INVESTIGATING THE POTENTIAL USE OF EXISTING BUILDINGS FOR VERTICAL FARMING

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ABSTRACT

There are numerous reasons for the implementation of Vertical Farming (VF). Some of these include the reducing quality of natural land, the less water consumed in the production process, the ability to control and monitor the growing environment and the plant's nutrients.

This research aims to investigate whether or not existing buildings can be used to accommodate urban vertical farms. The objectives were focused on reviewing existing legislation, building design considerations, the possible usage of VF as a solution to urban decay, reviewing the global VF trends, and considering why real estate developers will not be interested in VF buildings.

A qualitative approach was followed to create more referable knowledge in the VF field as, currently, there is not an abundance of academic sources available. Semi-structured interviews were held with five key stakeholders. The study was restricted to brick and mortar buildings, while little attention was paid to plant production. The study was limited to the Cape Town Metropole. This study only considered commercial-scale food production. The researcher was not interested in the performance of the individual buildings but is rather interested in the built environment as a whole.

The findings suggest that, currently, it is only financially feasible to grow specialised products under controlled environments. Acknowledging that, possibly opens opportunities for new products to be explored and grown indoors.

The practical implications of this research translate to legislation that needs to be updated and technological developments that are required to make the implementation of vertical farming affordable for everyday food production. In the meantime, more specialised crops are expected to be grown under vertical farming conditions.

Future research can build on this study and should consider investigating the price correlation between the cost of land within cities where existing, vertical production areas can be found and the price of land in rural areas, where traditional farmland is located. The additional vertical production area gained in vertical farms should form part of the cost comparison between traditional farming land and VFs.

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LIST OF ACRONYMS

HVAC	Heating, Ventilation, and Air Conditioning
NDP	National Development Plan
RDP	Reconstruction and Development Programme
RSA	Republic of South Africa
SDGs	Sustainable Development Goal(s)
VF	Vertical Farm / Vertical Farming

DEFINITION OF KEY TERMS

Development - Includes any "physical intervention, excavation or action" such as the "construction, alteration, demolition or removal" of building structures and can also include land ordinance changes to promote (re)development of sites (Heritage Act No. 25 of 1999, 1999:(2)(viii)).

Energy Management System - Systems that control the energy demand by using integrated fans, HVAC systems, thermostats, light sensors, computers, and elevators which interact and monitor the effective management of energy usage within a building (Hersh, 2018:40).

Gentrification - Middle-class developers and homeowners who rehabilitate working-class neighbourhoods in urban cities cause capital reinvestment and sometimes replace the original inhabitants with more affluent communities (Chang, 2014:525).

Hydroponics - Hydroponics is a means of food production without using soil that instead uses nutrient-rich water to feed the suspended plant roots (Hersh, 2018:119).

Indoor Farming - Sometimes used interchangeably with the term VF, indoor farming in this research refers to cultivation in an enclosed building structure and incorporates technologies that result in higher yields indoors than achieved with conventional agriculture (Wittmann, Jüttner & Mempel, 2020).

Quantitative Research Method - A flexible research method that investigates research problems in depth and follows a combination of documentary data and interviews as a data collection method (Hammersley, 2013:12).

Sustainable Development Goals - A global 2030 agenda where countries work together to achieve 17 goals, measured through 169 targets that address multiple and complex problems to ensure human well-being, economic welfare, and environmental protection (Pradhan et al., 2017:1169).

Synergy - A pair of SDG indicators with a significantly positive correlation between each other, meaning that the different parameters support one another's goal (Pradhan et al., 2017).

Trade-off - A pair of SDG indicators with a significantly negative correlation between them, implying that the goal of one parameter will restrict the success of the other indicator's purpose (Pradhan et al., 2017).

Urban Farming - Some previous studies, such as Hersh (2018), investigated Urban Farming in terms of where and how food can be grown, focusing on incorporating food production in urban areas.

Vertical Farming - Focuses on perusing interior spaces of skyscrapers and high-rise buildings while incorporating greenhouse cultivation techniques to enable the growing of food produced indoors, with specific beneficiaries being urban environments Hersh (2018).

CHAPTER 1 - INTRODUCTION

1.1. FOREWORD

There is little value in researching something which previous researchers have already clarified. It is already known from the preliminary literature review that urban farming can shorten the food supply chain while reducing seasonality in produces and providing other sustainability benefits from both a food production and ecological perspective. This research will contribute to the already existing body of knowledge by investigating the possibility of combining urban regeneration with vertical farming. This research integrates Sustainable Development Goals (SDGs), Vertical Farming (VF), and Urban Regeneration to provide a response to all spheres of the economy: For the agricultural sector, a controlled weather environment; for the environmentalists, less environmental damage by employing a green solution; for economists economic stability, food security, and employment opportunities; for politicians an alternative to land reformation while meeting SDGs and to society an affordable and healthy food security solution.

