



**AQUAPONICS AS AN URBAN BUSINESS INITIATIVE TO ALLEVIATE FOOD
INSECURITY AND UNEMPLOYMENT IN THE WESTERN CAPE PROVINCE OF SOUTH
AFRICA**

by

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DECLARATION

I, Colin Jonathan, declare that this dissertation represents my own work and except where otherwise stated, I have referenced the source. This work has not formerly been submitted for academic examination towards any qualification in any Institution. The study represents my own perspectives and not primarily those of the Cape Peninsula University of Technology.

Signed

Date

ABSTRACT

People are increasing at a rapid rate and more than 50% have relocated to urban areas. This influx of people has elicited urban food insecurity and unemployment. The food industry finds it hard to keep up with the constant demand for sufficient, nutritious food resources for all people. The United Nations is pushing to resolve this matter by 2030 (Sustainable Development Goals) to get all people food secure. In the meantime, this study collaborates to mitigate food insecure consequences. Unemployment has exacerbated and has become a peril to social development attributable to a lack of sufficient income. Food insecurity affects risk-related health problems such as hunger, malnutrition, wasting and stunting. Aquaponics is a small business initiative and can range from a small-scale countertop pastime to a large-scale commercial establishment. Aquaponics necessitates two disciplines: aquaculture and hydroponics, growing leafy produce and fish in one operative close-loop system. The study employed qualitative data to acquire in-depth knowledge on the subject. The data indicated that aquaponics is capable of being important drivers of integrated food production systems. Findings suggest aquaponics as a dynamic and rapidly growing field with respondents who are actively experimenting with and adopting new technologies. Commercial aquaponics are effective when produced in favourable climate-controlled settings like greenhouses and tunnels, making use of methods and equipment found in both hydroponics and aquaculture productions. The results highlight the products that can be prioritised to reduce food insecurity in the Western Cape region of South Africa. Results further suggest support for this aquaponic business in order to help reduce unemployment. This survey is one of the few carried out on aquaponics in South Africa and provides information that can better inform policy, research, and training efforts regarding Aquaponics.

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DEDICATION

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ABBREVIATIONS AND ACRONYMS

AASA	Aquaculture Association of Southern Africa
BMI	Body-Mass Index
CCT	City of Cape Town
CSI	Coping Strategies Index
DAFF	Department of Agriculture, Forestry and Fisheries
DWC	Deep water culture
EAF	Ebb-and-flow technique
EC	Eastern Cape
FAO	Food and Agriculture Organization
FRT	Floating raft technique
FS	Free State
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GHI	Global Hunger Index
GP	Gauteng Province
HFSSM	Household Food Security Survey Module
IRB	Institutional Review Board
KZN:	KwaZulu Natal
MP	Mpumalanga
NC	Northern Cape
NFT	Nutrient film technique
NW	North West
RAS	Recirculating Aquaculture System
SA	South Africa
SSA	sub-Saharan Africa
Stats SA	Statistics South Africa
WC	Western Cape

WFO	World Food Organisation
WFP	World Food Programme
YES	Youth Employment Services

CLARIFICATION OF BASIC TERMS

The following are key terms as applied in this study:

Food Insecurity: a condition of extreme poverty, under-nutrition and malnutrition, which, amongst others, causes hunger, stunting and premature death (Steiner, Geissler & Schernhammer, 2019:4; Tranchant, Gelli, Bliznashka, Diallo, Sacko, Assima, Siegel, Aurino & Masset, 2019:185).

Unemployment: a multidimensional concept that denotes four major categories of unemployment: structural, frictional, cyclical and seasonal and does not have a single outcome or definition. South Africans are more exposed to structural unemployment and the Western Cape is challenged with seasonal unemployment (Banda, Ngirande & Hogwe, 2016:247).

Aquaponics: a process whereby vegetable plants and aquatic species (fish) are farmed concomitantly, involving a process of recirculation that takes place in a systematic closed-loop environment (Pollard, Ward & Koth, 2017:1). Aquaponics in this study involves a consolidation of aquaculture with hydroponics in a mutually beneficial ecosystem.

Hydroponics: a process where only plants (herbs, vegetables) are cultivated in water; fish is excluded and fertilisers are used (Sharma, Acharya, Kumar & Chaurasia, 2018:369).

Urban Agri-business: Agri - represents agriculture. Large-, medium- and small-scale urban Agri-farmer-business ingenuity or urban agriculture/farming is depicted as an adopted method of food production technology, a rural farming architecture modified to fit an urban ambiance (Haselhorst, Baldwin & Stwalley III, 2019:359).

Sustainability: is defined as using a limited resource to its maximum potential and preserving it for future generations in relation to its environment and ecology, whether as a hobby or as a business, in order to engage trade and industry profitability, social and economic constancy (Velten, Leventon, Jager & Newig, 2015:7834).

Household: a group of individuals living together and providing themselves jointly with food and/or other necessities for living, or a single person who lives alone.

Agribusiness: a concept of “the total of all operations involved in the manufacture and distribution of farm supplies; production operations on the farm; and the storage, processing, and distribution of farm commodities and items made from them” (Davis & Goldberg, 1957, cited by Van Fleet, 2016:3).

CHAPTER 1

INTRODUCTION AND PROBLEM IDENTIFICATION

1.1 Introduction and Background

Rapid population growth places immense pressure on food demand, necessitating continuous appraisal of the business sectors dealing with food production (Birkby, 2016:9; Malabo Montpellier Panel, 2017:3). This swift population increase in urban centres is one of the critical causes of food insecurity (Ayenew & Kopainsky, 2014:3). More than 7.9 billion people live on the earth (Worldometer, 2021:1), and these people need food daily. Research by Dos Santos (2016:402) reported that more than half of the world's population currently resides in cities, and this influx has elicited urban food insecurity (Mchunu, Lagerwall & Senzanje, 2018:12). The pressure on the current food system in cities can be ascribed to an overload of city dwellers (Birkby, 2016:9; Malabo Montpellier Panel, 2017:3).

In addition to the population hike, food insecurity can be attributed to many natural occurrences worldwide. These occurrences include climate changes, poor soil quality and water paucity (Dos Santos, 2016:403). Conventional farming businesses are impacted by these natural occurrences when crop yields decrease due to droughts caused by climate change. As a result, food becomes more expensive and buying power decreases, leading to the risk of food insecurity and hunger, especially during inoperative months (Devereux & Tavener-Smith, 2019:1-2).

Food insecurity is a phenomenon where there is an insufficient nutritious food supply for people (Govender, Pillay, Siwela, Modi & Mabhaudhi, 2016:2). Therefore, it is a threat to the United Nations (UN) sustainable development goal for 2030, which aims at providing everyone with an adequate nutritional food supply (Zuinga, Lynn, Mwesigwa, Norell, Sriram, & Tumusiime, 2019:189).

Unemployment is a socio-economic challenge with catastrophic effects on the economy, business, health, politics, and society (Ewetan & Urhie, 2014:41; McCartney, Hearty, Arnot, Popham, Cumbers & McMaster, 2019:e2). Lack of income by the unemployed leads to reduced demand or a shift in demand toward cheaper products, negatively impacting small businesses. Seasonal unemployment in the agricultural sector is one of the major issues due to seasonal farmworkers who usually experience the brunt of going hungry during specific periods (Ayenew & Kopainsky, 2014:7; Devereux & Tavener-Smith, 2019:1-2).

The aquaponics business is the fusion of aquaculture and hydroponics. Aquaculture is the business process that involves fish and other aquatic creatures, usually in a fish vat with

constantly recycled water, also known as a Recirculating Aquaculture Systems (RAS) (Love, Fry, Genello, Hill, Frederick, Li & Semmens, 2014:1). Hydroponics is a diverse nutrient solution technique for growing vegetables without soil. Thus, hydroponics involves growing plants only in nutrient-rich water without fish (Sharma et al., 2018:369).

According to Jie (2017:1), aquaponics is a method of addressing food insecurity. This production technique produces cost-effective and innovative renewable resource technologies that reduce costs at certain inputs. This includes savings on material, fertilisers and pesticides with recycled water being used (Pollard, Ward & Koth, 2017:1). Furthermore, production can be done indoors in a climate-controlled environment, ensuring food availability and possible employment throughout the year (Putra & Yuliando, 2015:283-284). This can address food insecurity and unemployment among South African seasonal workers (Devereux & Tavener-Smith, 2019:1-2). The aquaponics business in South Africa is still in its infancy, with only a few growers participating (Mchunu et al. 2018:16). However, in its emerging stage, practical endeavours are realised.

Due to the increasing demand for food and the growing food insecurity and unemployment, this study will investigate how aquaponics businesses can be promoted; in particular in urban centres, to provide fresh produce and reduce unemployment (Pollard et al., 2017:8; Metropolitan Area Planning Council [MAPC], 2019: 2-3).

1.2 Problem Statement

The growth in urban city population demands speedy solutions to city food supply and urban employment creation. Suppressed production capacity, increased demand for food and escalating levels of unemployment that deprive the working-age population of stable and consistent income characterise growing metropolitan cities (Haysom, 2016:5). According to Dos Santos (2016:403), the threats related to food insecurity are spearheaded by conditions such as rapid population growth, fluctuating temperatures, soil poverty and water scarcity. Therefore, as cities increase in size, so does the need to produce more food (Birkby, 2016:1; Malabo Montpellier Panel, 2017:9).

Stats SA (2021:17) reported that South Africa's official unemployment rate reached 35.3% in the 4th quarter of 2021, with unemployment in the Western Cape region hovering at 28% over the same period. Unemployment lowers potential output and poses both political and social unrest. On the other hand, individuals experiencing food insecurity and severe food insecurity in the Western Cape region were 15.5% and 7.3%, respectively (Stats SA, 2019:15). Also, malnutrition, a manifestation of food insecurity, accounted for two million fatalities globally between 1998 and 2018, with 1-2% and 7% among adults and children,

respectively (Steiner et al., 2019:4). Hence, this study found it imperative to assess the extent to which aquaponics can help mitigate both food insecurity and unemployment in the Western Cape region of South Africa.

1.3 Rationale and Significance of the Study

The study aims to provide a sustainable solution to food insecurity and unemployment in the Western Cape region of South Africa. The study looks into the ability of aquaponics businesses to reduce food insecurity and unemployment through continuous access to food supply and employment all year round, as opposed to only seasonal employment opportunities prevalent in the conventional agriculture business sector (Putra & Yuliando, 2015:283-284; Devereux & Tavener-Smith, 2019:1-2). In addition, the study will promote the benefit of a soilless aquaculture industry, attract newcomers into the industry and develop a business concept for a sustainable small-scale to commercial urban agri-business.

1.4 Objectives of the Study

The study's primary objective is to investigate how aquaponic businesses can reduce food insecurity and unemployment in the Western Cape Province of South Africa.

1.4.1 Secondary objectives

To ensure that the primary objective is achieved, the following secondary objectives were formulated for this study:

- To establish how aquaponic and hydroponic businesses operate in the Western Cape region;
- To assess output growth techniques in the aquaponics and hydroponic businesses to provide possible solutions to enhance business growth;
- To establish the extent to which aquaponics and hydroponics can mitigate the risk of food insecurity in the Western Cape Province; and
- To demonstrate how aquaponics and hydroponics can reduce unemployment in the Western Cape Province.

1.4.2 Research questions

The following questions were formulated for the study:

- How do aquaponic businesses operate in the Western Cape region?
- What is the business growth potential?
- What types of products are grown in the aquaponic businesses?

- How can aquaponics and hydroponics businesses assist in mitigating unemployment in the Western Cape region?
- How can aquaponics and hydroponics businesses assist in mitigating food insecurity in the Western Cape region?

1.5 Literature Review

According to Dimitri, Oberholtzer and Pressman (2016:604), aquaponics is both a rural and urban farming practice of food production (Haselhorst et al., 2019:359). Food can be manufactured in a smaller farm space, with less water usage, in a well-nourished area and with a fast-tracked harvest (Cohen, Malone, Morris, Weissburg & Bras, 2018:552). Production takes place in an enclosed environment making crops available in and out of season. Aquaponics can increase the production of fresh food in urban areas. Its operation involves a crop and fish growing technology that combines aquaculture and hydroponics in one close loop system (David, Pinho, Agostinho, Costa, Portella, Keesman, & Garcia, 2022:2).

Hydroponics is a system where only plants are cultivated in a rich-nutrient water garden, and no soil is required (Swain, Chatterjee, Roy, & Biswas, 2021:629-631). Various nutrient techniques are used where plant roots grow in nutrient-rich solutions, referred to as the grow bed area. Hydroponic plants can be directly controlled by the varying amounts of nutrients added and taken up by the plant's roots. Higher control of nutrients increases production and allows plants to grow larger, faster and be harvested in a short time conducive for consumption and selling (Department of Agriculture, Forestry and Fisheries [DAFF], 2011:1, 4; Swain et al., 2021:629-631).

Aquaponics is a closed-loop agricultural system that goes through a complete cycle, producing various plants, fruits, and fish (Janni, & Jadhav, 2022:1-2). The fish is kept in a fish tank that supplies fertiliser to the plants in the grow bed. The fertiliser (fish droppings) remains toxic while being transported to the grow bed, where the ammonia is oxidised with the help of nitrifying bacteria, which break down the nitrite to nitrate, allowing the plants to absorb all the nutrients safely. The plants act as a biofilter to clean the water of all contaminants, and the filtered water is returned to the fish tank for reuse (Dimitri et al., 2016:604; Janni, & Jadhav, 2022:1-2).

Food insecurity is defined as extreme poverty, undernutrition and malnutrition, including hunger and pre-mature deaths (Steiner et al. 2019:4-5; Tranchant et al. 2019:187 & Ntshobane, 2018:1). Food insecurity is prevalent when individuals experience very limited food supply, expensive food products, low-quality foods and, at times complete lack of

nourishment (Food Gardens Policy, 2013:3; Haysom & Tawodzera, 2018:117). Food insecurity has different dimensions, including individual, household, regional and national food insecurity (Pandey & Bardsley, 2018:139-141; Stats SA, 2019:6; Militao, Salvador, Uthman, Vinberg, Macassa, 2022:1-9). South Africa has been affirmed as food secure at the national level while reporting that nearly 20% of South African households experienced inadequate or severely inadequate access to food. At regional or provincial levels, 1.6 million South African households were believed to experience hunger in 2017, of which more than 60% reside in urban regions (Stats SA, 2019:24). In addition, many cities are exposed to severe food insecurity, which negatively impacts the cities' progress (Food Gardens Policy, 2013:3).

Unemployment in South Africa reflects an all-time high of 35.3% (Stats SA, 2021:17). Unemployment is a multi-facet term consisting of different structural, frictional, cyclical and seasonal unemployment categories. The South African working environment is more familiar with structural unemployment, while the Western Cape region sees seasonal employment as a major challenge (Devereux & Tavener-Smith, 2019:1). Structural unemployment exists where many employees become technologically redundant in the workplace. This refers to people losing their jobs based on outdated skill sets, causing a mismatch between the jobs on offer and the required skills (Banda et al., 2016:246-247). Seasonal unemployment alluded to people who might not be needed for work throughout the year, including sectors like agriculture, tourism, hospitality, and construction. In agriculture, in particular, workers are employed during certain seasons of various crops and are laid off soon afterwards (Devereux & Tavener-Smith, 2019:2; Singh, 2019:97). Job losses, therefore, affect people's capacity to afford and attain access to sufficient and appropriate nutrition.

1.6 Research Methodology

The term research methodology refers to a methodical process of development ensuring the correct implementation of the research design inside a specific research context (Mohajan, 2018:3). A research methodology systematically outlines the entire research process, including the literature review, research method, research design, systematic data collection techniques, and data interpretation and analysis for a particular research inquiry (Igwenagu, 2016:4-5; Kivunja & Kuyini, 2017:28).

1.6.1 Research approach

This study employed a qualitative research approach. Qualitative research entails various approaches, including ethnographies, grounded theory, case studies, phenomenological research and narrative research (Antwi & Hamza, 2015:222, Bengtsson, 2016:8). Ultimately,

each goal is to provide reliable and accurate reference points, and this requires a systematic collection, organisation, narrative and explanation of oral, written, and visual data. An interview guide consisting of unstructured and semi-structured questions was employed to gain as much first-hand information as possible (Boyce & Neale, 2006:5).

1.6.2 Research design

The research design is described as a plan or a blueprint indicating how the research will be executed (Mohajan, 2018:5). It is applied in response to the research objectives and questions to attain rich, in-depth data to interpret the study accurately. Kallet (2004:1229-1231) mentioned that a variety of research methods are available, and when researching a particular issue, it is imperative to select the proper method. Picking the correct form ensures validity and reliability. An erratic method will inevitably produce an erratic result, devaluing interpretations of the findings. An interview guide with unstructured and semi-structured questions was utilised to gather as much first-hand information as possible. A virtual interview was conducted through Zoom, where respondents answered questions from the interview guide. These outlined the background information of the business, business strategies, employment, and output trends. Food insecurity, food security, new start-ups and possible employment growth formed part of the interview. Therefore, the qualitative research method was considered to ensure the correct data were retrieved and effectively reciprocate the correct answers and unfold the how and why of the studied phenomenon (Mohajan, 2018:2-3).

1.6.3 Population

According to Rahi (2017:3), a population is described as a large number of individuals or objects that make up or represent a whole in a particular field, which designates the main focus of a scientific investigation. In this study, the population included all the aquaponic and hydroponic businesses and all semi-commercial and commercial growers already active in the Western Cape Province. The population was determined through existing data from the internet about aquaponic and hydroponic growers in the Western Cape Province.

1.6.3.1 Sample size and sample technique

According to Walliman (2011:94), a sample represents a larger group of respondents, the population. For this study, five businesses were selected: three aquaponics and two hydroponics. Engaging the whole population in the study is costly and time-consuming, making a sample size fit for use (Rahi, Alnaser & Ghani, 2019:1164). The non-probability sampling technique was applied in the study, which is the purposive sampling technique (Etikan, Musa & Alkassim, 2015, 2-3).

According to Lopez and Whitehead (2016:124-127), purposive sampling can provide information-rich feedback for an exhaustive study, necessary to draw from the respondent's vast level of experience. Therefore, specific respondents were chosen due to their traits or qualities, considering their expertise in the industry and, importantly, their business growth experience; this is also referred to as criterion sampling (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2016:2-3).

The purposive sampling technique is also beneficial because it does not require underlying theories or referring to a specific number of respondents; instead, the respondents are well informed on the subject matter. Therefore, even with a smaller sample size, potentially rich and in-depth data can be generated from every respondent (Lopez & Whitehead, 2016:125-127).

1.7 Data Collection

Data collection entails the gathering and measuring of the variables of interest.

1.7.1 Data collection instrument

Data collection is pivotal to ensure the research questions and objectives are answered and to assess the research outcome. Making use of the appropriate data collection instruments minimises the possibility of errors. This, in essence, confirms the integrity of the research (Adosi, 2020:1-3).

Data were collected using an interview guide consisting of unstructured and semi-structured questions (Boyce & Neale, 2006:5; Adosi, 2020:1-3). These open-ended (unstructured and semi-structured) questions assisted in obtaining a broader range of what the urban farming businesses had on offer locally and across the borders of the Western Cape. The interview guide outlined the company's background information, business strategies, employment, and output trends. It also contained sections pertaining to food insecurity, food security, aquaponics, and possible employment growth.

1.7.2 Data collection/fieldwork

The study initially intended to use face-to-face interview sessions. However, due to a life-threatening pandemic with close contact as the main risk, this was deflected to a remote platform (Archibald, Ambagtsheer, Casey & Lawless, 2019:1-2; Ali & Alharbi, 2020:2). Primary data were therefore collected through an electronic platform. The respondents were engaged using the Zoom app. In addition, virtual interviews were scheduled at convenient timeframes for all respondents.

The study preferred a face-to-face interview as most interviewees are usually more at ease in their own convenience space. When they are more relaxed, it allows the interviewer more freedom to get closer into their private space, including their personal feelings and emotions. These are usually realised when the respondent is in a relaxed space of their own (Dilshad & Latif, 2013:192-193; Mavhandu-Mudzusi, 2018:5-6). Furthermore, face-to-face interviews also increase the possibility of obtaining the correct answers relevant to the research questions.

1.7.3 Data analysis

Once the data were collected, it was analysed. Thematic analysis, an inductive data analysis technique, was used (Braun & Clarke, 2006:78; Braun & Clarke, 2013:2; Nowell, Norris, White & Moules, 2017:2). This technique can be applied either by using conventional tools such as coloured pens, paper and multi-coloured sticky notes, signifying handwritten notes (manual coding), or computer software. The study used manual coding as a suitable option.

Using codes is effective as every code is linked to an activity. However, the words and phrases from the collective information are usually very broad and vague. Therefore, the words and phrases were organised into categories to reduce the information, coding each piece of raw data according to its categories (Saldaña, 2016:7-8). Hart, Webb, & Danylchuk (2013:466) highlighted how codes develop within each category by applying the constant comparative method. The study used manual coding to identify categories, subcategories, and codes. Then, all the relevant responses were extracted, categorised and allocated manually to locate the answers to the research questions.

1.8 Ethical Consideration

Ethical considerations were employed to secure the study's integrity and protect the respondents. Connelly (2014:54-55) stated that a report on ethical considerations is essential. The researcher and respondents reached an agreement through a letter of consent disseminated prior to the investigation. Each respondent's signature of consent was attained in advance of the interviews. Respondents had peace of mind knowing that their contribution was completely voluntary. All ethical considerations were followed. Information to assist the respondents in making an informed decision concerning the study has been provided, cognizant that informed consent is imperative. Respondents were under no obligation and could withdraw from the research at any given time. The anonymity of all respondents was prioritised to ensure their protection.

This research considered the guidelines of De Clerck, Willems, Timmerman & Carling (2011:16-17) with relevance to the following:

- Zero tolerance to any stereotyping,
- Privacy serves priority.
- Respect and punctuality.
- Well prepared and friendliness to create a user-friendly or safe environment for the respondent, even remotely.
- To be rewarded with an effective recording of wording, ensuring correct interpretation (unknown terminology).
- Good listening skills and compliance with the code of conduct before going into the field (remote platform).

Ultimately, this work adhered to CPUT ethical standards and was issued with an ethical clearance certificate numbered 2019FOBREC711.

