreneurs/enterprises	A low number of enterprises. Enterprises are not innovation-focused.	An increased number of enterprises. Few established innovation focus enterprises.	A large number of enterprises. Most enterprises are innovation-focused.	Multiple large corporations dominate the market. Enterprises do not focus on innovation.
		The entrance vs churn rate of entrepreneurs	There is a slightly higher entrance ratio than the churn rate of entrepreneurs.	There is a continuous increase in the entrepreneur entrance ratio compared to the churn rate of entrepreneurs.	There is little to no difference in the entrepreneur entrance ratio and the churn rateof entrepreneurs.	There is a continuous increase in the churn rate of entrepreneurs compared to the entrepreneur entrance ratio.

		The intensity of the competition	There is no or minimal competition in the IS. There is a small number of actors that compete.	There is increasing competition among a growing actor base. The marketplace is competitive.	There is a large amountof competition in the IS. The market is moderately concentrated.	The market is highly concentrated or is dominated by few market leaders decreasing the intensityof competition.
F2		Sources and intensity of knowledge development	Minimal or no knowledge creation occurs from sector participants. No clear R&D efforts from enterprises.	Continuous increase of knowledge created. An academic institution in the sector's region has an increasing amount of knowledge production. A small number of enterprises are involved in producing R&D contributions.	A large amount of knowledge is constantly generated. Academic institutes produce large volumes of multi-topic knowledge. Enterprises are aiding in knowledge creation through published R&D efforts.	There is a decreasing amount of knowledge generation. The academic institute associated with the sector has a much lower output than usual. Enterprises have shifted their focus away from performing R&D.
		Who finances the knowledge development?	There is minimal or no funding for knowledge development.	There is an increasing number of well-known funding sources for knowledge development.	It is clear where to obtain finances, private or public, for knowledge development.	There is a decrease in the number of sources of funding for knowledge development.

	Knowledge development	Who leads research and development?	There are no leaders in research and development.	There is an increasing number of prominent leaders in research and development	There is a large number of prominent leaders in research and development	Leaders start decreasing their contributions and/ or start leaving the system.
		Relevance of knowledge produced	A small amount of academic knowledge produced is relevant to the sector's priorities.	There is a growing level of activity of academic knowledge produced relevant to the sector's priorities.	More sector-relevant knowledge is produced from academia and the private sector.	The knowledge produced has shifted focus away from the sector and is developed more for other sectors.
		Who collaborates toproduce published knowledge?	There is no to minimal collaboration among actors of published knowledge.	Actors collaborating to produce published knowledge increases rapidly.	There is clear evidenceof who collaborates when producing published knowledge.	Collaboration efforts, among actors, to produce published knowledge decrease.
		Who collaborates to produce knowledge from R&D?	There is no to minimal collaboration among actors of R&Dknowledge.	Actors collaborate to produce R&D knowledge increases rapidly.	There is clear evidenceof who collaborates when producing R&D knowledge.	Collaboration efforts, among actors, to produce R&D knowledge decrease.

F3	Knowledge diffusion	Are there partnerships or collaborations?	No clear partnerships between enterprises.	There are some collaborations among enterprises and between academic institutes.	Clear collaboration among enterprises and between academic institutes.	A decreasing number of collaborations among enterprises and academic institutes.
		How is knowledge shared?	Minimal or no knowledge diffusion attempts, or events occur in the sector.	Knowledge is mostly shared unintentionally, intentional knowledge events, and sharing are increasing in the sector.	Continuous formal events occur between various innovation-related parties related to the sector.	A decreasing number of formal events focused on previous innovations occur in the sector.
		Is the knowledge diffused relevant to the IS?	The knowledge diffused in the area has small relevance to the main sectors in the IS.	There is an increase in the efforts to diffuse sector-relevant knowledge.	There is a high level of activity to diffuse new and sector-relevant knowledge.	Participants in the sector have shifted their focus, from the currently diffused knowledge, decreasing its relevance.
		Who shares more knowledge?	There are no leaders in knowledge-sharing efforts.	There is an increasing number of prominent leaders in knowledge-sharing efforts.	There is a large number of prominent leaders in knowledge-sharing efforts.	Leaders start decreasing their contributions and refocusing their efforts on other innovations or sectors.