1.2. INTRODUCTION

Amaratunga et al. (2002) describe research as a process of inquiry and investigation that follows a systematic and methodical approach to increase knowledge. There is not much-known literature available in a South African context when applying this principle to the VF concept. It is further speculated that decaying buildings in urban areas have the potential to accommodate VFs. Leatherdale (2019) states that specific research fields lack the relevant info for the decisions that need to be made. While the global agenda is focused on SDGs, there is no better time than now to investigate whether genuine opportunities exist within the incorporation of VF. The combination of VF with SDGs seems to be a logical solution as it promotes SDGs' achievement while regenerating certain parts of cities.

1.3. BACKGROUND TO THE PROBLEM

1.3.1. SDGs

Some 193 countries committed to achieving global sustainable development over 15 years from 2015 to 2030 (Stats SA, 2019:1). The sub-goals (known as indicators) will be reviewed in the comprehensive literature review. For now it is noteworthy that the 17 SDGs which are summarised by U.N. (2020) to include the following: (1) End poverty in all its forms everywhere; (2) End world hunger, achieve food security and improve nutrition while promoting sustainable agriculture; (3) Ensure healthy lives and promote well-being for all ages; (4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all; (5) Achieve gender equality and

empower all women and girls; (6) Ensure availability and sustainable management of water and sanitation for all; (7) Ensure access to affordable, reliable, sustainable and modern energy for all; (8) Promote sustained and inclusive economic growth, while providing full and productive employment and decent work opportunities; (9) Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation; (10) Reduce inequality within and among countries; (11) Make cities and human settlements inclusive, safe, resilient and sustainable; (12) Ensure sustainable consumption and production patterns; (13) Take urgent action to combat climate change and its impacts; (14) Conserve and sustainable use of the oceans, seas and marine resources for sustainable development; (15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss; (16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels and (17) Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.

Countries are sometimes challenged to successfully achieve their SDG objectives as governments need to take a long-term outlook that prolongs past short-term political cycles (OECD, 2019:18). This is while countries such as Finland, Germany, and Japan, perceived to be more stable, appear to be making more remarkable progress with SDGs (Pradhan et al., 2017). In addition, they also happen to be the countries making more significant progress with the implementation of urban farming.

According to (Stats SA, 2019:31), the five strongest enabling connections between other SDGs includes the following: (1) An improvement in the GDP will result in a domino effect in meeting other SDGs; (2) An improved energy efficiency rate proved to be the second strongest enabling variable; (3) The sufficient availability of nutritious food and sustained access to it plays an important role; (4) The empowering of women can assist in achieving sustainable development and (5) Population growth, urbanisation, mining activities, alien invading plant species, and poor agricultural practices are inter alia some of the factors placing stress on the water provision system. All of these factors can be positively influenced by the introduction of VF practices.

1.3.2. Vertical Farming

Critics of VF practices do not always realise that the outside open air is often of poorer quality than the inside air in high-performing buildings (Hersh, 2018). Yet these same critics might realise that a decline in agricultural production results in increased unemployment rates (Mdungela, Bahta & Jordaan, 2017). This is probably why there is an international focus on retaining the interest of younger generations in the agricultural sector, as it is these persons who drive “innovation, energy

and creativity in developing new, environmentally responsible and highly productive farming practices" (White, 2015:331). Urban farming is driving innovation beyond the agricultural division and can redevelop global food supply systems while comprised of the following research fields: Architecture; Crop Science; Energy Technologies; Data Analytics, and Urban Planning (Gobble & Headrick, 2019:7). These fields are closely related to some of the fields that contribute to the complexity of urban redevelopment and include knowledge from real estate economics, land usages, community benefits, ecology, transportation, sustainability, place-making design, politics, and other related disciplines (Hersh, 2018:19).

Food production in a controlled indoor environment within proximity to urbanised areas without using soil or sunlight while using minimal water can be some of the main drivers of the next-generation agricultural revolution (Gobble & Headrick, 2019). This comes as vegetables produced in VF require much less space, as little as 5 per cent of the space traditional farming uses, while only using 8 per cent of the water (Benke & Tomkins, 2017:17). Further advantages include a shortened supply chain, reduced nutrient losses, lower transport costs, and reduced CO2 emissions together with fewer time lags between harvesting and consumer delivery (Pinstrup-Andersen, 2018:234). All of this is achieved with the reduced use of fertilisers, herbicides, and pesticides in an isolative building structure, which protects it from nature's natural forces (Benke & Tomkins, 2017).