1.9 Demarcation of the study

The study was based in the Western Cape Province of South Africa. The aquaponic respondents were in the Grabouw, West Coast, and Saldana areas. The hydroponic respondents were in Century City, Cape Town, and Kraaifontein, Bloekombos.

1.10 Outline of the study

Chapter 1

Chapter 1 introduced the background of the problem and stated the study's problem. This was further developed by employing a literature review, research method, research design, data collection techniques, data interpretation and data analysis for a specific research inquiry.

Chapter 2: Review of the Literature,

Chapter 2 reviewed all relevant literature to get hold of all essential secondary data related to the study like scientific papers, theses, dissertations, and published and unpublished sources locally and internationally.

Chapter 3: Research Methodology, Methods and Design

Chapter 3 described how the study's methodology was carried out in an all-inclusive systematic sequence, describing the methodology and design of the study, including the research philosophy and research process, as well as the sample size and data collection methods chosen.

Chapter 4: Research Findings

In this chapter, the research findings were outlined. The collected data was scrutinised and coded to accurately assess and ensure the correct answers were obtained to conclude the research questions and answer the inquiry.

Chapter 5: Conclusions, Discussion, and Suggestions for Future Research

Chapter 5 reviewed and concluded the study. Finally, recommendations are made based on the study results, and future studies are suggested.

1.11 Chapter Summary

This chapter has introduced the study, explained the problem behind the research and outlined the aims and objectives. It has also highlighted the ethical considerations for the study. The following chapter will provide an overview of related literature on the variables of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature for this study. It broadly reviews the variables of the study, which are food insecurity, unemployment, and aquaponics. The causes and problems of food insecurity and unemployment are elaborated. Also, the South African overview of unemployment and food insecurity is illustrated in this chapter. The existing literature is based on previous research mainly obtained from secondary data, including the world wide web, (e)books, journal articles, theses, and conferences relevant to the study.

2.2 Food Insecurity

The following information describes various aspects related to food insecurity in sequence:

2.2.1 Definitions of food insecurity

Food insecurity is broad and carries different dimensions, including household, national and seasonal food insecurity (Militao, Salvador, Uthman, Vinberg, Macassa, 2022:1-9). Hafner (2019: viii) defines household food insecurity as an economic and social condition with a limited or uncertain ability to acquire nutritionally safe and adequate food resources intended for the household. Tarasuk, Fafard St-Germain and Loopstra (2019:11) highlight that food insecurity affects both the individual and household-family due to the inability to afford a sufficient food supply. The deprived cannot buy good quality nutrition attributable to financial constraints, which cause many to go without food (Food Gardens Policy, 2013:3). Gracia-Arnaiz (2022:2) argues that food insecurity is not so much an issue of food availability as lacking access to procure adequate sustenance.

Militao et al. (2022:10) presents national food insecurity issues as a massive reduction in food available for each constituent. This is caused by rapid population growth and a minimal increase in agricultural yields. Therefore, this poses further pressure on food imports.

Food insecurity can be short-term and long-term. According to Nettle and Bateson (2019:2), short-term food insecurity refers to individuals who face an irregular diet, eat less per day, and have some meals excluded. As a result, these irregular eating habits encourage a bigger meal size. This has been explained as the cause of obesity because of food insecurity. On the other hand, suffering from long-term food shortages causes persistent food insecurity and worsens health (Food Gardens Policy, 2013:3; Lewis, Colon-Ramos, Gittelsohn & Clay, 2022:160). Households and people living below the standard of living are generally considered chronically poor, have poor livelihoods, lack resources, and face

significant food insecurity in the long run (Rizvi, Enns, Lucas Gergyek & Kristjansson, 2022:3-5). Seasonal food insecurity is when people experience food insecurity during certain seasons. This is common among people employed in the agricultural and hospitality sectors, where income fluctuates according to the year's seasons. This period of seasonal food shortage is expressed by Johnny and Mansaray (2019:65) as the hunger season.

2.2.2 Measuring food insecurity

According to Drysdale, Moshabel and Bob (2019:96), several tools are available to measure household food security. However, no accepted national standard tool is available to measure or appraise food insecurity in South Africa. Therefore, various tools have been developed to measure food insecurity at the national, local, and household levels of which the following could be employed:

1. The Coping Strategies Index (CSI) indicates a low-cost and unsophisticated measuring tool to measure the coping behaviours of household food insecure situations. The CSI is beneficial for monitoring food insecurity and providing quick and up-to-date feedback on the level of food insecurity relating to a specific situation or setting (Maxwell & Caldwell, 2008:1-2; Drysdale et al., 2019:97).
2. The Household Food Security Survey Module (HFSSM) was established in the United States and entails a household survey to help assess the individual or household experiencing hunger or food insecurity. This is determined by a series of 18 questions sent to the family about their experiences of food insecurity related to food spending and accessibility awareness. Their fears of missing enough meals are identified. The module examines any reduction in meals consumed by the individual family members, including adults or kids, customarily calculated for the preceding 12 months. Family units are then categorised according to the level of food insecurity and hunger, based on the frequency of such episodes (Drysdale et al., 2019:97)
3. Global Hunger Index 96 (GHI) measures hunger using four indicators: undernourishment, child wasting, stunting, and mortality (Von Grebmer, Bernstein, Patterson, Wiemers, Ní Chéilleachair, Foley, Glitter, Ekstrom & Fritschel, 2019:9-13). These indicators are of utmost concern even in South Africa (Food Gardens Policy, 2013:3; Ntshobane, 2018:1; Lewis et al., 2022:160). Therefore, policymakers are urged to address the problem of food insecurity, especially in smaller districts, by implementing various programs to mitigate these situations.

2.2.3 Drivers of food insecurity

The following factors have been identified as drivers of food insecurity.

2.2.3.1 Conflict

Fudjumdjum et al. (2019:10) describe that while certain farmers in civil war and refugee environments were too afraid to grow their crops, other farmers completely abandoned rural life to avoid fatal conflicts. This impacts a direct upsurge in food prices and food riots due to an increase in the risk of meeting the demand for adequate food supply.

2.2.3.2 Climate change

Fudjumdjum et al. (2019:4) describe the negative impact of climate change conditions on agricultural production. One of such includes anthropogenic activities or man-made hazards. For example, fossil fuels like coal, oil and gas are burned to meet the increasing energy demand. These, in turn, lead to increased greenhouse gas emissions into the atmosphere, leading to global warming with increasing severity and extremes of climate change conditions, affecting food production, food processing, food circulation and food consumption performance. These conditions directly impact food security, reducing food yields, and impacting availability, affordability, accessibility, utilisation, and stability of adequate food supply. In these situations, new policyholder adaptations and climate change-resistant coping strategies are needed to transform changes in production systems, technologies and food consumption patterns and promote nutritious diets.

2.2.4 The effects of food insecurity

Food insecurity brings many challenges to individuals, households, and the nation. The following section discusses some of the problems posed by food insecurity.

2.2.4.1 Poor health

Many children bear the effect of poor intellectual, social, and emotional development due to long-term inadequate nutritional foods (Bastian, Parks, Yaroch, McKay, Stern, Van der Pligt, McNaughton & Lindberg, 2022:2). If these children fall behind in school, it could negatively affect national productivity and reduce their economic potential for the future (Nettle & Bateson, 2019:2). Many heads of households experience depression, anxiety, mental disorders and poor health problems because of insufficient finances or low incomes to support their families (Rizvi et al., 2022:3-5).

2.2.4.2 Hunger

Hunger refers to the consequences of severe food shortages that increase the risk of starvation with fatal impacts on both adults and children (Steiner et al., 2019:4).

2.2.4.3 Malnutrition

Malnutrition is a variety of disorders, mainly caused by consuming too much or too little nutrients or poor-quality foods (Steiner et al., 2019:3-4; Kirsch, Matthews & Williams, 2020: 87). According to Food Gardens Policy (2013:3), adverse health conditions, particularly malnutrition, are almost inevitable if food insecurity persists. According to Chinnakali et al. (2014:228), malnutrition is the most acute consequence of food insecurity. Steiner et al. (2019:4-5) highlight the fatal impact of malnutrition, especially among children. Due to these dangers of food insecurities, Thow, Greenberg, Hara, Friel, Du Toit & Sanders, (2018:1108-1109) stress the importance of having access to sufficient nutritious food.

2.2.4.3.1 Effects of malnutrition

Malnutrition, which results from food insecurity, causes various diseases (Chinnakali et al. 2014:228). It is considered fatal and the greatest threat to civilian health worldwide. Malnutrition affects both underweight and overweight (obesity), and its contribution to child fatalities is severe (Steiner et al., 2019:3-4).

Steiner et al. (2019:3) point out that obesity is primarily caused by risky lifestyle factors causing the death of nearly 2.8 million annually. These fatalities stem from a low-level systemic inflammation involving illnesses such as diabetes mellitus, high blood pressure, heart (cardiovascular) diseases, strokes, and a range of cancers. Obesity is affirmed when the body mass index (BMI) of a person is screened at a range of thirty (kg/m²) or more (Steiner et al., 2019:4). In addition, indulging in unhealthy foods and lack of sleep contribute to weight gain in a person.

2.2.5 Methods to reduce food insecurity

Considering the various challenges and enormous impact that food insecurity carries, there is a need to come up with means to alleviate it. Therefore, this section deliberates on methods to modulate food insecurity.

According to the Urban Agricultural policy (2007:8-9) and Food Gardens Policy (2013:7), various methods have been tried to alleviate food insecurity. These include situations where various community members were issued with typical agrarian tools and equipment to start urban food gardens. A study by Misselhorn and Hendriks (2017:16) envisions government support for farmland and agricultural assets and skills development and educational support to give urban agriculture a chance to thrive where food gardens play an important role in improving food quality, including fresh fruit and vegetables. For this study, fish is also included. This can assist in generating knowledge about healthy food choices and build

social capital and community development through networking and collaboration (Misselhorn and Hendriks, 2017:16).

To reduce food insecurity, Joubert (2019:4) also points to methods such as laboratory-calculated yields, which include natural crops. With this, an indoor aquaponics business is being highlighted as a means of alleviating food insecurity.

2.2.6 Challenges faced in alleviating food insecurity

Sustainability is imperative for policymakers to ensure adequate controls are in place (Steiner et al., 2019:11). However, natural phenomena such as global warming, poor productive soil capacity, overpopulation and insufficient water supplies make it difficult to deal effectively with food insufficiency (Dos Santos, 2016:403; Stats SA, 2019:7). According to Gimenez, Blanc, Argillier, Pierre, Le Gouis & Paux (2021:2), the global population is projected to reach 9.7 billion people by 2050, which will provide a daily challenge for food provision. The current inhabitants of less than 8 billion people already impact the availability of sufficient food supplies, so a steep population increase could cause a significant challenge to producing adequate food supply to meet future demands (Worldometer, 2021:1).

Other challenges encountered when alleviating food insecurity include weather conditions, like increasing temperatures globally, where unusual droughts may affect crop output (Onyutha, 2019:4; Purwadi et al., 2020:4), and animals like fish may die due to rivers going dry. Onyutha (2019:13) therefore encourages the advancement of new fresh produce classes that will fit future climate conditions. In addition, due to an increase in urban dwellers, poor productive soil capacity is experienced, affecting plant densities as smaller arable lands become available, affecting productivity per unit area (Onyutha, 2019:4-5).

High unemployment rates are also a contributing factor which affects food insecurity and malnutrition (Food Gardens Policy, 2013:4).

2.2.7 Food Organisation and food insecurity

FAO was established in 1945 by the United Nations (UN) and, since 1979, congregates annually on 16 October, in an event known as the World Food Day, mainly to address global food and agricultural affairs. In conjunction with this event, The Department of Agriculture, Forestry and Fisheries [DAFF] and the FAO members utilise this platform to promote public awareness of food (in)security at the national level. Therefore, as a Member State of the Day, South Africa also commemorates the occasion by highlighting food and nutrition security and reflecting on the theme of World Food Day 2019, which was: "Our Actions Are

Our Future. Healthy Diets for A #ZeroHunger World.” Hence, it applied interventions to combat global hunger, malnutrition, and poverty with clear objectives that were designed to:

- Ensure South Africans are aware of the National Policy on Food and Nutrition Security.
- Strengthen alliances to contest hunger, malnutrition, and poverty and advocate public awareness on matters pertaining to the absence and scarcity of food supply countrywide.
- Promote research and technology development, i.e., the internet of things, for the development of symbiotic ecological food production systems to ensure sustainable food production and so on (South African Government, 2019:1)

This may indicate that even though the FAO member and DAFF run campaigns to raise awareness of the importance of healthy eating, many South Africans may still face the challenge of insufficient or severely inadequate access to healthy food due to high prices or financial constraints (Food Gardens Policy, 2013:3). In view of the objectives of the FAO member and DAFF, there is therefore still a great responsibility for the political care for the planning, monitoring, and evaluation of food safety, which consists of all major stakeholders, such as government, NGOs, public sector, and civil society groups (Misselhorn & Hendriks, 2017:1). Therefore, it is crucial to ensure that the correct method of obtaining accurate data is used to effectively ascertain how to support South African citizens in food insecurity.

There are several other organisations whose main aim is to deal with food security at the world, national and community levels. For example, the World Food Organisations (WFOs) impact many lives through their selfless assistance. These organisations are in collaboration with the World Food Programme (WFP). The WFP is a food-aid division of the United Nations and is the world’s largest humanitarian organisation, providing food aid to billions of people in 80 countries every year (Dennis, 2019:945). This is accomplished through various support structures like governments, international partners, researchers, and local communities. Furthermore, the WFP provides various food resource applications, employing programmes, innovations, handling food emergencies at a large scale, and policy and technical support to mitigate the risks related to food security (Dennis, 2019:945).

2.2.8 South African food insecure scenario

South Africa is considered the most food-secure country in Africa and ranks 44th out of 133 countries worldwide (Sihlobo, 2018:1). However, according to the 2016 General Household Survey, 13.4 per cent of people suffered from hunger (Stats SA, 2016:6). The urban areas of South Africa carry 63% of the population and can increase to 80% by 2050 (Haysom, 2016:5). In South Africa, food insecurity is structural, rooted in the country’s history and reflects huge structural inequalities (Misselhorn & Hendriks, 2017:1). Allen (2010:295) and

Hart, Davids, Rule, Tirivanhue and Mtyingizane (2022:2) highlighted how historical processes have shaped regions and social relations with vast disparities in wealth, power, and privilege, and this has implications for putting into effect equity through the localisation of food systems. Due to the vast disparities in wealth, many suffer the brunt of financial restrictions, which has diverse influences inclusive of accessibility and affordability, and the primary reason for food insecurity alludes to overly expensive diets (Misselhorn & Hendriks, 2017:1). Therefore, for financial reasons, many people are turning to cheaper alternative foods that contain substances high in energy value and low in nutritional value that affect the disorders associated with overweight and obesity-related with childhood stunting. Due to urban structural challenges, including poor income, many ways and means have evolved to obtain basic necessities.

Frayne, Battersby-Lennard, Fincham and Haysom (2009:13) report the on-going struggle of chronic food insecurity for many urban households in South Africa. Their study showed that households with moderate food insecurity went without food three to ten times over a four-week period, and households with severe food insecurity went without food more than ten times over four weeks. Food Gardens Policy (2013:3) appends that four out of ten households in Cape Town in South Africa's Western Cape go without food at least once a week for financial reasons. These were significantly exacerbated during the Covid-19 pandemic, where households went hungry every day (Van der Berg, Patel & Bridgman, 2022:5-6)

Furthermore, scientific literature to support basis the viability of an aquaponics business setting in South Africa has not been asserted with absolute certainty. Mchunu (2018:24) suggests that young people should engage in urban agribusiness to achieve sustainable economic freedom and create sustainable food security and production. Nedbank, an accredited financial institution in South Africa, financed an entrepreneurial initiative, The Youth Employment Services (YES), to empower young unemployed people to self-sustainable food production and job creation, in collaboration with the WILDTRUST, Tradeway, UnlockD, ORT SA and AFGRI (Nedbank Group, 2019:1-2).

2.2.9 Food insecurity for some provinces

The data below reflects some of the many provinces affected by food insecurity and is used to measure the different levels of food insecurity status in these areas.

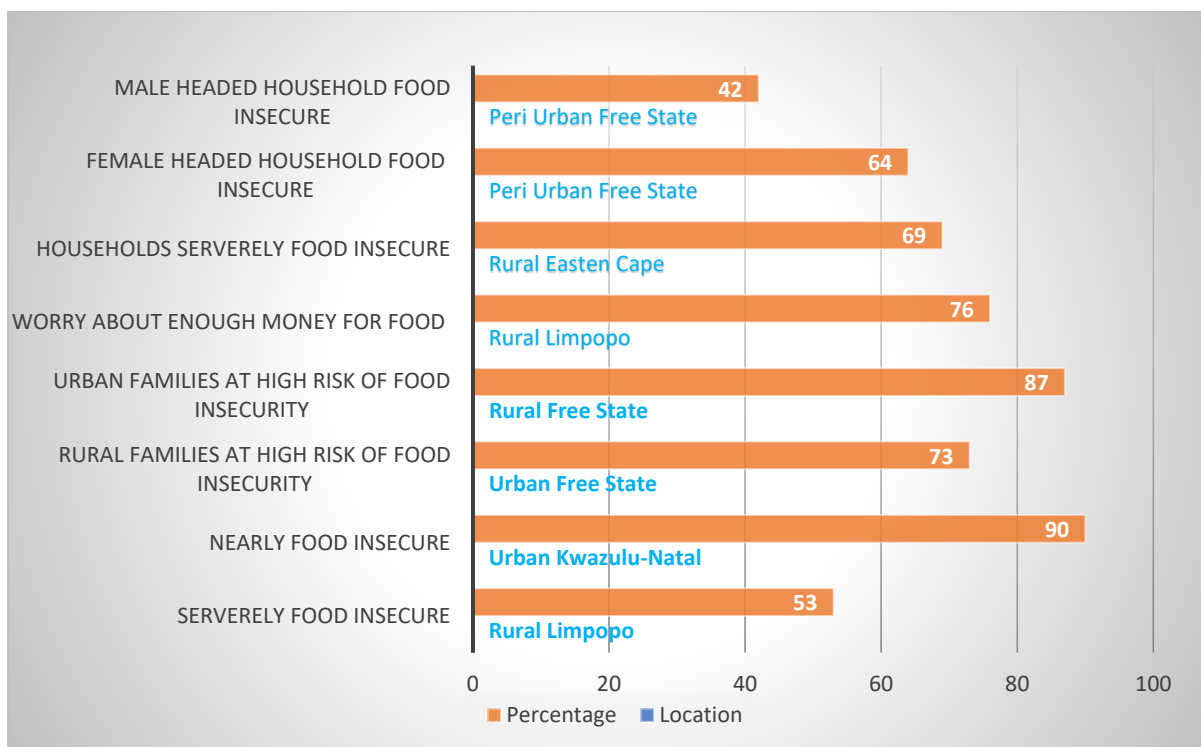


Figure 2.1 Food insecurity in some provinces in South Africa

Source: Misselhorn and Hendriks (2017:9)

Figure 2.1 indicates a high volume of food insecurity in various provinces of South Africa. Urban settings indicate a higher percentage of food insecurity than rural areas, of which KwaZulu Natal signals the highest risk of food insecurity at 90% and the lowest recorded in the Free State, reflecting 42%. On the other hand, the Free State exhibits the highest risk in rural areas, as high as 87% and the lowest captured in Limpopo at 53%. Thus, in urban areas, the risk of food insecurity is higher. These could lead to several disorders depending on the severity of food-insecure status (Misselhorn & Hendriks, 2017:9). Some households are moderately food insecure, while others are severely food insecure due to long-term food shortages. These results in undernourished conditions such as stunting, wasting, and obesity (Food Gardens Policy, 2013:3; Van der Berg et al., 2022:2-3), subsequently reflected in the following data:

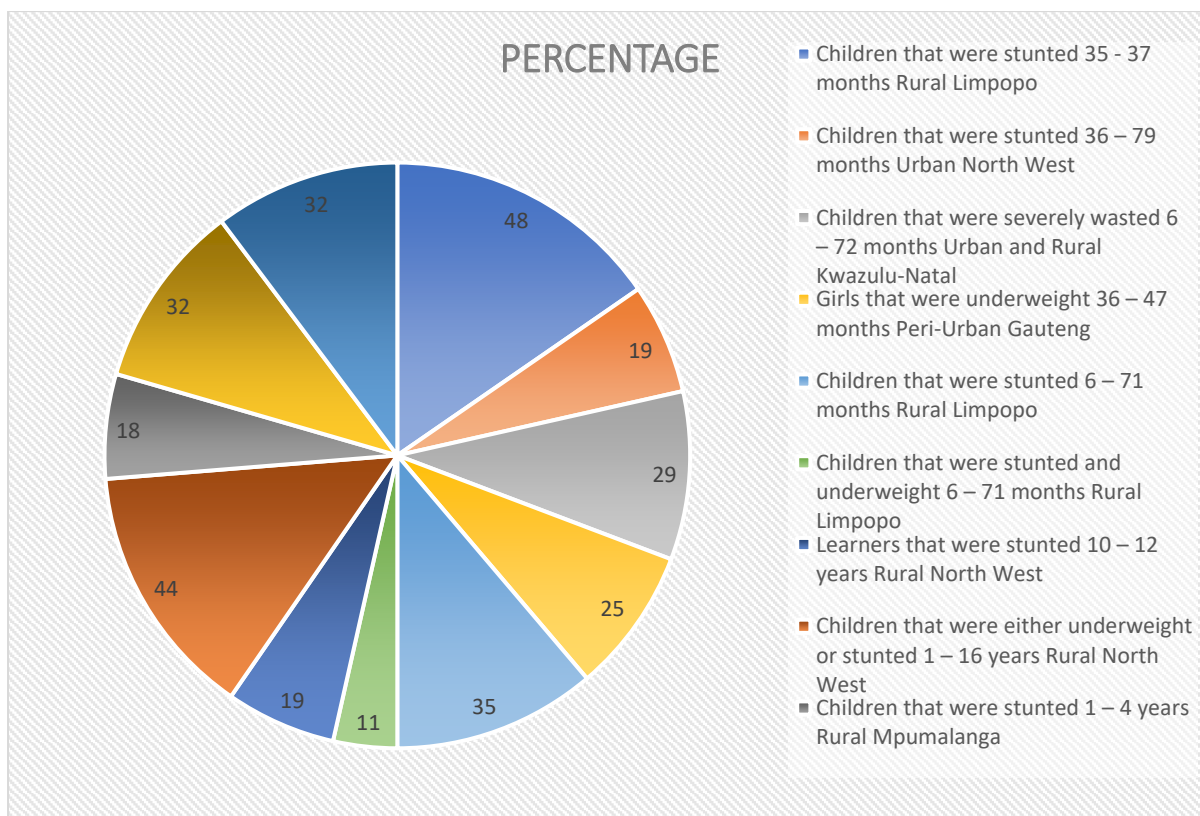


Figure 2.2 Results of food insecurity in some provinces

Source: Misselhorn and Hendriks (2017:9).