		The absorptive capacity of the IS's actors	IS actors struggle to absorb and utilise the diffused knowledge?	IS actors' ability to absorb and utilise the diffused knowledge improves.	IS actors absorb and utilise the diffused knowledge effectively.	IS actors reject the diffused knowledge as they have shifted their focus and don't absorb it anymore.
F4	Guidance of search	Do clear targets/goalsexist?	No innovation- orientated sector- focused targets and goals are set.	Innovation-orientated sector-focused targets and goals are being set and achieved.	Innovation-orientated sector-focused targetsand goals have been achieved in the region.	Innovation-orientated sector-focused targets or goals are not revised when met or failed to be achieved.
		Do the goals cause government involvement?	The government is not or is minimally involved with goal setting or contributing to achieving the sector-focused goals.	The government is increasingly involved with goal setting or contributing to achieving sector-focused goals.	The government is steadily involved with goal setting or contributing to achieving the sector-focused goals.	The government decreases its support for goal setting or contributing to achieving the sector-focused goals.
		Does existing or new legislation/ regulation actas a barrier or an enabler?	Current legislation actsas a strong barrier to innovation in the IS.	Impeding legislation is relaxed and/ or new legislation is introduced to aid innovation in the IS.	Impeding legislation is minimal and/ or new legislation strongly aids innovation in the IS.	Current legislation is outdated and hinders innovation, it needs to be updated again.

		Articulation of interest by leading customers	There is minimal to no interest articulated by leading customers in the innovation system.The IS actor's demand is not clear.	Leading customers increasingly articulate the interests showing the IS participant's demand.	It is clear what the IS's interest is and it is well articulated. All actors understand each other's demands.	The interest is not articulated well and the customer's interest has shifted to other innovations or sectors.
F5	Market formation	Are their policies, or incentives for the market?	No policies or incentives exist to promote innovation or innovative related solutions.	Policies or incentives to support innovation are introduced and utilised by various entities.	The market is well-formed and self-sufficient. Policies or incentives do not havea large effect on the market's growth.	The policies or incentives in place don't have any impact and the market is beginning to decrease in size due to other markets.
		The market size of aspecific sector	The sector's market is non-existent/tiny and would require work to develop.	The sector's market is growing rapidly and receives increasing growth.	The sector's market has slowed, but it is receiving a sustaining amount of support.	The sector's market is decreasing in size and needs to pivot to accept newer innovations.

		Who are the sector'smarket leaders?	It is not easy to identifythe sector leaders. The market is still for new entrants to succeed.	Clear sector leader(s) emerge and can be easily identified. There is still space in the market for new entrants.	Sector leaders are easily identifiable, they dominate the market making it difficult for new entrants to succeed.	The sector's marketstarts to lose its relevance and the sector leaders withdraw or shift their focus from the sector.
		What lifecycle stage is the market in?	The market is a niche market and has limited structural elements.	The market is bridging and welcomes more elements. The elements find it easy to grow.	The market is mature,it is large and well-established. Structural elements are comfortable and there is minimal change.	The market is declining and is either left to phase out or renewed by aiming to grow again.
F6		Nature of financialresources	There are few funding resources or mechanisms available.	There is an increasing number of different funding resources or mechanisms available.	There is a large variety o types of funding resources or mechanisms available.	There is a limited number of types of funding resources or mechanisms available.
		Accessibility of financial resources	Financial resources are not available or are difficult to obtain.	Financial resource access is increasingly easier, and investors are showing increased interest.	Established financial resources exist (i.e. established banks,	Financial resources are withdrawing their support from the sector.

					venture capital firms and angel investors).	
	Resource mobilisation	Accessibility of seed and venture capital (VC)	Seed and venture capital are not available or are difficult to obtain.	Seed and venture capital access is increasingly easier, and investors are showing increased interest.	Established access to seed and venture capital exists (i.e., established venture capital firms and angelinvestors).	Financial resources are withdrawing their support and leaving thesystem.
		Accessibility of infrastructure to provide basic needs (business-facing as well)	The infrastructure to meet basic needs is mediocre or non-existent.	The infrastructure to meet basic needs is improving and is accessible.	The infrastructure to meet basic needs is well-developed and stable.	No further investments into the infrastructure to meet basic needs are made, and they start to deteriorate.
		Availability of appropriately skilled workforce	There are minimal or no appropriately skilled workers available.	There is a large increase of appropriately skilled workers to employ.	There are plenty of appropriately skilled workers in the region.	There is a decreasing number of appropriately skilledworkers