Regardless of the advantages that technology can offer, the implementation thereof remains a lengthy process (Danquah, Ouattara & Quartey, 2018). But then again, "It's about transforming what we already have to get what we actually want" (Hersh, 2018:62). There is a significant change in the way that shopping is conducted today, as a shift towards an online market has caused retail, for example, to accommodate a greater number of eateries and less traditional clothing and franchise/department stores (Hersh, 2018). The investment growth experienced by the indoor farming market suggests a 37% increase over the five years from 2017 ($25.4 billion) to 2022 ($40.25 billion) and concludes an increasing interest therein (Gobble & Headrick, 2019:7). Hersh (2018) believes that using hydroponics becomes especially useful in cities, where many vacant buildings are presented, and unused, fertile, and non-polluted land areas are scarce.

1.3.3. Urban Regeneration

According to Hersh (2018:i), "Cities are acts of man, not nature; every street and building represents decisions made by people". This implies that the cities can be controlled in the planning process already. Even though the population growth and urbanisation rate cannot be regulated, they can be allowed for. The importance of planning became evident when the global population traded rural living for urban living in 2009 - when the majority of the world's population was for the first time

found in urban areas as opposed to the former rural regions (Wiskerke, 2015:1). This figure is projected to increase to 66% of the global population living in cities by 2050 (Wiskerke, 2015:1).

Many researchers have lately shown interest in investigating urban infrastructure construction with technology-driven implementations combined with nature-based innovations (Xiang, Yang & Li, 2020). Research such as this forms part and contributes to the VF research field. Combining agriculture and architecture (known as 'agritecture') to create urban farming redefines city designs (Gobble & Headrick, 2019:8).

Buildings used to grow crops indoors can either be newly constructed structures designed with the intended purpose or take on the form of existing buildings that are transformed to fit the purpose (Simpson, 2019:2). Examples of adaptive usages include turning old factories into office buildings or lofts; modifying banks to become restaurants or former schools to become senior housing (Hersh, 2018). Tablada and Zhao (2016:758) suggest that using building envelopes can solve food shortages and be achieved by viewing buildings as self-sufficient producers (instead of consumers) who generate their own energy, food, and water while reducing greenhouse gas emissions. Xiang, Yang and Li (2020) notes that large-scale demolition and reconstruction activities will not solve urban problems forever. It is not at this stage advocated that VF is the ultimate solution to urban regeneration. Although, Xiang, Yang and Li (2020)'s reasoning supports the remodelling of existing buildings at this stage to be a better alternative than demolition activities.

Munneke and Womack (2015) state that the critical deciding factor between demolishing or renovating a building is determined by the interior area and total erf size. The internal building area advocates a renovation, and the total erf area will support or reject a demolition. The outcome between a refurbishment and demolition is determined by the location, other redevelopment activities, and land-value to the property-value ratio (Munneke & Womack, 2015). It is not only in decaying urban areas that VF becomes useful. For example, in densely populated cities, such as Singapore (the second-most densely populated country in the world), vertical high-rise buildings constitute more space per area than horizontal surfaces such as roofs (Kosorić et al., 2019).

Yiannakou (2020) believes that there is not only one answer to approaching urban regeneration, as different countries have different socio-economic factors at play, governed under different urban policies. Therefore, Yiannakou (2020) states that individual European countries react differently to urban renewal. Urban decay is not only the result of individual buildings decaying but is instead the consequence of an area and its infrastructure decaying (Swanepoel & Smallwood, 2019).

1.4. PROBLEM STATEMENT

Little is known about the potential of urban vertical farms in South Africa. In addition, limited research has been undertaken on the adaptive reuse of existing buildings to accommodate urban vertical farms. The ability to house urban vertical farms in existing buildings has the potential to develop a sustainable food production source, create business opportunities in the process, and aid the attainment of the SDGs.

1.5. RESEARCH QUESTION

Can existing buildings be used to accommodate urban vertical farms?

1.6. PROPOSITION

Vertical farming can create opportunities for developers to remodel existing buildings where fresh foods can be grown under indoor farming practices.

1.7. RESEARCH AIM

This research aims to investigate whether or not existing buildings can be used to accommodate urban vertical farms.

1.8. RESEARCH OBJECTIVES

To answer the research question stated above, the research objectives are to determine:

The legislation provisions that exist for the implementation of VF;

What design considerations are required to make the vertical farms effective;

If VF a possible solution to urban decay;

What the global trends regarding VF are;

If real estate developers will be interested in VF buildings;

1.9. PROPOSED RESEARCH METHODOLOGY

In terms of assessing whether 'good practise' was used in research, Flick (2018) suggests that reviewing the reasons for selecting the research method is a good starting point. Benke and Tomkins (2017) state that a Quantitative or Qualitative investigation of VF can be undertaken by using Key Performance Indicators (KPIs) to assess different metrics such as modelling, analysis, literature review, and expert opinions. Pradhan et al. (2017:1178) state that both qualitative and quantitative research is required to understand the full extent of SDGs.