Many disorders are shown in Figure 2.2 because of food insecure locations in South Africa. Many children of different ages in different locations are experiencing the effects to varying degrees, with 29 cases of “severe wasting” in urban and rural KwaZulu-Natal, where the majority of those affected are located. The highest rate of stunting occurred in rural Limpopo at 48%, and the lowest rate of stunting occurred in rural Mpumalanga at 18% of children. Underweight is also reported as a significant problem among 10–12-year-olds, with a worrying rate of 32% in the North West Province and lowest at 11% in rural Limpopo. Although more food insecurity issues are reflected in rural areas, the key objective remains to alleviate “urban” food insecurity in the Western Cape Province. Therefore, the study presents a business model for urban agriculture to tackle food insecurity and unemployment.

2.3 Unemployment

Unemployment is a common universal phenomenon that severely impacts a country’s economy (Ojima, 2019:110). It is described by Dadaji and Khan (2017:24) as a social evil. Unemployment affects the individual and causes adverse effects on family structure,

homeownership, drug abuse, organised crime, prostitution, mental and physical health, and the economic well-being of a country (Young, 2012:610; Pollard & Booth, 2019:3 Garcia, Felonia, Lim, Pascua & Quiwa, 2022:32-34).

Unemployment has been documented as a widespread challenge in rural and urban spaces (Kabbani, 2019:4-5; Luy, Dong, Roobavannan, Kandasamy and Pande, 2019:2-3). Rural to urban migration does impact unemployment. Rural dwellers relocate to cities in the hope of getting a job. This set off pressure on a flooded job market, thus, causing friction and tension in the urban cities (Uddin & Uddin, 2013:397-400; Madhu & Uma, 2014:391-392; Ruwanza, Thondhlana, Falayi, 2022:6).

2.3.1 Types of unemployment

Unemployment is a multidimensional concept that carries many definitions and categories with no particular outcome (Banda et al., 2016:246-247). However, each relates to its own scope of consequence affecting many job seekers in relation to the following:

Frictional unemployment: involves workers who voluntarily decide to leave their current jobs for either better career prospects or those intended to complete full-time studies and return after a while to contest for a new post. This means a person in the short term would be out of a job and must look for work again (Kagan, 2019:1-2). The time it takes to shift from resignation to obtain new employment again is known as frictional unemployment.

Cyclical unemployment: occurs when a person is laid off from a particular job due to a downward spiral in the business cycle. This entails a lesser demand for certain goods and services. As a result, many workers' jobs are cut short to retain profit margins, inferring too little production/services to keep employees occupied (Dadaji & Khan, 2017:25; 2016:246-247).

Structural unemployment: is triggered by variations in the economy. This is impacted due to continuous discoveries of new resources, advancements in new technology, changes in end-user demand, globalisation in its various contexts and a lack of education. These economic changes demand a continuous upgrade of employees' skill set to stay abreast with current job requirements and avoid becoming outdated in their field of expertise, especially technological changes (Banda et al., 2016:246-247).

Seasonal unemployment: Agriculture sector is common for seasonal unemployment. This is when people are employed only during certain seasons like planting and harvesting seasons. After harvesting, most of the temporary labour force becomes unemployed (Banda et al., 2016:246-247; Ojima, 2019:112).

2.3.2 Costs of unemployment

The burden of unemployment is huge, with massive financial implications. Moreover, for the low income and poor, the consequences of health disorders are common (Pollard & Booth, 2019:3).

Social costs: of unemployment are, according to Gorjón, De la Rica and Antonio Villa (2019:4-5), influenced by three different protocol assessments indicating:

- a) Incidence: are the usual unemployment rate indicators.
- b) Severity: includes a cycle of unemployment and whether unemployment benefits or entitlements are available during a person's lack of income to protect a person's dignity.
- c) Hysteresis: refers to the phenomenon of the delayed effects of unemployment over an extended period during which the economy may have recovered. However, a person's social well-being and recovery status are still affected by the financial effects of an economic downturn even after re-employment.

Unemployment could affect an individual's social well-being; mentally, physically, and financially. A reduction in disposable income usually impacts a person's standard of living, which can lead to extended credit and loan-financed applications. If such commitments cannot be met, stress can cause adverse health inferences, thus incurring additional costs for the government (Young, 2012:610).

Business costs: Businesses suffer, especially when demand for products and services drops, often due to cyclical unemployment. A decline in productivity is also seen due to uncertainty among workers who fear for their jobs or working short time. Therefore, lower productivity means lower income. During an economic downturn or recession, the biggest fear is that a business may shut down completely (Dadaji & Khan, 2017:25; Verho, 2017:190; D'Antonio, 2019:121). This leads to massive tax losses, loss of disposable income, the burden of government unemployment benefits, worsening health conditions and more (Young, 2012:610).

Crime: Crime holds back domestic and foreign direct investment as international companies worry about investing in the country, creating trade insecurity (Garriga, & Phillips, 2022:2-5).

Health: Unemployment is linked to poor health, including mental health problems such as depression, bipolar disorder, and anxiety (Roccati, 2021:1-2).

Loss of output: Unemployment negatively affects the productive capacity of the economy because the unemployed are not economically active in producing goods and services, which affects the supply of the economy and hinders economic growth (Remya, 2019:67).

Riots: Unemployment increases the risk of social unrest and violence (McLaughlin, 2017:120-123). Urban riots lead to significant disadvantages for businesses, creating unfavourable and unstable conditions, especially in small businesses. One of the main consequences is food riots, mainly due to high food prices and widespread food shortages (Fudjumdjum et al., 2019:4).

Stress: Unemployment causes extensive financial restrictions and pressure on unemployed people, affecting psychological, worried, and stressful concerns, making unemployed people vulnerable. As a result, with no income to live on and while already starving, these individuals are willing to risk as much as they are willing to lose, be it theft or other malicious activities (Shah & Khuhawar, 2019:1-2).

2.3.3 South African unemployment scenario

South Africa, like any other developing country, faces challenges of unemployment. According to Bhana (2020:1), South Africa's jobless rate remains a stubborn and persistent issue, which has continued to escalate over the past decade, counting the severe impact of the 2008 financial slump and its enormous strain on employment. The Northern Cape exhibits the lowest unemployment rate at 25%, with the Western Cape a 3% gap for second at 28% and the Eastern Cape the highest among nine provinces at 45% (Stats SA, 2021:17).

South Africa suffered a shock with a sharp increase in the unemployment rate of 35.3% in the fourth quarter of 2021 (Stats SA, 2021:17). In addition, many South African households are negatively affected socially, economically, and ecologically, especially in poor and low-income communities (Urban Agricultural Policy, 2007:7-9; Food Gardens Policy, 2013:3; Banda et al., 2016:247-248).

The South African economy is continuously threatened by extremely low levels of economic growth (Brothwell, 2020:1). The negative growth rate influences the demand for labour and makes it difficult for new entrants to enter the job market. This draws significance as the supply of labour increases and the demand for labour decreases, thus causing fewer jobs than there are people looking for work (Mzungulu & Ndzendze, 2021:19).

Unemployment usually occurs when the supply of labour exceeds the demand for labour. However, the continuous demand for jobs in South Africa is currently challenged by the economy's inability to match a growing workforce with adequate job opportunities. In

addition, the South African economy, especially the labour market, is constantly impacted by structural and technological change, causing structural unemployment (Banda et al., 2016:247-248).

In South Africa, many job seekers lack or have no relevant skills to match employment needs, of which education plays an important role. Therefore, to meet the demand for full employment, South African businesses necessitate an industrialised skill set, in which skilled workers are prioritised over unskilled workers, affecting the employment status of low-income families. This can impact poverty, as many people are unemployed due to a lack of modern skills (Banda et al., 2016:247-248).

The study by (Putra & Yuliando, 2015:284) shows that city dwellers, with the help of policymakers, can use an aquaponics food production system to generate money all year round, addressing seasonal unemployment

2.4 Aquaponics

The below section gives an overview of aquaponics

2.4.1 Definition

Aquaponics can be described as the technology of two resources existing in one system, fish and edible plants reared in the same closed loop setting (Pollard et al., 2017:1). Hydroponics engages the process where vegetable root plants are reared with no fish and no soil; only rich nutrient water is used (Putra & Yuliando, 2015:284). Aquaponics, therefore, is hydroponics plus fish. This study includes hydroponics technology as a supported subdivision to aquaponics merged in the centre of the encircled process.

2.4.2 Historical background

Aquaponics in practice is not a modern phenomenon but rooted in prehistoric fundamentals. Arias (2019:3) provides prehistoric data confirming the techniques practised by the Aztecs, a Pre-Columbian Mesoamerican Indian clan in Central Mexico in the fourteenth, fifteenth and sixteenth centuries. These techniques, in concept, present similar attributes related to the status quo of aquaponics. According to Arias (2019:8-9), the Aztecs practised a type of premature aquaponics known as a floating garden, rearing fish parallel to leafy greens, herbs, and other vegetable plants in an open-air food production setting, predominantly in an urban space as underpinned (Boutwell, 2007:1-3). Jones (2002:2) and Kledal and Thorarinsdottir (2018:175-176) draw reference to the Chinese farmers in the Pearl River Delta of South China around the same period of the mid-14th century as the first growers to cultivate their fresh produce (rice) aquaponically in an open space. Their technique involved

a land-water farming system (dike-pond system; comprising the mulberry-dike-pond system, the fruit-dike-pond system, etc.) applied as a flood control measure in the delta, automatically creating water and pond ecology. Ducks were trapped in cages floating on the water. Some of the food fell into the ponds when they were fed, providing sustenance to the finfish beneath. The droppings of the ducks and finfish eventually provided food to the catfish that ate their droppings. These inadvertently introduced a three-pronged tactic of producing rich-nutrient fertilisers that settled into the mud at the bottom of the ponds and rice fields, used to substitute for the shortage of animal manure. Therefore, a single feeding application was enough for the yield of four crops.

2.4.3 Aquaponics business operation

Dimitri et al. (2016:604) recognise aquaponics as an urban farming practice that enhances the growth of plants in an urban setting. It combines aquaculture (aquatic creatures) with hydroponics (water vegetation). In aquaponics, it is possible to produce more food on a small area of land, with minimal water consumption, in a well-nourished environment and with a fast harvest rate (Cohen et al., 2018:552). There is a wealth of integrity literature favouring various aquaponic endeavours that have thus far been tried and tested extensively (Love et al., 2014:1-2). Depending on the region, climate, and other factors, different structures are used, including tunnels, greenhouses, and many more, with a wide variety of fresh produce and fish adapted to a specific environment. Aquaponics is an initiative developed to find a solution to produce food in an urban environment different from the conventional rural setting. This makes it a more self-sufficient, sustainable, and resilient method of combating global natural events, rapid population growth, arable land collapse, climate variations, and influencing drought conditions (Masyk & Fritz, 2017:3-5).

2.4.4 Hydroponics

Hydroponics is not a new phenomenon but is considered a sustainable resource, preserved from historical practice, and recognised as a complementary mechanism for providing fresh food (Arias, 2019:8-9; Swain et al., 2021:629). A business application of hydroponics can be described as the process in which edible plants such as herbs and vegetables are grown only in water outside of normal soil conditions and to the exclusion of fish. Fertilisers are being applied (Treffz, Zhang & Omaye, 2015:1372).

Hydroponics is a hybrid word, two words combined as one; hydro, signifying *water* and *ponos* representing labour (Sharma et al., 2018:364). The technique represents a strong resemblance to aquaponics. Hydroponics submits a supportive role to aquaponics. This study presents hydroponics as a subset to better understand its role in complementing the

complete production of an aquaponics food production system. Similar characteristics are employed; growing food in a small footprint, using less water and supplying fresh produce in a controlled environment in-season and off-season (Putra & Yuliando, 2015:283-285; Treftz et al., 2015:1372).

Commercial hydroponics technology is considered an effective livelihood in applying urban Agri-business to create jobs for job seekers. In addition, business technologies in hydroponics have the following advantages.

- Low-cost strategy,
- Easy to operate
- Easy to maintain
- Entails less labour
- Economical overall setup and
- Lower operational cost (Sharma et al., 2018:364,366, 371)

2.4.4.1 Distinctions between aquaponics and hydroponics

Hydroponics differs from aquaponics in that in hydroponics; only leafy products of various classifications are produced, while in aquaponics, these leafy products of various sorts are produced together with an added twist of fishery. When fish are added to the process, the dynamic changes from a typical hydroponics operation to an aquaponics system (Pereira, 2019:3-5). Pereira (2019:1) highlights the difference between aquaponics and hydroponics based on personal preference: budget, climate and amateur or commercial approach.

Cost plays a significant role, especially as far as aquaponics is concerned (McCarthy, 2011:1). For instance, aquaponics requires more equipment (fish food with added supplements such as calcium, potassium, magnesium, and iron to help convert ammonia into nitrate), mechanical filters and biological filters to establish an integrated system of product sources. However, aquaponics is described as more rewarding (Pereira, 2019:1-3).

Aquaponics is presented in a carbon-based (organic) setup with no pesticides or chemicals other than hydroponics, where fertilisers are used. Of note, both business scopes produce leafy green products as their primary substance, which is conducive to livelihood and commercial practices (Sharma et al., 2018:367-368; Pereira, 2019:1).

2.4.5 Aquaponic business techniques

Aquaponics entails various business techniques, which are, as a rule, hydroponically employed, alluded to as a floating hydroponic (water) garden (Swain et al., 2021:629-631).

Vegetable plants are cultivated in water only; conventional soil is excluded. In an aquaponics closed-loop system, there are three main hydroponic sub-systems (techniques); floating rafts, nutrient films, and ebb-and-flow (EAF) technique (gravel beds) (Wongkiew et al., 2017:4-5; Sharma et al., 2018:365). Aquaponics technology consists of practical applications that can assist cultivators in ascertaining the best location, structure, and product type relevant to each unique aquaponics business setup, as explained next (Love et al., 2015:69).

- **The floating raft technique (FRT)** – is a method of growing root vegetables in polystyrene boards, also known as an aquaponic raft system or a deep-water culture system, floating above the water surface. Holes are cut into the polystyrene boards, and effectively, net pots are placed into the holes. These refer to plastic containers filled with various growing mediums to support the plants, providing adequate air circulation and drainage. The growing mediums refer to clay, gravel, and perlite. The roots of edible plants can find their way through the open spaces at the bottom of the supported net cups or pots into an effluent solution beneath. A beneficial bacterium removes all toxic waste and creates food safety conditions. Plants can extract all nutrients through the roots to ensure healthy vegetable growth. This technique is beneficial for cultivators with limited start-up monetary resources, using low-cost labour and restricted space (Storey, 2016:1; Anando, Andriani, Hamdani & Zahida, 2022:86-87).
- **The nutrient film technique (NFT)** – edible plants grow in long narrow water channels to ensure the plant roots obtain the necessary water, nutrients, and oxygen. This can be recognised by a thin film of water-nutrient solution that constantly flows down each water channel. In NFT, a separate bio-filter is needed, which is different from where plants often mimic the concept of bio-filter. Furthermore, NFT, while effective for hydroponic operations, has problems in aquaponic operations with pipe blockages due to solids from fish droppings (Wongkiew, Hu, Chandran, Lee & Khanal., 2017:4-5). Therefore, not every system may be favourable for all situations (Pattillo, 2017:15).
- **The ebb-and-flow (EAF) technique** – includes a container (called a media or grow bed) either filled with gravel, perlite, or clay, which is sometimes submerged with water from the fish tank via a water pump. It allows a certain amount of water into the grow bed where the beneficial bacteria settle for a certain period so that it provides nutrients and moisture to plants. The beneficial bacteria break down toxic fish waste within the media-filled bed, and ammonia is exchanged for nitrite and eventually to nitrate. The nitrate (fertiliser) is safe to be absorbed as nourishment for the plants. After trekking

full circle, filtered water is pumped back to the reservoir through a flood and drainage method. This method uses no additional filtration, making it easy to operate (Sharma et al., 2018:365-366; Oladimeji, Olufeagba, Ayuba, Sololmon & Okomoda, 2020:60-63).

Employing the appropriate technique ensures the correct material is chosen in the business, mainly to avoid fruitless expenditure. In addition, these various materials provide support to stabilise the roots and store microorganisms. For example, choosing the correct pump type with the floating raft technique (FRT) is critical, including either a pump that regulates a constant flow or one that switches on and off intermittently.

Innovation also plays an integral part in aquaponics food production, especially when it comes to hi-tech, relating to the internet of things (James, 2017:5; Ulum, Ibadillah, Alfita, Aji & Rizkyandi, 2019:1-5). James (2017:5) reports on the benefit of using an automotive aquaponics business operation process, especially considering how to operate an aquaponics food production device away from home. The internet of things allows cultivators to communicate via mobile devices, employing smartphones to run their operations, merging technology with agri-business activities remotely.

Employing these apparatuses ensures the cultivator is kept up to date (frequent alarm settings) with live feedback of the quality, temperature, pH, and the flow of water in the reservoir. The cultivator will be able to control these conditions remotely and have analytical data available to assess year on year growth and yield of crops and fish (Ulum et al., 2019:1-6). Of note, the internet of things is not related to the focus of the study; instead, it tries to indicate a more sufficient innovative means to execute production with better precision to ensure a more effective and efficient output.

2.4.6 Benefits of an aquaponics business

Like other business settings, the aquaponics sector has certain business-specific benefits. As mentioned earlier, the ability to engage in real-life phenomena to undo the effects caused by the global episodes of nature (Dos Santos, 2016:403). Due to the rapid population growth of cities, adequate food access and availability are a challenge. However, in the case of aquaponics, it does not matter in or out of season; planting and harvesting take place all year round. The weather conditions are of little concern as temperatures are controlled internally. As a result, harvest times increase the availability of additional food and potential employment at any time of the year (Putra & Yuliando, 2015:283-284), thus, addressing food insecurity (access) and unemployment of South African seasonal workers (Devereux & Tavener-Smith, 2019:1-2).

Aquaponics root vegetables proliferate and grow in less than half the standard time of the traditional production period to harvest. This is possible because sufficient nitrogen (rich nutrient solution) is added to the water system, allowing the plants to grow quicker and bigger. This allows for early harvesting with even greater production capacity in smaller spaces to ease the supply and demand of today's vast urban population growth. As a result, additional food becomes available more rapidly to relieve the pressure on food shortages (Dimitri et al., 2016:604).

Another advantage is that this food production system minimises or does not require additional fertiliser (Oladimeji et al., 2020:60). Beneficial nitrifying bacteria function as a catalytic converter in the growth-bed area. Fish poo that treks from the reservoir contains hazardous ammonia that can kill the fish. Beneficial nitrifying bacteria convert ammonia to nitrite, which is then further broken down into nitrate. Nitrate acts as a fertiliser to feed root vegetables. Leafy vegetable products are grown without using chemicals such as pesticides and herbicides, creating an eco-friendly environment and saving costs of such products.

Aquaponics preserve 80% - 90% of water, other than conservative agricultural water that usually runs to waste by excessive irrigation, filtration, and evaporation (Cohen et al., 2018:551). Toxic water contaminated with fish excrement is naturally purified by the vegetable roots that act as natural bio-filters. As a result, all toxic waste is removed from the nutrient-rich water, and fresh filtered water is reverted to the fish reservoir for reuse (Saha, Monroe & Day, 2016). Furthermore, additional advantages include:

- **Sustainable land management:** The business requires only a small production footprint, such as old buildings, vacant plots, greenhouses, high tunnels, raised beds, containers, rooftops, and vertical farming applications, providing maximum yields (Dimitri et al., 2016:608).
- **Cost reductions:** Low mortgages on vacant land and buildings, low transportation costs (short supply chain, close to customers), low food storage costs and minimal water costs. This positively contributes to a reasonable gross margin (Dos Santos, 2016:402-403; Cohen et al., 2018:551).
- **Nutritional benefits:** Appropriate as a nutritious, active, and healthy (organic) source of life to ensure and maintain a well-adjusted diet, especially to cure undernourishment and malnutrition (Velten et al., 2015:783; Steiner et al., 2019:4).
 - a) Enhance food security; continuing food supplies all year round, weekly harvesting

- b) Create organic food; as no chemicals are used at all; improve a healthy lifestyle, especially those with malnutrition, hunger
- c) Safer edible fish: (no mercury in fishponds compare to the oceans)
- d) Preserving water; (lower consumption); 80% - 90% of water is retained (Cohen et al., 2018:551).
- e) Craft two-income/revenue streams:
 - Fish: tilapia, bluegill/brim/sunfish/crappie, koi, fancy goldfish
 - Leafy green: any leafy lettuce, herbs such as basil, mint, chives, tomatoes, peppers, and cucumbers (Love et al., 2014:8)

2.4.7 Economic benefits of aquaponics

Past studies indicate the opportunity to create new jobs through a large-scale commercial aquaponics operation (Love et al., 2015:70). For example, Love et al. (2015:70) presented evidence of 780 recruited employees; 538 full-time and 242 part-time reported at different locations internationally, besides the 1,720 volunteer employees as indicated in their study. These emphasise the possibility of job creation in a commercial aquaponics edifice.

Aquaponics, like any business, requires entrepreneurial skills, sound business decisions based on experience and knowledge spread across plant sales, aquaponics training courses, fish marketing practices and the sale of aquaponic systems to run a commercial aquaponics business successfully (Leaffin, 2019: 2-3). In addition, aquaponics provides access to various business inputs to do more with less for sufficient food resources, financial gain, and employment, i.e., more food can be produced with less of a production footprint and water use (Dimitri et al., 2016:604).