		Availability of a high-skill workforce	There are minimal or no high skilled workers available.	There is a large increase of high skilled workers to employ.	There are plenty of high-skill workers inthe region.	There is a decreasing number of high-skill workers
F7		Strength of resistance to change for a specific sector?	The sector's participants are resistant to change and are not open to innovative ideologies or influences.	The sector's participants are opening to different innovations and are starting to welcome them into their everyday lives	The sector's participants are accepting of innovative solutions and continuous change. There are plenty of examples of what innovation does for the sector. A clear buy-in can be seen by prominent entities.	The sector's participants are startingto lose trust in new innovations and what innovation does for the sector.
	Creation of legitimacy	Is there recognised actor support?	There are no recognisable brands or enterprises supporting innovation	Large enterprises are starting to support and fund innovation activities and actors within an area.	There is consistent and committed support from recognised enterprises for innovation activities and actors within an area.	Large enterprises are withdrawing their funds and support forinnovative activities.

		Are there mechanisms to engage with the community?	There is no to little way for innovation driving actors to engage with the community.	There is an ever-growing number of ways to engage with the community on innovation topics.	There are established mechanisms to engage with the community.	Current engagement mechanisms are overused, and the communities focus shifts while participation decreases.
		Do actors lobby for sector support? (Are there resources or formal structures to empower lobbying for actor support?)	Actors do not or barely lobby for support fromthe appropriate support actors in the IS. There are no formal processes to follow to lobby.	Actors are increasingly lobbying for their required resources, changes to legislation, and implementation ofgoals.	There is a continuous group lobbying for required resources, changes to legislation,and implementation ofgoals.	Lobbying groups' presence is diminished and there is decreased lobbying activity. Formal processes become difficult tonavigate.
		Are the benefits of innovation marketedeffectively?	No to minimal effort to market innovation is performed.	The benefits of innovation are increasingly marketed more and made clearerto actors in the IS.	The benefits of innovation are marketed effectively and are understood by actors in the IS.	There is confusion regarding the benefits of innovation, some of the benefits expressed are outdated and should be revised.

14 APPENDIX D: MATURITY MATRIX APPLICATION-RESULTS

Table 19 Maturity Matrix applied to the WC Agriculture and Agri processing sector -results.

	Function	Lifecycle stage (see table 2)	Function Score
Function 1: Entrepreneurial Activity			
F1.1	Number of new entrepreneurs/ entrants		2,5
F1.2	Private vs public sector enterprises	3	
F1.3	Number of entrepreneurs/enterprises	2	
F1.4	The entrance vs churn rate of entrepreneurs		
F1.5	The intensity of competition		
Function 2: Knowledge development			
F2.1	Sources and intensity of knowledge development	2	1.66
F2.2	Who finances the knowledge development?	1	
F2.3	Who leads research and development?	2	
F2.4	Relevance of knowledge produced		
F2.5	Who collaborates to produce published knowledge?		
F2.6	Who collaborates to produce knowledge from R&D?		
Function 3: Knowledge diffusion			
F3.1	Are there partnerships or collaborations?	2	2.00
F3.2	How is knowledge shared?	2	
F3.3	Is the knowledge diffused relevant to the IS?		
F3.4	Who shares more knowledge?		
F3.5	The absorptive capacity of the IS's actors		
Function 4: Guidance of search			
F4.1	Do clear targets/goals exist?	2	2,33
F4.2	Do the goals cause government involvement?	3	

F4.3	Does existing or new legislation/ regulation act as a barrier or an enabler?	2	
F4.4	Articulation of interest by leading customers		
Function 5: Market Formation			
F5.1	Are there policies or incentives for the market?	3	3,00
F5.2	Market size of a specific sector	3	
F5.3	Who are the sector's market leaders?	3	
F5.4	What lifecycle stage is the market in?		
Function 6: Resource mobilisation			
F6.1	Nature of financial resources	3	1.75
F6.2	Accessibility of financial resources	2	
F6.3	Accessibility of seed and venture capital (VC)	1	
F6.4	Accessibility of infrastructure to provide basic needs		
F6.5	Availability of appropriately skilled workforce		
F6.6	Availability of a high-skill workforce	1	
Function 7: Creation of Legitimacy			
F7.1	Strength of resistance to change for a specific sector?		2.00
F7.2	Is there recognised actor support?	2	
F7.3	Are there mechanisms to engage with the community?		
F7.4	Do actors lobby for sector support?		
F7.5	Are the benefits of innovation marketed effectively?		