2.4.8 Challenges faced by aquaponic businesses

The aquaponics business is not exempt from facing challenges that could hamper its proper functioning and development. According to Goddek et al. (2015:4206), aquaponics is a complex design and application system that requires extensive knowledge and specific field skills across a wide range of theoretical and practical disciplines. From a theoretical level, the producer is stretched to advance the applications of environmental, mechanical, and civil engineering design concepts. Aquatic and plant-related biology, biochemistry and biotechnology are also on the radar of importance, including dynamics requesting proficiency in economics, finance, and marketing. Added to the long list of required expertise, system-specific measurements and control technologies denoting computer science for automatic control systems are deliberated (Goddek et al., 2015:4206). All technological and theoretical

aspects affect start-up challenges and the effectiveness of producing at the highest level of efficiency and productivity (Goddek et al., 2015:4206). The start-up challenges faced by aquaponic businesses are described below:

- High start-up costs are one of the main challenges of an aquaponic food production system, usually influenced by the different sizes of various aquaponic structures and designs and the preference for personal, educational, or commercial use (Collymore-Taylor, 2022:15-16).
- A lack of basic knowledge of chemical engineering technology can infer critical misapplication of importance, i.e., matching and balancing the system to achieve the correct application of chemical control to the crop. Therefore, the correct pH levels in an aquaponics system are pivotal (Goddek et al., 2015:4206-4207). Unexpected variations in pH levels, temperature, ammonia, or nitrite readings can cause a distressed and even lethal environment to the fish community (McCarthy, 2011:7).
- Electricity also plays a fundamental role in an aquaponics food production sequence. A power outage could have adverse effects as the water pump, electric heater, and air pump could shut down. Hence, preventing the effluent from flowing to the grow bed. In addition, the sequence of converting toxic ammonia into nitrate is also disrupted, directly affecting oxygen and nutrient levels, an essential element for the survival of fish and plants (McCarthy, 2011:6-7). To reduce such hazardous conditions during power outages, a backup portable petrol or diesel generator can be installed to combat such failures (McCarthy, 2011:12).
- Choosing the suitable material for the right aquaponic business design is essential to ensure a smooth recycling process and avoid wasteful spending (Storey, 2016: 2-5).
- Technological advantages also play a vital role as some countries or regions are not technologically apt or trendy, which impedes further innovative mechanisms to increase business proficiency. Thus, additional food production could have been achieved, and the potential for job creation likely could have been achieved, pointing to the Internet of Things or the applied techniques of the fourth industrial revolution (James, 2017:2).

2.4.9 Aquaponics business in South Africa – an overview

This study is set in the Western Cape Province of South Africa, one of nine provinces located on the south-western tip of the African continent. It ranks third in magnitude, covering an area of 129,449 square kilometres and is home to the third largest population in South Africa, estimated at just over 7 million (Stats SA, 2020a:23; Wikipedia, 2021:1). Most of these residents, almost two-thirds, live in the municipal (urban) area of Cape Town, the

provincial capital and also the legislative capital of South Africa (with the Houses of Parliament), commonly known as Cape Town (CCT). The Western Cape Province shows strong economic, agricultural, and social-class structures, including perceptible influence in the tourism industries, and has the second lowest impact on unemployment (28%) in South Africa.

Peer review data related to starting an aquaponics business is relatively scarce in South Africa. On the other hand, there is plenty of available data on the internet describing the subject (James, 2017:1; Philipp, 2019:5; Forest Friends Urban Farm, 2021:1). Mchunu (2018:2-6) and Mchunu et al. (2018:12) recorded a national survey recognising aquaponics as a global phenomenon still in its infancy in South Africa; consequently, in the absence of adequate survey data. Their study reveals that existing producers lack the knowledge applied to an aquaponics food production operation and operate mainly on a small scale. Mchunu et al. (2018:12) suggest raising awareness to promote commercial aquaponics in South Africa by enlisting expert support from existing commercial and semi-commercial breeders.

Adequate financial support is required to advance the emergent status of South African aquaponics. Foundations are essential to ensure that regular research (testing) is conducted to scientifically support the benefits of growing fresh vegetable crops aquaponically (Love et al., 2015:67-68; Dimitri et al., 2016:605; Mchunu et al., 2018:12-13). Lapere (2010:1) tested aquaponics and whether it might be feasible to run it as a business. However, the study indicates that most farms in South Africa were not economically viable. Lapere (2010:3) identified certain constraints that indicate aquaponics in South Africa is a high-risk business with an insufficient return on investment. According to Wolf, Geisendorf and Figeac (2019:2), to appraise the sustainability of any process, all inputs and outputs must be considered.

Mchunu et al. (2018:13) conducted a national survey in South Africa in 2016, counting all provinces except Limpopo, no response. KwaZulu-Natal (KZN) was indicated as the location with the most aquaponic operation's activities rating at 32%, trailed by Gauteng Province (GP) with 20%. The Eastern Cape (EC) and Western Cape (WC) reflected 16% operations activities. The provinces indicating lesser operation's activities were Free State (FS, 7%) and North West (NW, 5%). Mpumalanga (MP) and Northern Cape (NC) reflected a minimum of 2%. Three scale systems are indicated: hobby, subsistence, and commercial scale systems. The hobby scale system is reflected mostly in KZN and the most commercial scale systems in GP and WC. The subsistence scale systems are reflected in all provinces equally. Mchunu et al. (2018:14) indicate the number of aquaponic operation's activities of each scale system in the Western Cape as follows: Hobby; 1, Subsistence; 2 and Commercial; 3.

The study intends to increase these aquaponic activities in the future. Aquaponics is affiliated with the Aquaculture Association of Southern Africa (AASA) (Aquaponics SA, 2016:1).

2.4.9.1 Aquaculture Association of Southern Africa (AASA)

The AASA has existed since the late eighties, a novice at the time, mainly established to represent the interest of the aquaculture industry in Southern Africa. However, the association has made its mark and has become a structure with representative capacity in provincial, national, and international forums, providing and advocating relevant information for various aquaculture industry sectors to improve aquaculture in Southern Africa. These commitments to the aquaculture industry are based on marine (saltwater) species related to oysters, mussels, abalone, and prawns (AASA, 2018:1).

Freshwater species such as trout, catfish, tilapia, and ornamental fish important to an aquaponics stream are also readily monitored. The oversight extends to service providers specifying feed companies, equipment suppliers and veterinary facilities. The AASA is committed to development through the platform of forums, conferences, bi-monthly newsletter services and the like for its members. This reflects a compelling observation of the study as a sequence of best practices to create research-based evidence to advance the embryonic state of aquaponics in South Africa (AASA, 2018:1; Mchunu et al., 2018:12)

2.4.9.2 Aquaponics Association of South Africa

The development of the Aquaponics Association of South Africa extends to the urban farming industry; an urban agribusiness phenomenon brought together under the umbrella of the Aquaponics Association of Southern Africa, also known as Aquaponics SA. Aquaponics SA entails a member's only platform marketing a well-represented stand for the aquaponics industry in Southern Africa. Association members are categorised into different Membership Types and categories with different registration fee applications. Membership Types include commercial and non-commercial, which means a density of more than 150 square meters of planted area and a production of more than 1 ton of fish per year (Aquaponics SA, 2016:1). Only members of the commercial Membership Type are entitled to represent at the annual general meeting (AGM).

Aquaponics Innovation was founded in 2016 under the umbrella of Aquaponics SA, specifically to manage the coordination and quality control of an emerging industry (Mchunu, 2018:12; Aquaponics Innovation, 2019:1). The research and development carried out by the association, including all results, is disseminated intramural. Consequently, aquaponics in

South Africa is urbanised, but there is limited scientific research and data. Regular aquaculture training courses and workshops to promote aquaponics business are held in different aquaculture settings (Aquaponics Innovation, 2019:1).

Aquaponics is currently recognised in a variety of business operation functions, including:

- Urban Farming: at various locations across the country, (Mchunu et al. 2018:13) supplying a variety of vegetables comprising basil, red salad onions, various lettuce types, mint, chives, and garlic.
- Retail: Aquaponics Solutions tools and equipment include aquaponics kits that offer complete commercial and home starter systems.
- Training: workshops to promote aquaponics are held across the country (Aquaponics Innovation, 2019:1).

2.4.9.2.1 Hydroponics South Africa

The hydroponics business is becoming increasingly popular in South Africa. Greenhouse tunnels (closed system) are described as best suited for hydroponic systems in South African landscapes, suitable for indoor food production (shade netting structures) to withstand harsh weather conditions as well as to withstand the intense UV radiation of the African sun (Du Plooy, Maboko, Van den Heever & Chiloane, 2012:148). Popular crops grown in some hydroponic systems in South Africa include tomatoes, cucumbers, and peppers, typically in drain-to-waste systems, and lettuce and herbs, typically in gravel flow systems.

2.4.10 An aquaponics carbon-based economic business model

At this point, the study intends to present a key concept and design formulated to support the literature in context, raise awareness of aquaponics as a business, engage entrepreneurs and investors in its benefits and stimulate the economy by creating jobs and reducing food insecurity. The study attempts to establish an urban agribusiness phenomenon as a common knowledge economy. This reveals a carbon-based economic business model that fuses aquaculture with hydroponics. This model is illustrated by an awareness approach that refers to a breakdown of technologies that bring processes and businesses together in a circular (recirculated) economy, which presents a controlled organic food system captured in reused and recyclable technology (Urbinati, Chiaroni & Chiesa, 2017:3-8). The study stages a cascading aquaponics business model in the order of the following: Aquaponics green groceries; craft a new aquaponics venture to an effective business start-up; maturing the new venture and create new job opportunities; to raise

sufficient greengrocers, hence, providing the cultivator and the market with additional nutritious food resource; ultimately to boost food security (Dimitri et al., 2016:604).

The business model provides a commercial display to attract entrepreneurs, policymakers, and potential investors willing to finance an aquaponics business start-up (Pons, Long & Pomares, 2013:18-24). Therefore, policymakers must use apt policies and stimuli to address potential market failures, thereby adopting a sustainable practice of safe and reliable food production. This comprises cost-saving benefits; water is reprocessed, arable land is preserved, energy is safeguarded, pollution is controlled, transportation costs are curtailed, etcetera (Goddek et al., 2015:4214; Milicic, 2017:7).

Figure 2.3 below illustrates the researcher's aquaponics business awareness model.



Figure 2.3 Aquaponics carbon-based business awareness model

The above model responds to the risk of food insecurity to mitigate the current pressures that hamper food security. This model refers to all potential producers in the future. Awareness narrated to a nutritional food production system to aid as a proxy to enhance food security has been created amongst citizens of the Western Cape Province. This model also addresses the financial deficiencies that many citizens experience in response to a possible new entrepreneurial opportunity, possibly to create new employment opportunities. These opportunities are viewed as favourable at micro-scale, domestic level; indirect and macro-commercial; direct, expedient to provide adequate food and address unemployment (Pattillo & Rotole, 2017).

2.5 Chapter Summary

Secondary scientific literature was identified, reviewed, and presented to support business selection applications involving crop-growing techniques that demonstrate their capacity to enhance food security and initiate two possible income streams relevant to leafy fresh produce and fish cultivation. In addition, SMMEs are beneficial to economic stability hence the pursuit of an urban agricultural entrepreneurial commercial functionality. Next, chapter three outlined a methodological context with relative sequencing to steer the investigation in the right direction.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology and the design of the study. The chapter also gives full details in justifying the chosen methods. Finally, it elaborates on the data collection method used to achieve the study's objectives adequately.

Research methodology is a process that is carefully designed for how an investigation should proceed in a particular research context (Mohajan, 2018:3). Research methodology propounds reference to the entire research process systematically (Igwenagu, 2016:4-5; Kivunja & Kuyini, 2017:28). The methodology reflected a procedural framework for research design (Mohajan, 2018:2). This chapter provided an adequate response to the research questions formulated at the beginning of the study (Boyce & Neale, 2006:5).

3.1.1 Validity and reliability

According to Kallet (2004:1229-1231) and Noble and Smith (2015:34), validity alludes to the integrity with which a study is conducted, applicable to the variety of research methods available. Data collection plays a fundamental role in this (Tongco 2007:147; Lopez & Whitehead, 2016:128). Research data can be accessed through multiple methods, oral, visual, or written. Using the right data collection tools will minimise potential errors and confirm the integrity of the research. To ensure data integrity, the study used an interview guide to collect all relevant information, including unstructured and semi-structured questions (Boyce & Neale, 2006:5; Adosi, 2020:1-3). In addition, open-ended questions were applied to expand data collection; as a result, much more primary data was collected than anticipated.

Face-to-face interactions were circumvented due to a deadly pandemic, and interviews were alternatively conducted via a computerised platform to obtain first-hand data. The Zoom application was conveniently used for a scheduled calendar appointment based on the convenience of respondents' scope of operations, including the date and time and permission given to record the interview session, but primarily to ensure their safety (Ali & Alharbi, 2020:1; Archibald et al., 2019:1-2). To ensure the data remained credible and to avoid unnecessary speculation about the integrity of the data, recorded visual and audio data was used to ensure accurate feedback and allow respondents to validate all interpretations as authentic. The visual and audio data were captured word for word in Word text. All relevant responses were effectively extracted and applied during data analysis.

From this, accurate findings and recommendations can be derived that drive food security and profitability when considering aquaponics as a business (Dilshad & Latif, 2013:192-193).

Reliability represents consistency within the analytical procedures employed to ensure the credibility of results, and qualitative research remains rigorous (Kallet, 2004:1229-1231; Noble & Smith, 2015:34). Qualitative research gives meaning and identifies hidden patterns in words. It helps to put a specific scenario in context so that the big picture finally comes into view and all the speculation is eliminated (Leung, 2015:324). The data has been converted verbatim from audio/video to Word text format.

3.2 Research Philosophy

Research philosophy provides an opportunity to explain the rationale for conducting a particular study. There are usually three main paradigms within research: positivist, interpretive, and pragmatism (mixed) paradigms (Antwi & Hamza, 2015:218-223; Kumatongo & Muzata 2021:17-20). These capture the various tools to achieve the desired outcome for a particular study, including quantitative tools where numbers are imperatives referred to as positivists, which are subjective to a given and specific outcome. Conversely, qualitative tools are interpretative (inductive), using words to construe the subject under study in its complete perspective (Kumatongo & Muzata, 2021:18-19). According to Antwi and Hamza (2015:223) and Kumatongo and Muzata (2021:20), mixed methods combine quantitative and qualitative methods into a single investigation. The objective of corroborating the collected data one to the other is achieved by:

- In convergent designs, quantitative and qualitative data are collected concomitantly, and the two sets of data are analysed autonomously. The two databanks are mixed by merging results during interpretation or sometimes during data analysis to keep potential research rigorous.
- This is underpinned by an explanatory design that includes using qualitative data to clarify quantitative results that warrant further consideration.

This study investigated the set of circumstances concerning food shortages and high unemployment in the Western Cape Province of South Africa to conclude (validate) the reality of what was theoretically and practically perceived.

The research followed an interpretive type of inquiry (Antwi & Hamza, 2015:218-219; Kumatongo & Muzata, 2021:18-19). However, epistemologically, the inquiry was initiated from an explanatory perspective to obtain the best possible answers to the research questions and validate (justify) any new data unearthed (Alharahsheh & Pius, 2020:40).

Therefore, an interview guide was formulated as a framework for structured and unstructured use. This involved describing a particular activity, process or interpretive point of view through the lens of the respondents. Therefore, to obtain background information on the individual companies, business concepts, employment and production trends. In addition, variables such as food insecurity, food security, new start-ups and potential employment growth were incorporated to ensure accurate and exhaustive feedback. Therefore, in the context of an explanatory perspective, the study points to a qualitative research approach to resolve the inquiry.

3.2.1 Research approach

There are three research approaches, namely qualitative, quantitative, and mixed-method approaches (Mohajan, 2018:3). The study utilised a qualitative research approach. Qualitative research allows the researcher to follow a systematic sequence of inquiries to drive a comprehensive description of the researcher's understanding of a social or cultural phenomenon, taking into account the individual's belief system, perspectives and experiences (Bricki & Green, 2018:4). Qualitative research provides the strategy and a conceptual framework to navigate through the different phases of the research process. In addition, the process signifies how specific data relevant to the study was collected, measured and analysed (Astalin, 2013:118; Mohajan, 2018:5-6). Qualitative research takes many forms and is vital to achieving the desired research result. Therefore, the study committed to an interpretative qualitative research method as the best option to obtain all the salient data intended to provide the applicable answers to explore and unfold the (how and why) of the phenomenon under study (Kumatongo & Muzata, 2021:18-19).

3.2.2 Research design

The research design is described as a plan or a blueprint that indicates how the research will be conducted (Mohajan, 2018:5). It is applied in response to research questions to obtain rich and in-depth data to support and unravel the study. The research designs entail many methods, such as exploratory, descriptive, narrative, phenomenology, case studies, grounded theory, and ethnographic or could involve a fusion of different designs in terms of mixed methods (Creswell, 2014:41; Tracy, 2019:65).

Choosing the correct method validates the reliability of a research process, ensuring that the outcome is rigorous and the interpretations of the findings are compelling (Kallet, 2004:1229-1231). In addition, according to Tracy (2019:235), a reliable report provides confidence among readers to act and make decisions based on the data and findings.

This research engaged an exploratory design that attempts to investigate the studied sample concerning its social context. The researcher intended to make sense of their world and social reality in terms of opinions, behaviours, attitudes and social interactions. A qualitative approach was used, conducting electronic interviews using an interview guide to collect, analyse and interpret visual, oral and textual data in compliance with all ethical protocols (Kumatongo & Muzata, 2021:19).

3.3 Research Processes

According to Bengtsson (2016:8-13), the research process encompasses the entire research process from planning to presentation to exemplify the reliability of the data, particularly to ascertain how the data and analysis procedures are performed and ensure that no relevant data has been excluded.

The researcher used the following steps to conduct research:

- Pinpoint the research problem;
- Review the literature;
- Identify the purpose of the investigation (considering an exploratory and inductive approach) and the population;
- Ascertain the research instruments applied to collect, analyse and interpret the data;
- Provide findings and appraise research that uncovers the problem and
- Make recommendations for possible future developments in the study (Bengtsson, 2016:9-10)

These steps provided a periphery for the core objective. This research identified a suitable research area and engaged all the relevant stakeholders. All steps given, in order, are considered beneficial to achieve the aim of the study (Bengtsson, 2016:8).

3.4 Population and Sampling

Population implies everybody or everything the researcher wants to understand, while sampling refers to selecting a segment of the population for investigation (Rahi, 2017:3).

3.4.1 Population

A research population includes a sizable group of respondents or subjects, including everyone in a particular region where a particular study is being conducted (Rahi, 2017:3). It is essential to select an appropriate population during a qualitative research process to ensure that all relevant data related to the study are collected (Lopez & Whitehead,

2016:124). The population referred to in this study denotes all aquaponic and hydroponic businesses compared to semi-commercial and commercial growers already operating in the Western Cape Province, extracted from existing data.

3.4.2 Sample size and sampling technique

The details below explain the sample size and sampling technique.

A sample represents a selected subset of an inclusive population (Walliman, 2011:94; Lopez & Whitehead, 2013:124). It will cost a lot and take too much time to involve the whole population; hence a sample size is preferred (Rahi, 2017:3). Five businesses were selected as a sample, three aquaponics and two hydroponics businesses. This is not the first study to use a qualitative sample of 5 respondents. Attributable to the low percentage of arable land available, Botha (2014:2) investigated five mining sites to ascertain if these sites could be rehabilitated and reinstated for agricultural use to initiate aquaponic practices to address food security threats in South Africa.

In qualitative research, choosing the proper sample is imperative as an erratic technique can negatively affect a study's results and outcomes (Lopez & Whitehead, 2013:124). The study employed the non-probability sampling technique, including a Purposive Sampling technique (Etikan et al., 2016:2-3). Using a predetermined criterion, employing the purposive sampling technique enabled rich, informative feedback regarding each respondent's in-depth level of experience, suitable for an exhaustive inquest (Lopez & Whitehead, 2013:124-125). This technique does not require underlying theories, nor does it refer to a specific number of respondents. It is the researcher's prerogative to determine what needs to be discovered in a particular cultural domain, typically by experts who are capable and willing to share their knowledge or proficiencies (Tongco, 2007:147).

- The study selected a specific sample of aquaponics and hydroponics participants based on their traits or qualities, taking into account their experience in the industry and their experience in business growth, which implies a selection of criteria (Palinkas et al., 2016:2-3).
- Purposive sampling, also called the non-random sampling technique, was considered favourable because it does not require underlying theories or a specific number of respondents, but each has comparative knowledge of the subject under study (Tongco, 2007:147).

3.5 Data Collection

Data collection is pivotal in research as it contributes to a better understanding presented in a theoretical framework (Tongco, 2007:147). Therefore, data can be obtained through human-to-human interactions (communication), including audio recordings or written words and body language, which can be considered actual or potential data. Consequently, respondents' thoughts, feelings, experiences, reactions, actions, interactions, language and processes in their social and/or cultural setting are inclusive data to help determine the context of the study (Lopez & Whitehead, 2016:127).

Data collection emulates ways of sharing ideas, be it oral, visual or written. Interaction takes place between two or more individuals engaging in discussions of mutual interest (Dilshad & Latif, 2013:191). There is more than one specific method to retrieve research data. It can be obtained through focus groups, surveys, questionnaires, observational interviews and the like (Dilshad & Latif, 2013:191-193). Time management is crucial during research interviews. Although respondents provide valuable data, activities such as listening, observing and writing or typing simultaneously could result in the loss of valuable information resources (Lopez & Whitehead (2016:129). Oral data with the respondent's consent, including audio/visual material, can be of great help in the research process. In this study, the exact transcribed information was used during data analysis to report accurate findings and ensure correct information regarding aquaponics is obtained (Dilshad & Latif, 2013:195-196).

The data was collected via the Zoom platform due to a pandemic called Covid 19, a deadly airborne disease (Archibald et al., 2019:1-2; Ali & Alharbi, 2020:5). Consent was obtained, and respondents agreed to provide first-hand data for the study. In addition, a calendar appointment appropriate to their scope of work was assigned to each respondent, including the date and time of the interview session. These assisted the study in providing accurate feedback and ensuring respondents could validate the authenticity of all interpretations.

3.5.1 Data collection instruments

Data is collected through a data collection instrument (Bastos, Duquia, González-Chica, Mesa & Bonamigo, 2014:918). Data collection is pivotal to ensuring the research questions and objectives are answered. Making use of the appropriate data collection instruments minimises the possibility of errors and so confirms the integrity of research (Adosi, 2020:1-3).

An interview guide was used to collect the data for the study. The interview guide consisted of unstructured and semi-structured questions to acquire as much first-hand information as possible (Bricki & Green, 2018:11). In addition, the interview guide provided a layout seeking

background information about each business, business strategies, growth prospects, employment, production trends and food security.

3.5.2 Fieldwork

The researcher conducted the fieldwork. Face-to-face meetings were initially planned, but social distancing imposed by the COVID19 pandemic as a precautionary measure of safety mechanisms to prevent the spread of the virus made this impossible (Ali & Alharbi, 2020:1-2). The study then used Zoom video, an online communication platform with some limitations (Archibald et al., 2019:5). Finally, the study used the interview guide to collect the most truthful and accurate responses (Boyce & Neale, 2006:5).

3.6 Data Coding

Coding is the process of labelling and organising qualitative data in order to detect different themes and similarities (Medelyan, 2019:1-5). Coding is a universal part of qualitative research, fundamental to the analytical process and the methods by which researchers break down data to create something new. It is the process of analysing qualitative text data by disassembling the data to see what it produces before reassembling it in a meaningful way (Elliott, 2018:2850). Raw data is gradually reduced, removing irrelevant and unusable information (Bengtsson, 2016:11-12).

According to Saldaña (2016:3), a code in qualitative research is "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data." These denote interview transcripts, respondent's observation field notes, journals, documents, literature, photographs, video, websites, e-mail correspondence, artefacts and the like. Coding is also an imperative component of awarding excellence to an investigative report. The qualitative analysis process requires the researcher to acquire admirable coding skills to gain a certain level of competence in decoding, deciphering the research inquiries, discovering new facts, and coming to new conclusions through the data analysis. Saldaña (2016:1-2) comments that data coding is entirely the researcher's prerogative as to whether to code a particular research project, usually relevant to the individual's value systems, attitudes and beliefs regarding qualitative research.

According to Medelyan (2019:1), open-ended survey questions or free-text questions anticipate more actionable insights, leading to hundreds or even thousands of free-text replies. When the preliminary data is collected, it is still in its original (raw) schema and presented ambiguously. The information needs to be truncated and organised into

categories. Hart et al. (2013:466) share a guideline on developing the codes in each category. This study used manual coding to identify the different categories and sub-categories to explore insights. However, the process was applied differently outside the normal scope of conventional manual paper-and-pencil analysis of coloured pencils, paper and multi-coloured sticky notes (Braun & Clarke, 2006:89). The study used blank Word documents instead of sticky notes and used font colour and text highlight colour as the colouring process to code the various words, phrases, sentences and paragraphs, eventually answering the research questions. In this way, relevant answers to research questions became noticeable when the amount of data became smaller, and new data was no longer available.

3.6.1 Coding process

The data were coded using descriptive, in vivo and pattern coding to narrow down the data and generate ongoing topics to find the answers to the research questions (Saldaña, 2013:87; 91, 209).

The descriptive coding depicts the initial coding phase with various data forms, including interview transcripts, field notes, journals, documents, diaries, correspondence, artefacts, and audio-visual footage (Saldaña, 2013:88). Descriptive coding was used to draw attention to the initial responses recorded from the interview transcripts. The data were recorded in mp3 and video format. Data directly related to the research questions and business model was highlighted first, creating chunks of information.

Saldaña (2013:209) describes pattern coding as developing the category label that recognises similar coded data. Similarities were noted, and a particular colour was used to differentiate the phrases or sentences with the same meaning. Information was further coded, and the data downscaled, leading to new insights (Saldaña, 2013:212).

As codified information was minimised, some of the required answers to the research questions began to surface. Most of the data were applied in vivo, using direct quotes from respondents to label relevant codes mostly articulated in sentences and paragraphs. In vivo coding refers to the exact expression of the respondents related to the straightforward narratives, ideas, and direct meanings that each expresses (Saldaña, 2013:91; Manning, 2017:2). In vivo coding also refers to verbatim, literal, and natural coding. Codes are placed in quotation marks. In vivo coding aid is a manual coding method other than the automated NVivo software application for analysing raw data (Saldaña, 2016:38; Manning, 2017:3; Feng & Behar-Horenstein, 2019:564).

The data were coded, categorised, and organised thematically into words and phrases, sentences, and paragraphs. The data were shifted in various sequences relevant to the responses obtained via the interview guide to unravel the answers needed to solve the research problem.

3.7 Chapter Summary

The research methodology has been presented in the sequence of importance. The primary objective was to provide actionable insights, ensure the data is rigorous and fit for business applications and apply the informed business decision in an urban Agri-business setting. The research design, population, sampling, and data collection method have been explained. Finally, this chapter explained how data was coded in preparation for analysis. The next chapter explains the results of the study to assess if the collected data can provide the relevant answers to the research questions and the awareness business model.

CHAPTER 4

FINDINGS

4.1 Introduction

The previous chapter gave a detailed explanation of the methodology employed in this study. This chapter now unveils the findings of the study. Findings allude to the information that has been corroborated against the data collected in the field (Ríos-Saldana, Delibes-Mateos & Ferreira, 2018:4). Collected data are presented in the form of tables, figures, and charts. The data presented here attempts to answer the research questions formulated at the beginning of the study.

The study aimed at answering the following research questions:

- RQ1: How do aquaponic businesses operate in the Western Cape region?
- RQ2: What is the business growth potential?
- RQ3: What types of products are grown in the aquaponic businesses?
- RQ4: How can an aquaponics and hydroponics business assist in mitigating the risk of food insecurity in the Western Cape region?
- RQ5: How can an aquaponics and hydroponics business assist to mitigate unemployment in the Western Cape region?

4.2 Data Preparation

Manual coding was used in preparation for data analysis. The recorded data from the virtual zoom interviews was transformed into Word text, recorded verbatim, primarily to aid manual coding during the data analysis process.

The broad brushstrokes of raw data were narrowed down in depth (Medelyan, 2019:1). Word(s) and phrases related to the research questions and business model have been highlighted. All highlighted information has been extracted and pasted onto a blank document page, producing chunks of information. Some of the highlighted information has been re-highlighted, and data that has not been re-highlighted has been removed. The answers to the research questions and business model became visible as the data was reduced.

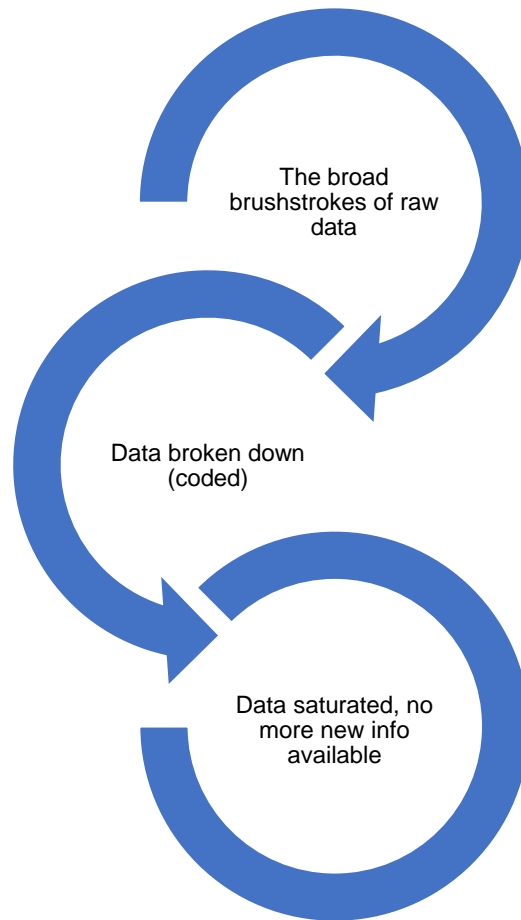


Figure 4.1 Data breakdown

Source: Medelyan, (2019:1)

Figure 4.1 illustrates the broad brushstrokes of raw data broken down in depth to realise its value. This is in response to the raw data usually presented broadly, is often very equivocal and needs an exhaustive tone down (Medelyan, 2019:1). All collected data were scrutinised, coded, and saturated until no new information could be obtained to answer and conclude the research questions.

4.3 Data Analysis

Data analysis is pivotal in qualitative research to provide solid evidence (Maguire & Delahunt, 2017:3351). Once the data were collected, it was analysed (Bengtsson, 2016:9-10). According to Burnard, Gill, Stewart, Treasure & Chadwick (2008:429), two primary approaches are used to analyse qualitative data: the deductive and inductive approaches. Therefore, it is imperative to employ the correct technique for data analysis.

The deductive approach has to do with a structured or predetermined framework used during the analysis of data. Therefore, it is depicted as relatively quick and easy. However, it signifies an inflexible approach to viewing the risk of subjectivity in the whole analysis process since the coding framework is usually set in advance, which significantly impacts the development of the theme and theory. Therefore, to ensure the integrity of the study, this approach is not considered appropriate.

On the other hand, the collected data is used to develop the analysis structure to generate a new theory in the inductive approach. The inductive approach entails an inclusive process making it time-intensive and therefore often appropriate for the application, especially when little or nothing is known about a phenomenon under study. Burnard et al. (2008:428) describe inductive analysis as the most frequently used technique for analysing qualitative data.

To provide commendable data analysis, Thematic Analysis, the inductive technique of data analysis was used (Vaismoradi et al., 2013:399-401; Bengtsson, 2016:9-10; Nowell et al., 2017:2, 8). The Thematic Analysis technique produces two streams of applications, the conventional manual paper-and-pencil analysis, comprising the use of coloured pens, paper, and multi-coloured sticky notes; thus, going old-school with hand-written notes or the researcher can make use of automated software. The study utilised the manual coding process (Nowell et al., 2017:6-8). All feedback was allocated into various questions, in an attempt to realise the desired outcome.

4.3.1 Data analysis process

Data analysis is pivotal in qualitative research to provide substantial evidence. The collected data needs to be analysed to explicate the process of moving from raw data to results and confirm the merits of the analysis (Bengtsson, 2016:11). Qualitative data analysis was used to interpret the information provided by each respondent to understand the data and understand each respondent's views and meanings in their own words (Swanson & Holton III, 2005:225). To achieve this, a different colour coding was applied. All responses to the various sections of the interview guide have been generically highlighted, using the same colour for each respondent in each section.

Four different colours were used to indicate the specific critical responses in each section. Similarities, differences, particular applications, or points of differences were pointed out, each on a different page as the coding process unfolded. This method was applied differently to the conventional sticky notes, colour pencils and whiteboard approach. The researcher made use of Word blank documents with text highlight and font colour

application. The data were narrowed down accordingly because of the research questions and the business model.

Appendix C displays four different text highlight colours used to highlight each respondent's responses (feedback) in each section (A–D) in relation to the interview guide, applying the same colour across the board to differentiate the various sections.

In addition, the video/audio data were recorded verbatim, and some words were repeated or missing in the sentence. The missing words were replaced with new words indicating a dark red font colour to make the data easier to read during coding. At the same time, a different colour (orange font) was used to emphasise specific words or phrases of similar meaning to identify patterns and create potential themes during coding.

4.4 Respondent Demographics

According to Chanthi and Chairpravit (2019:16), demographics designate the general factors of the population, namely gender, age, race, nationality, education, career, position, marital status, and economic status. The demographic data represents the population sample selected to represent the entire population of semi-commercial and commercial aquaponic producers in the Western Cape Province. Table 4.1 depicts a demographic breakdown of the respondents.

Respondents	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
Gender	Male	Male	Male	Female	Male
Position	Owner	Managing Director	CEO	Owner	Equal partnership
Race	White	Coloured	White	White	White
Education	Diploma	Post-graduate	Degree + diploma	Degree	Not provided

Table 4.1 Demographics of respondents

Further elaboration on the respondents' demographic characteristics is given below.

4.4.1 Gender

Four males participated in the research; two represented aquaponics, two represented hydroponics and one female represented aquaponics. The sample, therefore, consisted of 80% males and 20% females in business. Figure 4.2 illustrates the gender split of respondents.

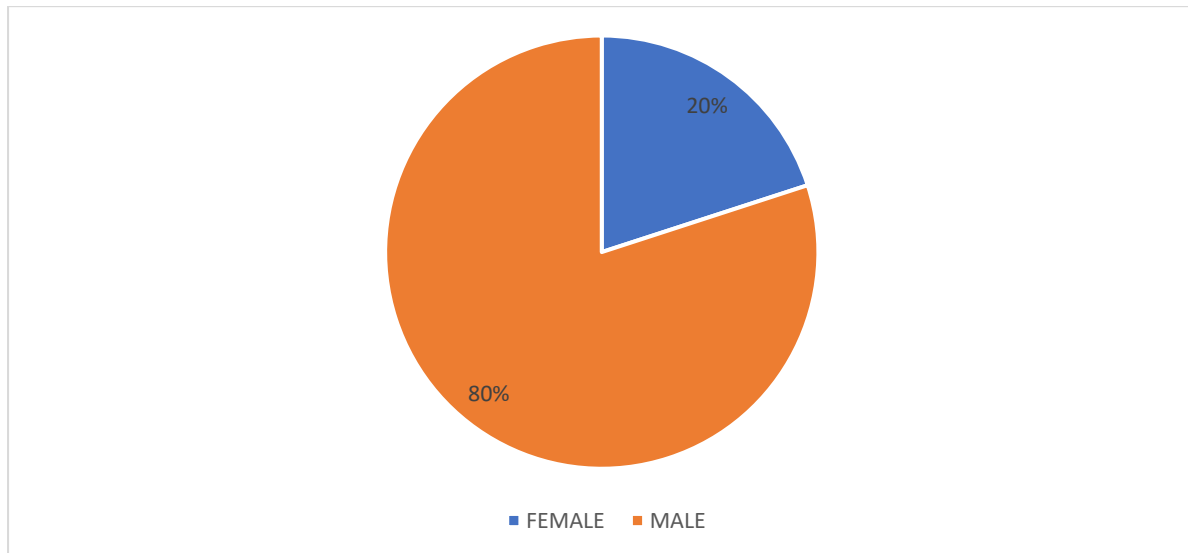


Figure 4.2 Gender of the respondents

Figure 4.2 illustrates an 80/20 male dominance split in the urban agricultural business sector of the Western Cape Province, which might be a typical display in rural and urban agricultural practices (Bryceson, 2018:61). Men are usually regarded as heads of households, hence the need to earn more and do more. However, females appear to be more dominant and active in certain countries, engaging in greater rural and urban agricultural activities than males (Bryceson, 2018:61).

4.4.2 Positions of the respondents

The sample represented the various positions profiled for each respondent in their respective field of operation.

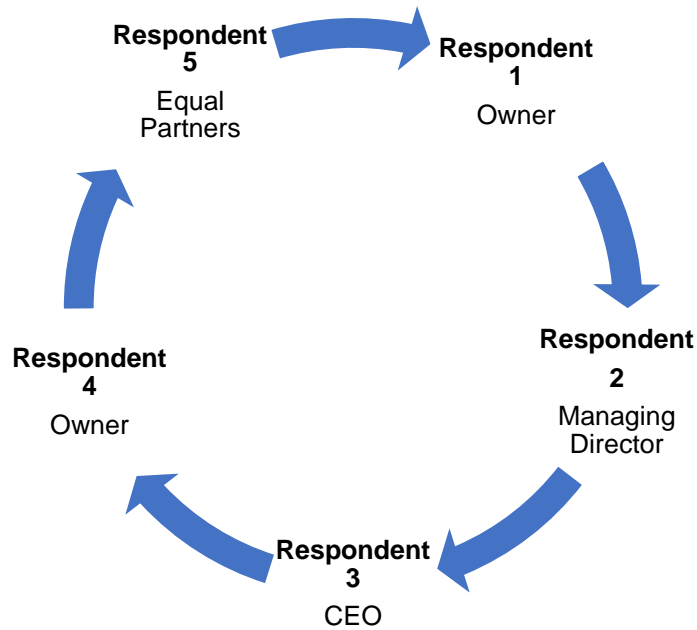


Figure 4.3 Positions of the respondents

Figure 4.3 displays the various positions held by the respondents. Two respondents (1 and 4) are owners of the aquaponics business. Respondent 2 functions as the managing director in the hydroponics field. Respondent 3 held the position of CEO, also set in hydroponics. Respondent 5 shared an equal partnership with his wife in an aquaponics business.

4.4.3 Race

There were four White urban farmers and one Coloured urban farmer among the respondents. Whilst responding to the question, “How do you predict your future employment trend in the coming five years?” Respondent 1 answered:

You have to have farming in your bones, “not a race thing. It’s a culture thing.” This indicates that being a farmer does not allude to a specific race.

However, according to Brown (2019:5), farmers in South Africa are predominantly White, and land ownership is an issue.

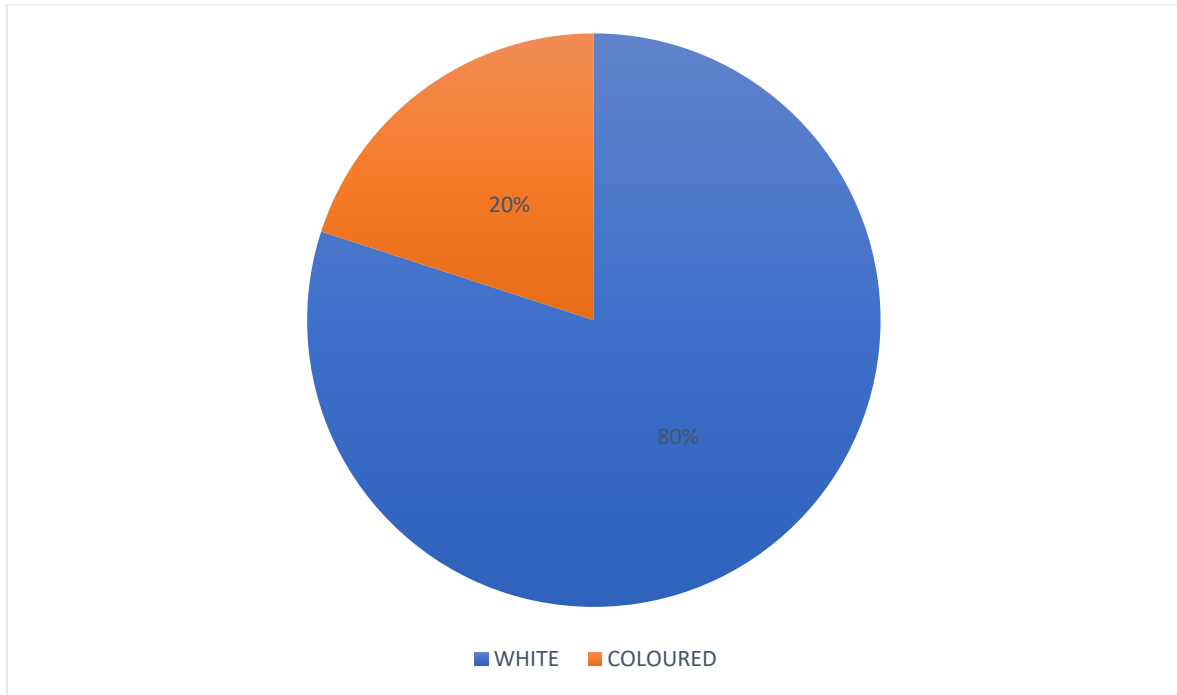


Figure 4.4 Race of the respondents

4.4.4 Education of the respondents

Information on the educational level of each respondent was collected, and the results are shown in Table 4.3 below.

Respondents	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
Education	Diploma	Post-graduate diploma	Degree + diploma	Degree	Not provided

Table 4.2 Educational levels of the respondents

Pertaining to the question, “What is your highest educational qualification?” All the respondents achieved a relatively good educational level. Respondent 1 accomplished a diploma in mechanical engineering. Respondent 2 obtained a post-graduate diploma in applied ethics. Respondent 3 completed a degree in industrial psychology with an added diploma in business. Respondent 4 attained qualification with a degree in marketing.

4.5 Business Types

Urban agribusiness encompasses many types of businesses. However, only two types were considered for this study: Aquaponics and Hydroponics.

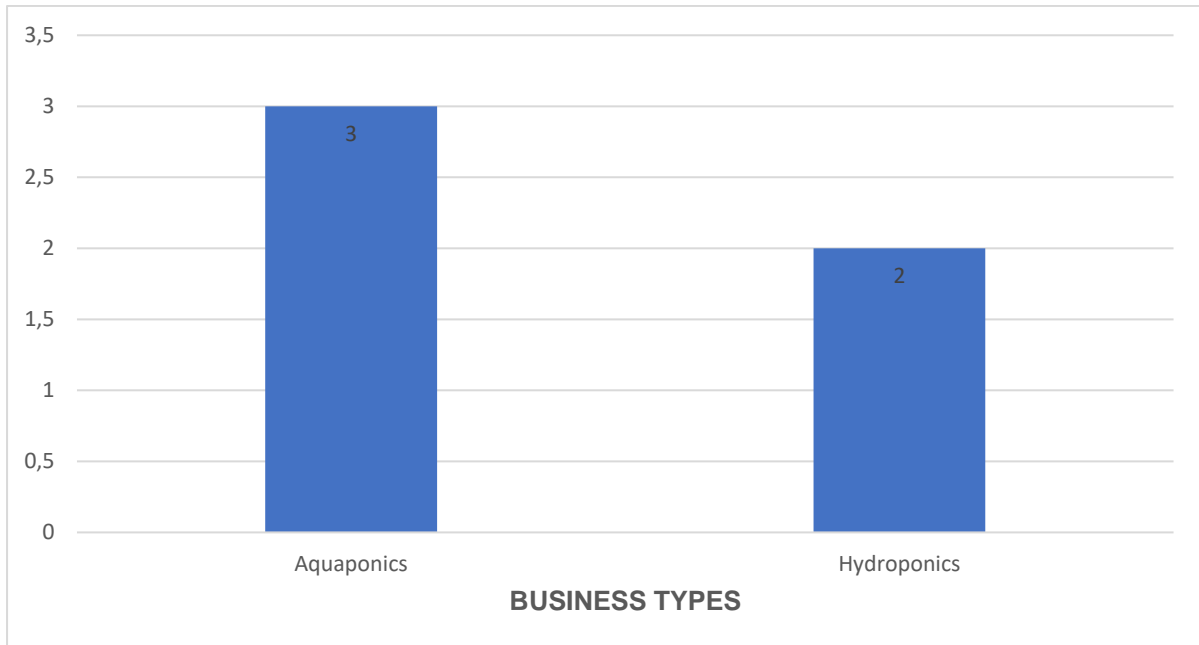


Figure 4.5 Business types

In the sample, three businesses were aquaponics and two were hydroponics. Hydroponics grows vegetables only (Diver, 2006:2). Hydroponics, a drip irrigation system, is described as less complicated and cheaper than aquaponics. Aquaponics requires a more elaborate design, including fish and bacteria, to maintain a constant chemical balance, which involves high start-up costs (Pereira, 2019:1-4). The study intends to raise awareness of the aquaponics market. Mchunu et al. (2018:14) reflect on only three commercial activities of aquaponic operations in the Western Cape Province.

4.5.1 Period of operation

The information on the period of operation was collected and the results are displayed in Figure 4.6 below.

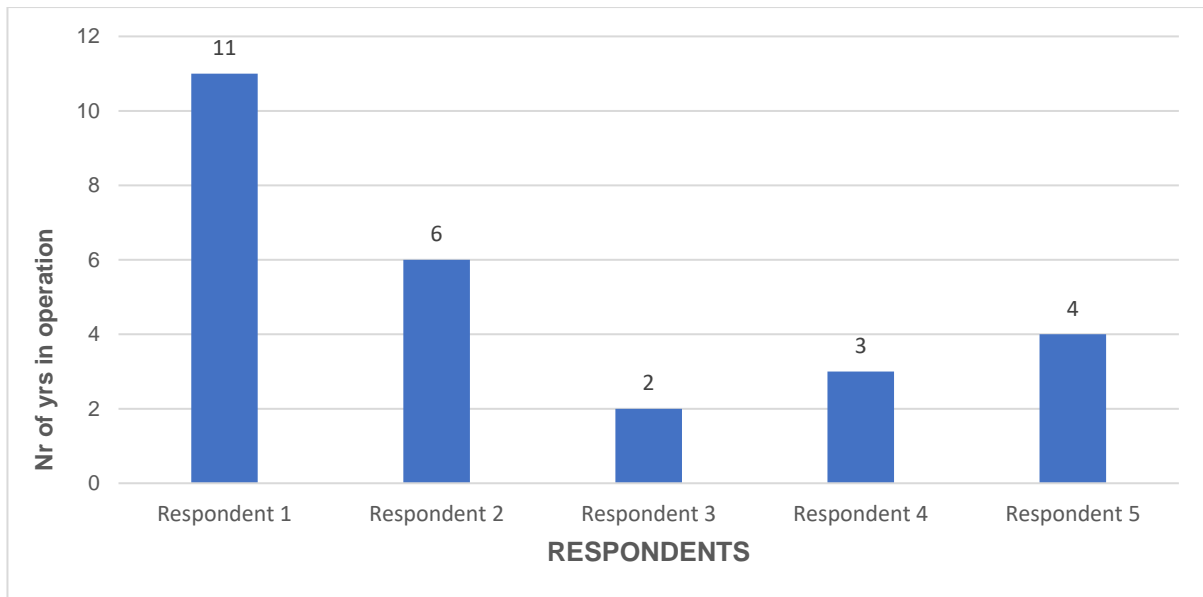


Figure 4.6 Number of years in operation

Figure 4.6 illustrates the period each respondent has been in operation. Respondent 1 reflects the most extended period, operating eleven years in an aquaponics food production system, with Respondent 2 working six years in the hydroponics food production market. Respondent 5 indicated a period of four years practising aquaponics as a business. Respondent 4 had been active for three years in aquaponics and was the only female respondent growing fruit trees aquaponically. Finally, respondent 3 reflects a minimum of two years of developing sustainable growing systems in the hydroponics business. All businesses are still young and developing considering the years of operation, between two and eleven years.

The following sections explain the results of the study and how the results answer the research questions.

According to Kiger and Varpio (2020:5), themes do not simply develop from the data but basically depict a vigorous and interpretive process. Themes emerge from the coded data through analysing, merging, comparing, including graphically mapping and showing the relationship between the various codes. Hence, a theme is a result of the emergent stages of coding. Codes could entail a word, phrase or sentence extracted from the data collected in the field. For example, Respondent 5, in response to “What is your field of expertise?” the response led to an additional question - “you’ve mentioned aquaponics as the next big thing. Can you maybe elaborate on that?” “Aquaponics the next big thing” could be presented as a

theme enacting three merging codes: "urban farming," "aquaponics", and "the next big thing". Aquaponics and urban farming are merging into the next big thing.

The researcher used the research questions to direct the query and achieve the desired research outcome. The clustered raw data was broken down into smaller parts, analysed and compared across multiple transcripts, at times overlapping different sections of the interview guide. Therefore, in response to the same perspective, the same descriptions and patterns were expressed within the dataset, whether to convey specific business attributes, similarities, or patterns (Lester, Cho & Lochmiller, 2020:99-101).

4.6 Recognising a Business Opportunity

The main focus of the study was to assess the potential of aquaponics as a business to combat unemployment and food insecurity. The question – “What is your field of expertise?” helped determine that none of the respondents had any background in agriculture. However, all respondents recognised a business opportunity or gap through different ways of presenting and creating a successful storyline in a green urban agricultural setting.

Table 4.3 exhibits the strengths, knowledge, skills, and experiences of each respondent, which influenced the decision to engage in a business opportunity in both urban Agri-business scopes

Respondent 1	The competency to solve complex business problems has triggered the challenge of entering the urban agricultural market with multiple benefits.
Respondent 2	“I have a reference in my childhood, where we stayed in the Eastern Cape, where we always had to make a garden, work in the garden and you know a lot of our food come from that;” emphasises some reference to the status quo, initiated by government projects (opportunities) with the offer of funding and land.
Respondent 3	An acquaintance kindled my interest in the technology of aquaponics. After numerous difficulties with certain complex issues of aquaponics, a shift to hydroponics was employed. Private and government project applications (prospects) aid to airlift the opportunity to its current standing.
Respondent 4	The search for a cure (healthy diet) triggered by a terminal illness constituted the interest in organic aquaponics food. It set off a career change which eventually added to a lucrative business venture.
Respondent 5	The love of nature and marine life merged the opportunity for an aquaponics business initiative.

Table 4.3 Factors that contribute to recognising a business opportunity

4.6.1 Research and development

Intensive research and development activity is considered essential, especially before starting a new business. Regarding the question “What types of products do you grow?” Most of the respondents indicated that they had to do research and trials on the products they grew. Of note, respondent 1 elaborated on the choice of product to emphasise the imperative of thoroughly investigating the potential of each product through intensive research and development activity. *“Well, I have to say for the first six years, it was intensive research and development effort here. So, I had to do trials on literally on hundreds of different crops and grow them through multiple seasons.”* The following question - “Why did you choose to grow those types?” confirms the significance of performing multiple trials. *“I started trials, growing trials with different crops... when I got the market research to see what crop we will try first; those were the big three, tomatoes, peppers, and cucumbers.”* Intensive research and development add the advantage of making quick, informed decisions and knowing precisely what the market demands to meet its demands as quickly as possible. It promotes the sustainability of new business start-ups, fostering a competitive advantage.

According to Lapere (2010:1-4), a new venture necessitates feasibility. A business’ target market plays a critical role in being sustainable. The customer becomes the standard focus, so businesses choose not to grow what they want but rather to grow what the market

demands. This statement is underpinned by Respondent 1; *“What I grow at the moment is not what I necessarily find interesting or what I want to grow. I’m growing what the market is demanding of me.”* Concerning the following question - *“Why did you choose to grow those types?”* Respondent 5 also accentuates the importance of responding in favour of what the customer demands. *“We grow what they want. Well, the main reason is sales, obviously, and it’s a fixed product that people will keep on buying.”*

At the beginning of the study, some questions were set with the intention of discovering the answers from the study data. The first question set was to find out how the aquaponic businesses operate in the Western Cape region of Cape Town.

Research question 1: How do aquaponic businesses operate in the Western Cape region?

The following question, *“Explain an Agri-business concept in the light/view of your business.”* triggered various interpretations in contrast to the urban and rural set of operations. The difference mirrors multiple benefits in an urban agrarian setting against the rural scope of operation. Product identification and the most suitable technique necessary for an urban food production setup are imperative from the beginning of the business concept. The most appropriate method carries advantages, as indicated by respondent 2; *“You can create an economy of scale on a small piece of land, just because you can engage with a crop that can grow vertically, like tomatoes for example, because you get different types of tomatoes... and it has a lifespan of either 7 to 8 months. So, that means I can harvest for a period of 6 to 7 months, where I know I have a reoccurring crop in that space all the time.”* The study confers different scales of operations; backyard, semi-commercial and commercial, whereas respondent 1 is the only business that introduced commercial status cultivated in a condensed area of *“3 and a half hectares.”* *“As far as I know in the Western Cape, I am the only truly commercial aquaponics farmer.”* Respondent 1 had developed, tried, and tested various products for their usefulness in the marketplace to determine what can grow productively and cost competitively (in contrast to the open field growers) to find traction in the marketplace. The benefit of growing sufficient sample products first cultivates the confidence to serve the market with surety.

Respondent 2 designates minor scale status; *“it’s very difficult because as a small-scale farmer you are at risk if you don’t follow those things correctly”*, and respondent 3 highlights backyard capacity; *“I think the people now have the capability of growing food at home... our system I mean the African grower vegetable garden... use pots... it’s a vertical garden.” ... we grow all types of herbs, leafy vegetables and your small bush or your small fruit-bearing plants, like your chillies and peppers and things like that work very well in our system.”*

According to Aquaponics SA (2016:1), there are three business categories under section A: non-commercial status, small scale status, and commercial status. Commercial status signifies a density of more than 150m² plantation area and the production of more than 1-ton of fish annually. This indicates that most of the aquaponics respondents may have commercial status.

Respondent 1 engaged a commercial aquaponics set-up that draws from an international business design that warrants an effective business outcome. This enhances the opportunities for best practice applications and lessons learnt; how to handle substantial supply and demand to serve the market, no matter how small or big the demand. Respondent 5 reflects multiple business streams of income alongside its core agri-business set-up, cultivated within one hectare. Respondent five's other businesses comprise a nursery school, coffee shop and training on the far side. *"We don't only got aquaponics; we got aquaponics, we just started a small plant nursery and added to that we got a coffee shop... And we are busy with a big project here in Louisville rural area which is sponsored by YES... youth employment services... to do Skills development in this area..."* A wicking bed is suggested as an extension to an aquaponics set up to run parallel as an additional source of food production, which adds to a minimal of 90% less water usage.

Respondent 4 does business in a greenhouse area, growing various leafy products and fruit trees aquaponically in one space and engaging in multiple income streams. *"There are different incomes in Aquaponics... You can do training, you can sell worm farms, you can sell organic compost... So, I've been in the business industry working on e-commerce projects for retailers... I'm now dealing with Pick 'n Pay; my other client is the PEPCOR group, so that is Ackermans, Refiner, Shoe City, and Dunn's. So, I'm actually in the advertising industry, advertising in marketing."* The multiple income streams enhance profitability and cover slower months and ensure sustainability. *"So, we sell worm farms as well, so yes, I suppose that in itself means that if your crops aren't doing well, because let's say, it's winter and it's freezing wherever you live, you have other income streams."*

Research question 2: What is the business growth potential?

Each respondent displayed a different journey to their business development, which increased product demands and food production footprint. All respondents indicated growth in their businesses. According to Respondent 1, the market still holds a lot of growth potential for the products that are currently in demand; *"We grow nine different products at the moment. There is a lot of growth potential in those products volume-wise that we've been offered by the market, and we grow with what the market is demanding and not*

necessarily prefer to grow.” The respondents were asked: “Describe your business growth trend in food production in the past five years.” Each respondent introduced their own perspective of what they want, how much and how far they want to grow their respective business stream(s). For instance, one tunnel (hectare) of fresh produce suffices for one respondent's production capacity; fits additional streams of income, while three and a half hectares provide too little space for another. The following exemplifies more detail:

Respondent 1: An intensive involvement of the business is apparent, starting with intensive research and development as the initial expansion, developing from civic to farming; *“we went through an intensive and extensive research and development period... my business has gone through 4 growth stages. The first phase was research and development... the second phase, we added another 50% of production space...The third expansion, we double those combine space of the first two expansions again.... We are currently five times the production area we were before, and in the last two months, we're expanding our production space again.”*

Other than an increase in the food production footprint, there has also been an increase in the number of manual workers; *“We steadily employed more people as our production footprint has grown.”*

Another question was posed: “What business growth strategies, if any, are you taking that you think are unique to your line of business?”

Respondent 2 mentioned the technological advantages of social media and online marketing; *“It's a lot of interesting technological things to take advantage of, social media, marketing online...It actually increases our footprint, also giving us a better price at the end of the day because we are skipping a lot of middlemen in the process...So we getting better prices for our good quality vegetables and fruit...On social media, people... can see where the food is coming from... the food began to tell a story... that gives you a higher value.”* Respondent 2 indicated an overall expansion of 33% of production space was realised within the period of five years, with additional greenhouse infrastructures already in progress.

Respondent 3: In response to the question, “Explain how you intend to increase your food production versus consumer demand,” the respondent replied, *“We are in the process of getting a factory... if the volume picks up, we are capable of delivering a product at any volume.”* Therefore, such logistic efficacy can benefit a broader client base that is optimised to secure sufficient food availability.

Respondent 4: Shifted from a corporate context to an urban Agri-business and is the only respondent to cultivate both vegetables and fruit trees aquaponically; *“with Aquaponics, you can grow different things, so I think I’ve mentioned to you some of my fruit trees, I grow guavas, kiwis, pomegranate, lemons, lettuce and multiple herbs.”* Furthermore, diversified applications such as aquaculture training, selling worm farms, organic compost, etc., as mentioned above, are presented as alternative means for additional income streams, especially during the slower months, which also provide entrepreneurial and employment opportunities; *“So what I was saying about diversify is there are different incomes in Aquaponics... You can do training, you can sell worm farms, you can sell organic compost.”*

Contributor 5: In reaction to the question - “Describe your business growth trend in food production in the past five years”, the respondent shared information highlighting two additional business ventures comprising a coffee shop and a nursery in a symbiotic relationship with an aquaponics mainstream; *“We don’t only got aquaponics... we just started a small plant nursery and added to that we got a coffee shop...”*

Training was also presented as an additional source of income. The government has launched a significant business training initiative, sponsored by several benefactors, to advocate small business opportunities and construct an effective skills development trade fair, counting aquaponics, baking, and welding skills to enhance employment creation. Table 4.4 reflects the different achievements of all the respondents in their respective periods of operation.

Respondents	Growth Impacts	Growth Rate %	Diversified Offers
Respondent 1	Current production space measured five times the production area of what it was in the past.	300	None
Respondent 2	Increased the land with the infrastructure of greenhouses.	33	Social media & online marketing
Respondent 3	Factory		None
Respondent 4	1 Greenhouse		Aquaculture training courses, selling worm farms & organic compost; Corporate & E-commerce projects for retailers.
Respondent 5	1 Hectare footprint		Coffee shop & nursery and YES training project.

Table 4.4 Growth potential

Each business is run in its own sphere of expertise, allowing for ample business opportunities in the organic stream with various possible options for success, deliberating a conscious mix of income streams. Each entity has grown gradually through various business applications and financial solvency (self-sustaining) with reference to respondents 1, 4 and 5 or through assistance from private or government entities; provided for respondents 2 and 3.

4.6.2 Financial challenges in business

The respondents were asked about the challenges they have encountered in their business operations. The question was asked, “What challenges have you encountered in your business?” The common challenge among the respondents was the financial def. Businesses needed some finance to expand. Some of the respondents used their own finances to cover the cost of their business set-ups, while others had financial aid. All respondents had different responses but portrayed the same economic challenges.

Respondent 1 responded as follows; “*Everything was bought and paid for on a cash basis.*” Although Respondent 1 could pay cash to set up his business, this did not spare him the financial impact of multiple experimental research and development costs over a 6-year period. In addition, intensive travelling worldwide to attain sufficient business traits in aquaponics added to hefty start-up expenses.

On the other hand, respondent 2 obtained some funding for his business. *“I had an opportunity in agriculture. I had access to capital.”* Van der Walt (2019: 3) confirmed that Respondent 2 has applied to the Western Cape Department of Agriculture for funding to start a hydroponic farming business.

Respondent 4's response clarifies; *“I decided... to give up corporate and to buy a smallholding”* In addition to being able to purchase land and start a business, challenges such as high utility bills impacted the business' cash flow; *“our electricity is so much more, I think it's up to, it's almost 35% more.”* Furthermore, slow spells during the winter mandated alternative measures to maintain the business' profitability, like selling worm farms, organic compost, etc., as cited earlier. For Respondent 4, in addition to aquaponics, all business connections related to marketing and other business ventures serve as an additional source of income expedient during slow periods.

Respondent 5 ledged on to the high start-up costs in relation to aquaponics; *“I don't think it's easy for anyone just to start off like 100 000 or 200 000 to actually make money out of it. You have to invest more than a million to start seeing a turnover.”* This clearly indicates the costly implications of start-up an aquaponics business even with hard cash competencies. This resulted in additional revenue streams to keep the business going; *“when you go into aquaponics, you won't get rich. 100% sure... but if you have aquaponics linked to other businesses, then yes, then you can make money.”*

To conclude, both hydroponic businesses received financial assistance from government or private entities in their respective business inceptions. Every respondent was challenged financially in its scope of initiatives. The question was probed; *“Suppose you were given extra support... what kind of support do you need?”* Everyone's response is captured below with each individual's needs.

4.6.3 Government support

Respondent 1 shared his view; *“I think it's pretty mature for government to get involved in this type of industry where government can play a facilitating role... but we can benefit, once the industry is a little bigger and a little more mature. We can really benefit from government giving funding to youngsters to get trained in the skills set that we require in this industry. The role of government... appetising to the sources to big capital”* affirms the YES employment project highlighted by respondent 5, initiated by the national government to create extensive future business opportunities, including aquaponics; *“The whole point of this is to do Skills development... It's basically like a small campus, so we are teaching them aquaponics, welding all of those things in 1 year and then they will be able to go out into the*

world and be qualified for what they do.” Therefore, making aquaponic business entities more accessible, thus relieving the pressure of food shortages and unemployment.

Respondent 2 highlighted; *“If they would give me the money in my hand, I would do miraculous things... I won’t say no thank you.... I think more infrastructural investment. I think new and niche markets, the blueberry industry... the upcoming farmers again now being left behind with this unlimited market which is blueberries; for example... these are the ones I think are infrastructural and also access to land... mostly as a business if you have access to land. Owning a farm is a different toy because there’s so many other legalities towards your responsibilities to that land but having access to land means you can do business, you can create jobs, and you can do what you need to do, you know, propelled the area forward.”*

Respondent 3 stated, *“Probably on the advertising side, the web, online sales. Getting the product known or getting the product out there is daring. We are in talks with a company called Veldskoen... they might be interested in joining forces so that we can sell the product online. If I get the support in advertising the necessary getting the product out there, then I expect to grow quite nicely.”*

Respondent 4 provided input; *“The first support steps should include subsidy on grid-energy costs or the supply of Solar Energy kits... electricity cost in rural/agricultural areas more expensive than in urban areas. Other support measures could be access to infrastructure finance at mitigated interest rates... financing institutions... expansions, etc., even though some schools now offer aquaponics as a subject!”*

Respondent 5 responded, *“If it talks about financial support, I can put up an extra two tunnels... I probably put up some gravel beds and also wicking beds, then I got three techniques how I can grow my leafy crops and grow my fruiting crops and grow my rooting crops. Then that will turn... more than double the production.”*

The data shows that more young industrialists are needed, and that the industry needs to evolve and eventually mature for the government to increase its financial support. Utility costs are a hot topic, hence the need for power generation equipment. Advertising also plays a significant role in further growth development.

Research question 3: What types of products are grown in the aquaponic businesses?

4.6.4 Food production type

There are many different food production types to choose from, and a few steps are needed to ensure the success of each crop.

Respondents	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
Food production type	Leafy green; baby spinach & fruity crop; peppers, as well as fish; bream	Leafy green; turnip & fruity crop; tomatoes	Develop Growing systems for leafy green; spinach & fruity crop; chillies	Leafy green; watercress & fruity crop; mulberries & fruit trees; kiwi's and fish; tilapia.	Leafy green; mix lettuce & fruity crop; cucumbers, congruent with rearing fish. Additionally, rooting crops like potatoes

Table 4.5 Food production types

The respondents presented various food types specifying what they grow and specialise in.

Respondent 2 *“Currently, we specialise in tomatoes, so we want to be identified as the tomato people from that area. We also concentrate on turnips because that is also a good cash crop at the moment.”*

Respondent 5 specialises in mixed lettuce as a primary source of income. *“In aquaponics we only do mixed lettuces because that is what makes money for us. That pays the bills.”*

Respondents 1 and 4 specialise in a broader choice of products. Respondent 1 identifies, *“We grow nine different products at the moment; baby spinach, it's one of our main crops for the last three years,”* whereas respondent 4 is congruent with the various leafy green products; *“where do I start; tomatoes, cucumbers, peppers, salads, herbs, spinach, pak choi, watercress and kale” are the only one growing fruit trees aquaponically.*

Respondent 5 advocates using the wicking bed method; *“Addition to that you can get your rooting crops, which is turnip, carrots, beetroots, potatoes. Those rooting crops are not directly connected to aquaponics, but you can build an additional wicking bed... Then aquaponics water feeds that wicking bed.”* These rooting crops are firmer foods that complement common leafy greens in aquaponics to alleviate food insecurity.

Fish is cultivated by all the aquaponic growers, typically for fertiliser. Respondent 1 indicated that *“We need the fish as fertiliser; it’s the main source of the base component of our fertiliser.”*

This was supported by Respondent 4, who responded as follows; *“so the fish add nutrients to the water, the plants take up the nutrients and then clean the water again for the fish.”* Respondent 5 added, *“You can utilise aquaponics water, rich fertilised water into your garden and stuff.”*

Only edible fish are retailed, for example, tilapia and bream, as mentioned by respondent 1; *“If you look at tilapia and bream”*, and respondent 4 also indicates; *“In aquaponics, you grow your fish as well; tilapia is one of the healthiest protein-rich sources. So have your fish that you are growing in your tank, and you have your plants.”* Respondent 5 confers, *“Well, in aquaponics, you got your fish which is a protein; well, you can bake it or do whatever you want with it.”*

Leafy green products are familiar to both aquaponic and hydroponic growers. Respondent 3 verifies, *“we grow most herbs, leafy vegetables and your small bush or your small fruit-bearing plants, like your chillies and peppers and things like that work very well in our system.”*

It is noteworthy that for some, aquaponics is not only used as a stand-alone business initiative but is also linked with mixed-income streams. Respondent 5 employs different methods to ensure feasibility; *“when you go into aquaponics, you won’t get rich... Not just aquaponics, but if you have aquaponics linked to other businesses, then yes, then you can make money... We don’t only got aquaponics; we got aquaponics, we just started a small plant nursery, and added to that, we got a coffee shop.”* Due to slower operating periods, respondent 4 found ways and means to improvise through diversified measures; *“So what I was saying about diversify is there are different incomes in Aquaponics... You can do training, you can sell worm farms, you can sell organic compost, so that’s a good way of looking at entrepreneurship and employment.”*

4.7 Aquaponics and Employment

The collected data exhibits a significant disparity in employment in the table below. A small percentage of permanent and temporary employees per site seems quite common in a commercial aquaponics setup (Love et al., 2015). The employment status of all the respondents is illustrated in the table below. It shows the number of employees and excludes owners as they are perceived as employers.

Table 4.6 below reflects a sizable employment gap between respondent 1 and the rest of the respondents.

Respondents	Total employees	
	Full time	Temporary
Respondent 1	21	
Respondent 2	2	
Respondent 3		1
Respondent 4	2	
Respondent 5	2	

Table 4.6 Employment structure recorded with significant disparity

Closing the gap and realise a significant increase in job creation in the urban agricultural market anticipates lessons learnt, applications and best practices for an unusual employment phenomenon. Respondent 1 demonstrates the possibility of extensive employment opportunities realised (more than 20) on a relatively small production footprint of only 3.5 hectares of land, while the other respondents have 1-2 employees. The farming business is not accustomed to year-round employment (Ayenew & Kopainsky, 2014:7; Devereux & Tavener-Smith, 2019:1-2). Idling seasons are an acceptable norm. The sample's employment rate for hydroponic and aquaponic business types was very low. Most of the respondents 2, 4 and 5 in Table 4.6 have a very low percentage of permanent employees.

In contrast, Respondent 3 only uses one temporary worker, indicating, "*I have a subcontractor, so I just have one... it's not a permanent employee.*" So, employment in aquaponics does not include large numbers in general. Instead, it runs in variants of permanent, temporary, and voluntary staff at a very low scale (Love et al., 2015:70).

Research question 4: How can an aquaponics business assist to mitigate unemployment in the Western Cape region?

Respondents were asked: "Describe the possibilities, if any, of increasing employment in your agribusiness." The respondents presented different perspectives on employing additional staff in an urban agrarian setting. Some respondents felt that it is unnecessary, as

the day-to-day operations do not require it. The study ascertained that increasing employment could only occur when businesses grow and for growth to happen, more capital is needed. However, work can fluctuate depending on the seasons. This is shown in the responses below.

Respondent 2 stated, *“there are times where we have to harvest, and there are times where we have to prune, and we don’t necessarily need the same amount of people for the same amount of activity”*.

Respondent 4 remarked, *“You know in summer you harvest a lot more, up to 50% more than you would in winter. So, let’s say I have large orders, I will get someone temporarily in to help with the packing, to help with the labelling or to help to seal my bags, but they not permanent on your payroll.”*

Respondent 3 replied, *“I try to keep the company lean and mean. Unfortunately, employees are salary, and salaries are money and starting a business you don’t have a lot of resources. Not really had employment plan and don’t intent to. I don’t really want to employ people.”*

Respondent 5 responded, *“I would like to train the next in line so that they can also help the company to become bigger and better.... I would transfer computer skills that’s one, and then some social skills as well.”*

Respondent 1, unlike other respondents, reported ample permanent employees. In response to the question, “How many employees do you have?” He replied, *“21 employees.”* With the expansion of the production area, new employees also increased; *“We steadily employed more people as our production footprint has grown.”*

Due to the agriculture industry with regular seasonal work practices, the status quo is clearly disputed (Devereux & Tavener-Smith, 2019:1-2). The data reflects a possibility of a continuous food production operation process and employees having the opportunity of a stable income year-round, as indicated; *“At the moment we produce just under three tons (baby spinach) a week, one of nine products... 52 weeks of the year... it’s one of our main crops,”* hosting *“21 employees.”* Respondent 1 demonstrates the possibility of running a profitable stand-alone aquaponics business with high volumes of fresh produce with an extensive staff complement. This requires current and prospective growers to acquire the same skills as running consistent operations across a broad spectrum to secure the more prominent grower’s contracts with major national retail groups, including restaurants, guest houses and conference centres and wholesale trade to employ more or less the same results.

The urgency to ensure year-round employment capacity could help decrease the staggering unemployment rate towering at 34.9% in the third quarter of 2021 amid the current pandemic (Stats SA, 2021:1). Every sector, including the food production sector, plays a fundamental role in creating a business ambience for employment. The respondents were asked, "What are the obstacles to your business employment growth?" and the responses pointed out to lack of money to pay the workers. The following responses were obtained.

Respondent 2 *"Yes, there are obstacles as with any business there are I think most apparent are financial constraints ...We steadily employed more people as our production footprint has grown...we are going to increase, already we have, with infrastructure of greenhouses."*

Other respondents expressed fear, citing the uncertainty of increased output brought about by new workers.

- a) Respondent 1 *"It is very difficult to predict if an employee will be a productive employee or whether they work hard in the next six months or sit on their laurels for the next few years."*
- b) Respondent 3 *"To get the right people is going to be quite difficult."*
- c) Respondent 4 *"So it's hard to say yes if you expand, you going to need more staff."*
- d) Respondent 5 *"you have to work on weekends, and unfortunately many people don't like to work on weekends or during holidays that is the time that people want produce."*

Respondents pointed out winter as a challenge to employment growth. Due to the colder water, there is less production activity, and the fish eat less, which means less fresh produce is cultivated. The other obstacle to employment was the risk of hiring an unsuitable or unproductive staff. A lack of finances, infrastructure, temporary versus permanent jobs and the risk of employing a mismatch are detected obstacles.

The study further tried to ascertain from the respondents how these employment obstacles can be overcome by asking, "How can these obstacles be overcome?"

Respondent 1 suggests specialised training is better than no training, up to some training developing into good training. Therefore, responding to the formal training structure introduced by Respondent 4, *"We've identified that there are different levels of training"*.

The mentorship training type ensures a valuable internship through hands-on and relevant experience, which Respondent 2 describes as greenhouse management, to ensure that the necessary and appropriate skills required for the urban farming business are secured.

Respondent 4 is the only one who indicated the importance of formal training before commencing an aquaponics business set-up. The need for bigger aquaponics production footprints serves as a motivation for more financial support from the government. Therefore, specialised training can develop the capacity to manage large vicinities and attract large sums of money to invest in these businesses.

Respondent 2 projected; *“The coming five years, we’re going to project our leap. I think we’re going to increase our employment capacity by 40%... I can see it from a government point a view that agriculture is a very big priority. It was a priority in terms of job creation on their agenda.”* The status quo reflects only two workers, apart from; *“normally we have between 5 and 10 at this time of the year”* Furthermore, *“we have run on full production, and we are going to increase... already... we have, with infrastructure of greenhouses to produce even more high-quality vegetables, either hydroponics or in the ground measures.”* Respondent 2 prefers to use more temporary workers, so a larger production footprint offers the opportunity to employ more workers seasonally.

Research question 5: How can an aquaponics and hydroponics business assist in mitigating the risk of food insecurity in the Western Cape region?

To assist in answering the above research question, a question was asked: “Describe, in the order of importance, the aquaponics products that you think can help alleviate food insecurity?” Most respondents highlighted the green vegetables that grow fast, and respondents 1, 4 and 5 stressed fish. The hydroponic growers generally advocated for spinach, while the aquaponics added protein which is fish.

Respondent 1 provided feedback that people need something rich in minerals, vitamins, and protein complementary to staple food. These include the baby leaf spinaches, chards, celery, and the like; *“You need the bulk, and then you put the nice to have things with it. So, talk about the baby leaf spinach or the chard we grow, the celery we grow... but you can’t survive on it even with the good portion of fish”*.

Respondent 2 actively mentioned products such as lettuce, tomatoes, leafy greens and, in particular, tomatoes which add traditional value to the food. For instance, *“if you have pap and spinach, you put a little tomato in there with onion, then it’s a different scenario. You don’t need your meat; that crop and think lettuce and so forth is something that can help with that.”*

Respondent 3 referred to products such as spinach and kale, calling them superfoods because they are easy and quick to grow and can be sold or bartered with. Peppers and

chillies were added to the list with a little fruity twist; growing strawberries; *“Yes, I think definitely the spinach and kale, those types of superfoods grow easily and quick. And it is something that the people can sell as well or barter with; peppers and chillies also grow well. We are now testing strawberries... to see if the people in the community can grow strawberries... so; it might be a source of income.”*

Respondent 5 rates fish as a protein that can be served (baked) with various fruiting vegetables such as tomatoes, cucumbers, and leafy greens such as lettuce, kale, and spinach for a balanced diet. In addition, root vegetables such as beets, carrots, turnips, and potatoes are added to the green leafy vegetable mix, grown in parallel with an aquaponic structure called a wicking bed that uses only 10% water. Most of what households need can be produced in an aquaponics system, as confirmed; *“Well in aquaponics you got your fish which is a protein; well, you can bake it... You can grow fruiting crops like tomatoes and cucumbers. Then, you get your leafy crop, which are your lettuces, your kale, and spinaches. Addition to that, your rooting crops which is turnip, carrots, beetroots, potatoes. Those rooting crops are not directly connected to aquaponics, but you can build an additional wicking bed. Then aquaponics water feeds that wicking bed. So, you can grow everything you need for your households using aquaponics the method. That technique also uses 90% less water.”*

Aquaponics holds a higher nutritional value other than traditional agrarian methods. Nutrient-rich water benefits the plants to grow and look presentable for retailing. All the respondents clearly identify aquaponics as an alternative to the current staple food output. All respondents confirmed that it is not the solution to food security; however, considered suitable to alleviate food insecurity. The Respondents view aquaponics as a portion of nutritious food, as highlighted by Respondent 5 *“Aquaponics provides all the nutrients that the body needs other than to live off only polony and “wit brood” (white bread)”*.

Respondent 5 also states, *“Well, aquaponics in itself won’t do that alone... my personal opinion is it won’t solve the food sovereignty, aquaponics alone.”*

Respondent 1; *“Aquaponics can play a complementary role, but it won’t solve the problem... I don’t think aquaponics will ever play a significant role in food insecurity, but we will play a complementary role to what the bulk staple growers do.”*

4.8 Chapter Summary

The results of the study were presented in this chapter and pre-gathered to achieve the desired outcome and to answer the research questions of the survey. Respondents provided

adequate and relevant data to support the potential of aquaponics to function as an urban business initiative to alleviate food insecurity and unemployment in the Western Cape Province of South Africa. Subsequently, a summary, conclusion, and recommendations for future research reference are given in the next chapter.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter, therefore, summarises the study and concludes to ascertain if aquaponics as an urban business initiative could alleviate food insecurity and unemployment in the Western Cape Province of South Africa. It also gives recommendations based on the study results.

5.2 Summary of the Study

5.2.1 Literature

The study used relevant information to verify if aquaponics would be viable as a semi-commercial and commercial entity in solving unemployment and food insecurity in the Western Cape Province of South Africa. As a result, adults and children skip meals or even go without food (Nettle & Bateson, 2019:2). This directly impacts health implications resulting in malnutrition, undernutrition, and hunger.

The agriculture industry provides a seasonal working environment. Temporary employment is more prevalent than permanent employment during this period. Globally, the urban farming business provides evidence of permanent employees between 1-2 per site and additional temporary workers when needed (Love et al., 2015:70). Temporary staff is laid off soon after harvest time (Devereux & Tavener-Smith, 2019:1-2). However, the study introduces an unusual phenomenon of an entity with the capacity of sufficient job creation and food production output all year round. In an urban agrarian food production setting, there is no idle period, expedient to permanent job opportunities and financial resources in and out of season. Growing fruit trees aquaponically and applying the wicking bed method to enhance additional food resources; are all deliverables able to assist the U.N.'s S.D.G. objective for 2030 that all people become food secure (Zuinga et al., 2019:189). Therefore, unemployment and food insecurity are addressed head-on with a single complement.

5.2.2 Methodology

The study used qualitative data to gain in-depth knowledge on the subject. A total of five aquaponic and hydroponic businesses were interviewed. The sample size provided a broad overview of sound business decision making and a strategic breakdown of what is necessary to pursue an urban farming business. An interview guide assisted in maintaining the boundaries to an effective outcome to ensure the correct answers to the research questions were obtained (Boyce & Neale, 2006:5). Data were retrieved via an electronic platform (using the Zoom app) where all the respondents were engaged. All integrity

protocols were followed meticulously to ensure each respondent's safe and contented environment. Consent was obtained way in advance of the investigation. Unstructured questions were used. Concerning data preparation, manual coding was employed to prepare the feedback for practical data analysis. The recorded data from the virtual zoom interviews was transformed into word text, word for word, to make it easier to carry out manual coding during the data analysis process—the thematic analysis method aided as a guideline to retrieve the relevant answers. The broad brushstrokes of raw data were thoroughly reduced (Medelyan, 2019:1). This was achieved by using different font colours and text highlight colours. All the relevant data within the sentences were highlighted and those of no use deleted. The chunks of data already earmarked for use were highlighted again on a blank document page, which was not removed. Eventually, the answers to the research questions became visible each time the data shrunk.

5.2.3 Summary of results

The study affirms that aquaponics can be essential for integrated food production systems. This is asserted drawing from the following:

Research question 1: How do aquaponic businesses operate in the Western Cape region?

The study draws relevancy from the mix aqua/hydro sample size regarding an urban agrarian operation in the Western Cape Province. The study confers different scales of operations; backyard, semi-commercial and commercial. Some make use of tunnel structures, and others utilise greenhouses. Backyard crop growing includes pots. Product identification, as well as the most suitable technique necessary for an urban food production set-up, is one of the critical issues.

The most suitable technique has the advantage that vertical cultivation, e.g. tomatoes, can achieve economies of scale on a small piece of land. The timing of the harvest is critical as a single plant can produce 6-7 times over a 7-8 month period, compounding into a large amount of fresh produce known as recurring crops. Supply and demand is a crucial factor that influences the output.

Therefore, no matter how small or big the demand is, it is imperative to serve the market readily. For lessons learnt and best practice applications, an international business design has been proposed that ensures an effective business outcome by knowing how to deal with significant supply and demand at scale. This comprises more extensive grower's contracts with bigger national retailer groups and engaging restaurants, guest houses and conference

centres, etc., realised on a 3.5-hectare production footprint; 24hrs a day, seven days a week for 52 weeks uninterrupted.

Hence, sufficient food supply is produced weekly in a condensed area, including multiple product types in huge volumes. The type of fertiliser (technique) used also plays an essential role in the production volume achieved. Each respondent made an impact, and the study drew on all relevant skills and expertise; research and development, training, expanded infrastructure, e.g. wicking bed method, growing fruit trees aquaponically, bartering, etc. Other ways include; Respondents 4 and 5 reflect multiple income streams such as corporate marketing and a coffee shop and plant nursery, alongside their core agri-business set-ups to ensure sustainability.

Research question 2: What is the business growth potential?

All the respondents reflect an expansion in their businesses. Each respondent experienced an increase in product demand and food production footprint. As a result, there was potential to gain market share while the market still has a lot of growth potential in terms of volume relative to the products currently on offer. In response to the question asked: "Describe your business growth trend in food production in the past five years", each respondent had their perspective of what they wanted, how much and how far they wanted to grow their respective business stream(s).

The data shows that Respondent 5, with response to aquaponics, is entirely satisfied with expanding the business to the maximum size of a one-hectare tunnel. However, this links to other businesses, a coffee shop, a plant nursery, and training with the YES government project. Respondent 1 had shown tremendous growth that had expanded to five times the production footprint when they started the business and was still expanding their production area again at the interview.

The number of employees has also increased with the growth of the production area.

Another question was posed: "What business growth strategies are you taking that you think are unique to your line of business?"

Respondent 2 highlighted the technological advantages of social media and online marketing that triggered an increase in their production footprint. Plus, they earned better prices as many brokers were skipped. Their overall expansion amounts to 33% of production, with additional greenhouse infrastructure already in progress at the time of the interview. Respondent 3 was in the process of acquiring a factory and, with this logistical

efficiency, was able to benefit from a broader customer base optimised to ensure sufficient food availability and to be able to deliver a product in any quantity.

Respondent 4 has achieved a lot in three years, produces several fruits and leafy vegetable products and is the only one to grow fruit trees using aquaponics. The company also has other businesses related to its aquaponics operation, such as training in aquaculture, sale of worm farms and organic compost and corporate marketing.

Research question 3: What types of products are grown in the aquaponic businesses?

Various food types were presented, showing what each respondent grew and what they specialised in. For example, respondent 2 aspires to be recognised as the tomato people from that area. Turnips are used as a cash crop to cover the essentials like wages and electricity. Respondent 5 specialised in the different types of (mix) lettuce as a primary source of income. Respondents 1 and 4 specialise in a broader choice of products. Respondent 1 classifies baby spinach as one of the main crops for the past three years. Respondent 4 presented multiple leafy green products, including watercress and of note, is the only respondent to grow fruit trees in an aquaponics system.

To enhance the prospects of other fresh produce, Respondent 5 recommended the wicking bed method, in which rooting crops like potatoes and carrots are cultivated; built parallel to an aquaponics structure in which aquaponics water feeds that wicking bed with a minimum of 10% water assuage. The multiple products available mean that most of what a household needs to subsist can be produced in an aquaponics system that can alleviate food insecurity.

Fish is cultivated by aquaponic growers, more as a fertiliser, but can also be retailed. Edible fish like tilapia and bream can be enjoyed with leafy green products for added proteins and a balanced diet.

Leafy green products are familiar to aquaponic and hydroponic growers and even fit the hydroponic growing system. Respondent 3 verifies that leafy greens like spinach are the most important among their clientele; they also used to barter especially involving the poor.

Research question 4: How can an aquaponics business assist in mitigating unemployment in the Western Cape region?

Respondents were asked the question: "Describe the possibilities if any of increasing employment in your agribusiness. "Employing additional staff regularly in an urban agrarian setting is not customary. Love et al. (2015:70) show a common international trend of a minimum of permanent and temporary employees per site at various commercial aquaponic

set-ups. The status quo of aquaponic and hydroponic respondents also indicates a deficient employment status, except for respondent 1. Most respondents have different views on hiring additional staff. Some respondents felt that this is unnecessary as day-to-day operations do not require it to have the same number of employees daily.

Finances presented a significant constraint affecting the business's growth potential and employment status. However, employment can fluctuate depending on the seasons. The employment status of the majority of respondents was minimal, which affirms the common global trend (Love et al., 2015:70). However, Respondent 1 disputes the norm of recording more than 20 permanent employees, contrary to 1-2 of the other Respondents. This is developed in a small plot of 3.5 hectares. The operation functions day and night, seven days a week, all year round (365 days), so seasonal work is not a problem.

Ideally, the study represents the type of commercial capacity favouring the current situation, active in a small footprint counting a few hectares. Best practices and lessons learnt are vital objectives to engage the same strategy and apply the wicking bed method and growing fruit trees for further scaling to grow to a potential capacity of 10, 20 or 50 hectares. As a result, to foresee hundreds of new specialised employment. Subsequently, training carries significance in developing a skilled staff complement to enhance sustainability. Hence, the study alludes to the imminent business training opportunities through the YES business training initiative, including aquaponics.

Research question 5: How can an aquaponics and hydroponics business assist in mitigating the risk of food insecurity in the Western Cape region?

To assist in answering the above research question, a question was asked: "Describe, in the order of importance, the aquaponics products that you think can help alleviate food insecurity?" Most respondents highlighted the green vegetables that grow fast, and respondents 1, 4 & 5 highlighted fish.

People will be able to enjoy a balanced diet through the various leafy green products on offer and the fish and rooting crops (carrots and potatoes). Staple food can be enhanced with food rich in minerals, vitamins and protein (fish). Various fruits are also presented amongst the products on offer. These are considered nice to have things, like baby leaf spinach and chard, supplemented with a good portion of fish (protein) and various fruits to ensure a healthy nutritional meal. Respondent 2 suggests pairing healthy leafy greens like lettuce and tomatoes, but especially tomatoes, which could add value as a substitute for meat depending on the dish. Respondent 3 pointed out products such as spinach and kale, which are referred to as superfoods and suitable for retail or bartering. Strawberries are also in the

mix as an opportunity forward for individuals in the community as a possible source of income.

Respondent 5, other than fish with various leafy vegetable products like tomatoes, lettuces, kale and spinach, introduced the wicking bed in which rooting crops such as carrots and beetroots are cultivated. This structure is erected parallel to an aquaponics build, which only needs 10% water. Hence, most household diets can be farmed aquaponically.

Respondent 4 brings a fruity touch to various fruit trees, kiwis and guavas, providing an all-inclusive nutrient intake to combat food insecurity disorders and financial gain. Aquaponics holds a higher nutritional value other than traditional agrarian methods. Nutrient-rich water benefits the plants to grow and look presentable for consumption and retailing. Nutritive food (production); is the primary resource produced to ensure all citizens have access to safe and nutritious food to meet their nutritional and food preferences for an active and healthy lifestyle (Zuinga et al., 2019:189).

5.3 Conclusion

According to Milicic et al. (2017:2), aquaponics is believed to have future potential as a sustainable integrated food production method. However, its development is still in its infancy, and just a few businesses are economically viable as a stand-alone minimum production size, especially in the Western Cape Province (Mchunu et al., 2018:16). Therefore, this study focused on awareness of how aquaponics can be made a common practice in society with its different scales of operation; backyard, semi-commercial and commercial start-ups.

The study showcases various business strategies to reach its goals. Therefore, it provides an overview of aquaponics and presents the different commercial techniques compatible with the corresponding products to achieve maximum performance. The output is spread over the diverse fields of operation with different perspectives and desired outcomes, considering additional income streams practised by some. Currently, there is no real competition in the urban agricultural field. Volume-wise there is still much potential for existing products in demand to supply the market with plenty.

Formal training (where somebody has to pass an exam) is presented as an imperative before commencing an aquaponics system or business start-up. However, the study results indicate successful business opportunities without a prior agricultural background in both business types. One business entity reflects the desired response, ample 'food and employment' results without previous agrarian experience.

The study raised awareness of urban farming and aquaponics to attract governments, policyholders and investors to fund future urban Agripreneurs. Therefore, the YES business training program, along with further research, could be the appropriate means by which aquaponics can be promoted to gain the confidence of governments, policyholders, investors and future urban farming Agripreneurs to popularise aquaponics as a standard practice outside the confines of infancy (Mchunu et al., 2018:2).

5.3.1 Food sovereignty

For this reason, given the size of the relevant food production footprint, it is then possible to concentrate on the necessary quantities demanded by the market locally and across borders through grower's contracts with expanded (widespread) capacities to meet the required quotas. These comprise the bigger retail groups, national retailer groups (ZZ2), restaurants, guest houses and conference centre's wholesale trade. Therefore, the demand for additional food supplies triggers the need for more significant amounts of food.

Increased food quantities are fundamental and complement the open field production to support the U.N. 2030 Sustainable Development Goals, aiming to end hunger and ensure access to safe, nutritious food all year round (Pollard & Booth, 2019:2).

Therefore, a production footprint with adequate capacity to productively grow large quantities (kilograms) of nutrient-dense food on a small footprint is sought to achieve as much as possible with as little as possible.

5.3.3 Employment capacity

The study identified a clear distinction between Respondent 1 and all the other Respondents. Two things are observed; a small space is efficiently optimised, and high volumes of food are produced in a highly productive environment. Due to the sheer volume of production, more employees are needed to keep up with supply and demand, while at the same time; more employees are hired as production space grows. There are various ways among respondents to make a profit in an urban farming environment. These comprise a diversified approach such as aquaculture training, worm farm sales, wicking bed method of food production, growing food trees the aquaponics way, corporate engagements, coffee shops and nurseries, etc. It is not what you want to grow, but what sells or the customer demands. A large clientele also impacts large orders, so production, staff and land increase to ensure the balance between an adequate food supply and the right staff to manage a highly productive environment.

The study provided substantial evidence to consider aquaponics viable as a business and provide nutritive food resources to combat food insecurity and tender economic strength.

5.4 Recommendations

The following recommendations are presented based on the results of the study.

Research and development: Thorough and intensive research and development work are essential. Precisely knowing what the market wants, then growing exactly what the market demands. This requires intensive technology to quickly and accurately switch between products whenever the market demands it.

Supply and demand are crucial with the fundamental impact of the various growers' contracts. It is important to build good business relationships. The market should be able to trust the supplier. Once the market trusts a reliable grower, demand will gradually increase, leading to business growth. Respondents 1 & 2 showed 300% and 33% growth potential respectively. Respondent 1; *"In 2020, the year of Covid, we would have grown our production footprint by 300%..."* and respondent 2 indicated; *"We have increased the land that we have, so I think our capacity has grown by 33% steadily over the past period."*

Market knowledge: A farmer can do indoor farming business without interruption in all seasons with an aquaponic system. With proper planning, leafy greens, herbs and vegetables can be harvested weekly based on what produce grows best at what time of year. This can be ascertained in advance through intensive research and development. Customer demand plays a vital role, so it is also essential to mix and match to see what works and what does not.

It is essential to employ a suitable system technique to grow the market-related products. For instance, the NFT-system (technique) could be the pipes with the running water or deep water culture and flush and drain system. The growing medium also plays a pivotal role in supporting all new seedlings. Therefore, it is vital to understand what system technique is more suitable (a flat or vertical system) and what benefits the specific system has and ensure adequate space is available to rear the system.

Every system is unique to every business requirement. Hence, it is vital to utilise the most appropriate system technique within its affordable budget quotient, eloquently briefed in context to correspondent 3. Aquaponic systems can be pretty expensive, especially considering plant to cost ratio. This indicates how many plants the system can grow, how much it costs, and whether it makes "business sense".

Buyer's contracts: Of note, aquaponic growers can fill the seasonal gaps with fresh produce as buyers (retail group) would most likely keep them. The conventional grower is subject to the season, while seasonal influences do not restrict the urban grower. In this way, the grower has the advantage of capturing a more significant share of the market at premium rates, as displayed by Respondent 1; *"The quicker you can adapt, the more efficient you can adapt to it, the bigger the market share you can capture while the other guys are still trying to figure out what is going on."*

Negotiation Fundamentals: Effective negotiation skills are fundamental to realise the desired premium price for any retail product (Mburu, 2021:007-008). Respondent 1; *"So we could negotiate some grower's contracts with one of the retailers."* Respondent 2 adds; *I think in terms of negotiations with different types of people, even big corporations or you know your walker, anyone who needs to come into my business space. How you would approach them, either for them to market your product or to buy your product. So, I think that becomes a significant skill,"*

Negotiations could be linked to sustainable crops by marrying the right price with the relevant market to maintain sufficient reserves for the next season, thus activating a successful planting process as indicated, Respondent 2; *"that is to plant the full capacity that you can. Try to mitigate your price in the market in terms of that; what I mean is, when I am getting a bad price here, go and look for a better opportunity somewhere else or market it in a different way to get a higher value so that you can try to stay as close to your sustainable plan as possible, meaning that I have to be able to plant my next season. If I can plant my next season, that sort of somehow guarantees my cash flow,"* hence, ensuring food and job security.

Government support: plays a vital role in its direct impact on growing the economy. Respondent 5 illustrates the government's support with its initiative to train young people in various scopes of career paths, including aquaponics. The opportunity ensures that young people have the entrepreneurial skills to run an urban agrarian setup effectively. Respondent 1 mentioned that government support could allow urban farmers to obtain larger urban farm spaces of 10, 20 and 50 acres. This will significantly increase production capacity to combat food insecurity and create more job opportunities. However, aquaponics and hydroponics involve agro-tech methods to produce as much as possible with as little as possible, as highlighted below.

Best practices and lessons learnt: The study's main objective was to see if aquaponics can assist in mitigating food insecurity and unemployment in the Western Cape Province of

South Africa. The study discovered an agribusiness scenario with the capacity to grow many food resources with numerous job creation opportunities, conducted in a food production area of 3.5 hectares to employ more than twenty people. The method used to know how to deal with big buyers and how to optimise the opportunity to increase production and production footprint comes from an international business design. Through intensive research and development over some time, you can precisely know each plant's potential through multiple production changeovers to grow it in the shortest possible time to promptly serve the market. This takes place all year round, in and out of season. This means the typical idle period in conventional farming systems that causes food insecurity, such as malnutrition and hunger, is combatted through such a system. Therefore, best practices and lessons learnt are highly encouraged to increase food production output and job creation for all future Agripreneurs with more or less the same outcome.

Increasing crop base: Respondent 2 stated that the right Agri-technology, such as hydroponics, could provide access to creating an economy of scale on a small piece of land through vertical cultivation, such as tomatoes, as mentioned above. Respondent 3 also uses small backyard-scale vertical farming with pots that do not require electricity. Therefore, many households can benefit from growing food for family subsistence and retailing the food or using it as a barter system in poor communities. A wicking bed method is suggested to ensure that root crops such as potatoes, carrots and beets are added to provide additional nutritious food, as indicated by Respondent 5. Respondent 1 uses an international commercial aquaponics design. It warrants the capacity to handle substantial supply and demand to serve the market, regardless of the size of the demand, in high volumes, relentlessly. The study strongly suggests that in addition to growing fruit and leafy vegetables, aquaponic cultivation of fruit trees should also be considered an additional resource to improve food security.

Training: Training is seen by Respondent 1 as an initial foundation for ensuring effective business start-up and competent job skills in an urban agricultural business structure. This is recommended for all levels of the business, from investors to management and employees. Its importance has reached the government level, where it has been introduced as a subject in schools and is also part of the curriculum at university level, particularly at Stellenbosch University, as indicated by respondents 4 and 5. In addition, the government has launched a business training initiative called YES that teaches young Agripreneurs how to run an aquaponics or hydroponics business in 12 months to help build the economy.

5.5 Recommendations for Further Research

Below are the recommendations for future research:

Due to certain constraints of restricted in-face interviews, the physical settings were not visited. Once the current pandemic has subsided, a follow-up assignation is therefore recommended. This will help provide more detailed information on the primary benefits to be gained in terms of output growth and job creation at a sufficient level.

Of note, all of the other businesses had a track record of growing fresh leafy produce, fruit trees and the wicking bed application attached to aquaponic tunnel structures to grow additional root vegetables. Further research is needed to grow more fruits and vegetables in aquaponics.

The training business initiative currently being carried out by the government is also an avenue to be explored scientifically. This could enhance a smoother transition for the future training hubs. Hopefully, this could be the platform for the culmination of effective urban farming business awareness.

The hydroponic farming system also seeks to add value through the various projects to reach people in rural areas to grow additional food with subsistence capacity, either for sale or barter (exchange goods or services for other goods or services without the use of money). Respondent 3; *"we are going in the impoverished areas... we are going to a bartering system. We thought that the people would sell the produce that they grow, but they barter with it. They swap it for something else. I give you a bunch of spinach, and you look after my kids for tonight."* Aquaponics research can be extended to non-urban areas.

5.6 Limitations

This study had the following limitations:

- First, access to aquaponics businesses was difficult.
- Some critical questions for the interview should have been researched more closely, particularly training from a business perspective, which designates investor training, manager and system installer training, and the different time frames associated with each training activity, too little detail.
- Funding has been one of the major constraints to helping to structure the layout of certain sections in research academically to point and standard. The researcher funded his study.
- The industry was very new to the researcher.

5.7 Contribution of the Study

The study has contributed to the body of knowledge in the field. A contribution has been made to promoting aquaponic businesses and their potential to reduce food insecurity and unemployment. A contribution to job creation and reducing food insecurity was also made to policy makers in the Western Cape Province of South Africa.

The study also responded to the local government's urban food policy by introducing additional technology to current urban open field practice to enhance food production for communities applying the aquaponics method (Urban Agricultural Policy, 2007:9-11). The government is already involved through training, the YES program and two agribusinesses already operating through financial support. Since aquaponics is already being introduced in school platforms, this study can help with empirical evidence if accepted and used. All these together with the current leading research framework from this study is available and the carbon business model process to 'set' sustainable start-ups. Hydroponics technology is being encouraged, which also shows the potential to assist with additional urban food resources.

The study recognised aquaponics as a year-round agricultural food production option that can combat standard seasonal food production practices. This has triggered potential best practices and lessons to ensure future urban agribusinesses enjoy the same benefits of sustainable agriculture, thus ensuring sufficient additional food production. The study also identified an opportunity to increase job creation.

5.8 Chapter Summary

This study aimed to investigate whether aquaponics businesses can help alleviate food insecurity and unemployment in the Western Cape Province of South Africa. The study concludes by pointing out, based on the findings, that when aquaponic activities are assisted in growing, they can help reduce unemployment and food insecurity. Findings from Chapter 4 argue that increasing aquaponic production can help increase food security and employment. This information was obtained through a qualitative study conducted in the Western Cape region of South Africa. This chapter concludes the study. It has provided a summary of the study, conclusion and recommendations based on the study results. The chapter has also indicated avenues for future research.

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APPENDICES

APPENDIX A: CPUT ETHICAL CLEARANCE



P.O. Box 1906 • Bellville 7535 South Africa • Tel: +27 21 4603291 • Email: fbmsethics@cput.ac.za
Symphony Road Bellville 7535


Office of the Chairperson Research Ethics Committee	Faculty: BUSINESS AND MANAGEMENT SCIENCES
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The Faculty's Research Ethics Committee (FREC) on **12 September 2019**, ethics **Approval** was granted to **Colin Jonathan (202141594)** for research activities of **M Tech: Business Administration** at Cape Peninsula University of Technology.

Title of dissertation/thesis/project:	PROPOSITION OF A SUSTAINABLE SOLUTION TO FOOD INSECURITY AND UNEMPLOYMENT: CASE OF AQUAPONICS IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA Lead Supervisor (s): Dr D. Dubihlela
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Comments:

Decision: **Approved**

 Signed: Chairperson: Research Ethics Committee	30 September 2019 Date
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Clearance Certificate No | 2019FOBREC711

APPENDIX B: INTERVIEW GUIDE



INTERVIEW GUIDE 2020

Dear Participant

I would like to invite you to participate in an academic research that I am carrying out. The project research is entitled “**Aquaponics as an urban business initiative to alleviate food insecurity and unemployment in the Western Cape Province of South Africa**”. The research is part of my Master’s Degree at Cape Peninsula University of Technology, Cape Town, South Africa. The results of the study will be used for academic purposes and may be published in an academic journal. Your decision to participate is purely voluntary and your anonymity will be upheld in the survey. While your participation is critical for the study, should you wish to withdraw at any point during the study, you may freely do so. It is also your right to ask any questions and request any explanations.

Thank you

SECTION A. BACKGROUND INFORMATION

Please cross the applicable boxes

1. What is your position at the business?

CEO	Finance Manager	Production Manager	Marketing Manager	Field worker	Other (specify)
-----	-----------------	--------------------	-------------------	--------------	-----------------

2. Gender of the owner

Male	Female
------	--------

3. Type of Business

Aquaponics	Hydroponics
------------	-------------

4. How long have you been operating?

0 - 5 years	6 – 10 years	11 – 15 years	16 and more years
-------------	--------------	---------------	-------------------

5. What is your highest educational qualification?

Below matric	Matric only	Matric + technical	Diploma	Degree	Masters	Other (specify)
--------------	-------------	--------------------	---------	--------	---------	-----------------

6. What is your field of expertise?

7. Do you have any agricultural business training?

Yes	No
-----	----

7.1 If yes, describe the training?.....

8. In your opinion, do you require agricultural business training to do this business?

Yes	No
-----	----

9. If yes above, describe the kind of training you think would be required and who do you think should render that training.

SECTION B THE BUSINESS CONCEPT

1. Why did you engage in this type of a business?
2. Which type of products do you grow?
3. Why did you choose to grow those types?
4. Explain an Agri-business concept in the light/view of your business.
5. What business techniques have you learnt from your operation so far?
6. Explain how you intend to increase your food production versus consumer demand.
7. Describe your business growth trend in food production in the past 5 years.
8. Explain the steps you have taken to grow your food production.
9. What business growth strategies, if any are you taking that you think are unique to your line of business?

SECTION C EMPLOYMENT CREATION

1. How many employees do you have?
2. Describe the different skills that your employees have.

3. According to you, what additional skills, if any do you think your workers should have?
4. Explain your business employment trend for the past 5 year.
 - 4.1. How do you predict your future employment trend in the coming 5 years?
5. What are the obstacles to your business employment growth?
6. How do you think these can be overcome?

SECTION D FOOD SECURITY

1. Describe your output growth in the past 5 years.
2. Describe, in the order of importance, the aquaponics products that you think can help alleviate food insecurity?
3. How do you suggest the production of these output can be enhanced?
4. Suppose you were given extra support, describe the trend in your expected output growth.
5. What kind of support do you need to increase output?
6. Describe how you think aquaponics growth can help alleviate food insecurity.
7. Do you think your business can help alleviate food insecurity in the Western Cape Province?

THANK YOU FOR PARTICIPATING IN THIS RESEARCH

APPENDIX C: Colour Coding Applied

Colour coding applied

Respondent 1 Feedback section A	Respondent 2 Feedback section A	Respondent 3 Feedback section A	Respondent 4 Feedback section A	Respondent 5 Feedback section A
Respondent 1 Feedback section B	Respondent 2 Feedback section B	Respondent 3 Feedback section B	Respondent 4 Feedback section B	Respondent 5 Feedback section B
Respondent 1 Feedback section C	Respondent 2 Feedback section C	Respondent 3 Feedback section C	Respondent 4 Feedback section C	Respondent 5 Feedback section C
Respondent 1 Feedback section D	Respondent 2 Feedback section D	Respondent 3 Feedback section D	Respondent 4 Feedback section D	Respondent 5 Feedback section D

APPENDIX D: BREAKDOWN OF CODES

CONTRIBUTORS 1 – 5

SECTION 1

1. CONTRIBUTOR 1

Business type: Aquaponics

Position: **Owner**

Period: **11 years**

Gender: **Male**

Training: **Informal training**

Competencies: **Technical background,**

Business Strengths: **Complex business solvent problem-solving skills
research & development (R&D)
An experimental set up
20 years' product development
Business opportunity commercial farming
Cost effective best practice; lessons learnt
Backyard or hobby size system**

2. CONTRIBUTOR 2

Business Type: Hydroponics

Position: **Founder; Managing director**

Period: **6 years**

Gender: **Male**

Training: **Informal training**

Competencies: **Sports science background**

Business Strengths: **Interest in people improvising learn new skill
Access to capital small scale farmer**

3. CONTRIBUTOR 3

Business Type: Hydroponics

Position: **Founder; CEO**

Period: 4 years
2 years in Aquaponics 2 years in hydroponics
Gender: Male
Training: No training
Competencies: Technical background
Business Strengths: Develop sustainable growing systems

4. CONTRIBUTOR 4

Business type: Aquaponics

Position: Owner
Period: 3 years
Gender: Female
Training: formal training
Competencies: corporate background retail industry
Business strengths: mix streams of income nutrient values

5. CONTRIBUTOR 5

Business type: Aquaponics

Position: Equal Partners (wife)
Gender: Male
Period: Company 7 years aquaponics 4 years
Training: informal training
Competencies: technical background
Business strengths: Mix streams of income Skills Development
Entrepreneurial Passion
Business scope: initial setup input is substantial

when you go into aquaponics you won't get rich, 100% sure. Not just aquaponics but if you have aquaponics linked to other businesses, then yes, then you can make money

Aquaponics advantages:

Aquaponics: the next big thing

SECTION 2

1. CONTRIBUTOR 1 –

Business Type: Aquaponics

Business concept:

Small footprint; to use productively

Intensive production systems; interaction between the different components, cross subsidization of input cost the real competitive advantage of aquaponics

6 years intensive R&D. I travel the world to see other systems, a design. I based most of my design and execution around what the guys applied there.

I'm growing what the market demand; customer demand. Grower's contracts with some of the bigger retailer groups, national retailer groups and also grow some excess products to put into the restaurants and guest house and conference centers wholesale trade

Environmental impact: Taken a knock with Covid; 15% of my turnover.

Alternative solution: Crop change

4 Phases of Growth

First phase of development: Background not being in agriculture. Growing trials with different crops to see what grow: # 1, productively and # 2, cost competitively, compare to direct competitors grow(ing) outside in the sun.

Do (did) trials on hundreds of different crops, grew them through multiple seasons. Multiyear, multicycle and multi-season to see what can grow cost competitively (cost competitive cost points) at what point of the year.

Also to see what can grow well (and) find traction in the market place. It was a wide approach (R&D) to see what we could do; to what we could do more narrowly cost effectively; to what we could do more narrowly (niche) to what the market could demanding

- Red reflects add on to make it easier to read.
- Brownish color reflects more than one contributor mention the same information or structured under the same section of interview guide
- White gaps in between indicate the various sentences fused in the initial stage of coding.

APPENDIX E: GRAMMARIAN'S LETTER

22 Krag Street
Napier
7270
Overberg
Western Cape

29 December 2021

TECHNICAL EDITING

Cheryl M. Thomson

**AQUAPONICS AS AN URBAN BUSINESS INITIATIVE TO ALLEVIATE FOOD
INSECURITY AND UNEMPLOYMENT IN THE WESTERN CAPE PROVINCE OF SOUTH
AFRICA**

Supervisor: Dr D. Dubihlela

This is to confirm that I, Cheryl Thomson, executed TECHNICAL and REFERENCE LIST ONLY editing of the above-titled Master's dissertation of COLIN JONATHAN, student number 202141594, at the CAPE PENINSULA UNIVERSITY OF TECHNOLOGY in preparation for submission of this dissertation for assessment.

Yours faithfully

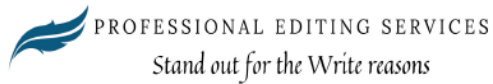


CHERYL M. THOMSON

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APPENDIX F: EDITOR'S LETTER



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Certificate of Editing

This serves to confirm that copy-editing and proofreading services were rendered to
for a master's thesis entitled

**AQUAPONICS AS AN URBAN BUSINESS INITIATIVE TO ALLEVIATE FOOD INSECURITY AND
UNEMPLOYMENT IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA**

By Colin Jonathan

with final word count of 35 730 on 19 May 2021

*I am a member of the Professional Editors' Guild (member number DUP015) and commit to the following codes of practice
(among others):*

- *I have completed the work independently and did not sub-contract it out*
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- *proofreading for mechanical errors such as spelling, punctuation, grammar*
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I confirm that I have met the above standards of editing and professional ethical practice. The content of the work edited remains
that of the student.

Gerald T du Preez, PhD

Membership: Southern African Freelancers' Association and Professional Editors' Guild (Membership #DUP015)

APPENDIX G: EDITOR'S LETTER

COLIN JONATHAN MTech Business Admin

ORIGINALITY REPORT

%**9**

SIMILARITY INDEX

%**3**

INTERNET SOURCES

%**0**

PUBLICATIONS

%**2**

STUDENT PAPERS

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