This research followed a qualitative approach by undertaking online, in-person interviews with relevant persons to obtain the information required. The research methodology employed was as follows:

1. A critical literature review was undertaken, which includes an agricultural background as a reference; while analysing the legal requirements and SDGs related to the study field; not neglecting the importance of reviewing sustainability, urban regeneration, and Technological Developments throughout the study;
2. The data collection process entailed semi-structured interviews with persons from the following backgrounds as their knowledge was considered to be transferable to the study:
    - Engineers: (to ascertain if existing buildings can carry the additional structural loads of plants and equipment as well as to discuss systematic movement in and around VFs);
    - Project management professionals (as they understand the VF implementation process);
    - Persons involved in imports and exports (as they understand the food production cycle, related logistics, and customer's mindset);
    - Persons employed by the City of Cape Town Municipality (to understand how governance authorities feel about the potential of VF and to identify opportunities under current legislation);
    - Other specialists related to the study field;
    - Any referrals made by some of the persons interviewed above;
3. The data gathered was analysed using thematic analysis and *NVivo* software;
4. Finally, conclusions are drawn, and recommendations are made from the data analysed.

1.10. DELIMITATIONS OF THE STUDY

1.10.1. The study was restricted to brick and mortar buildings (not hot-houses, food-producing tunnels, etc.).

1.10.2. There was little attention given to the plant production. The requirements of the plant production are important for determining the general design requirements of the building.

1.10.3. The study was restricted to urban areas within the City of Cape Town as opposed to suburban and other parts of the city / Republic of South Africa.

1.10.4. This study considers commercial-scale food production. Some previous studies, such as those conducted by Kosorić et al. (2019), analysed indoor food production undertaken by households who reside in high-rise residential buildings.

1.10.5. The researcher is not interested in the performance of the individual buildings but is rather interested in the built environment as a whole. For example, Forsberg & von Malmborg (2004) looked at separate buildings quantitatively by giving each criterion being investigated a score.

1.11. LIMITATIONS

1.11.1. Covid-19

The national coronavirus restrictions were adhered to at all times, but it did not impact an online approach of sourcing data. Covid caused a ban on traditional on-campus consultation with one's supervisor and challenged how interviews are conducted, as it induced a change to online communication instead of the former face-to-face relationships. Traditional face-to-face communication is not an option for the data collection in this research.

1.12. DISSERTATION OUTLINE

The thesis document comprises the following chapters:

Chapter 1 – The Introduction chapter - serves as an introduction to the research and can be seen as a summary of the thesis proposal made available to the reader. Herein the researcher provided basic information such as the research's reasoning, the aim and objectives, and some contextual background.

Chapter 2 – The Literature Review chapter - provides in-depth insight into the background of the problem. This is achieved by reviewing how other studies were undertaken and what their findings were.

Chapter 3 – The Research Methodology chapter - is interested in the method that this study followed to obtain data and respond to the research aim and objectives as outlined in Chapter 1. The techniques used by other researchers in Chapter 2 assisted in selecting the appropriate research method for this study. Topics such as ethical clearance and specific persons interviewed are analysed in this chapter.

Chapter 4 – The Data Analysis chapter - reviews and analyses the data collected in this study. The analysis of this data is done according to Chapter 3.

Chapter 5 – The concluding chapter - referred to as 'Conclusion and Recommendations'- summarises the research and the findings and whether any recommendations can result from this research and how these can be implemented if any.

1.13. ASSUMPTIONS

1.13.1. Urban decay is occurring.

1.132. There are vacant buildings.

1.13.3. It is botanically possible to produce food indoors.

1.13.4. There are possible economic opportunities for indoor farming.

1.13.5. Authorities will permit the indoor production of fruits and vegetables.

1.13.6. Consumers will show support for indoor-produced fruits and vegetables.

1.14. IMPORTANCE OF THE STUDY

1.14.1. To possibly identify an alternative to food supply and security solution;

1.14.2. To possibly identify an alternative urban regeneration approach;

1.14.3. To understand the building's requirements to function as a VF;

1.14.4. To investigate current legislation surrounding land usages and the permitting of vertical indoor farming;

1.14.5. To create an understanding of how SDGs and urban farming correlate with one another.

CHAPTER 2 - LITERATURE REVIEW

2.1. FOREWORD

The extensiveness of the literature review is owed to the complexity of the study. Due to the study encompassing such a vast array of fields, the reader needs to be well informed to understand the research method followed and the findings of the study. Urban agriculture is synonymous with vertical farming and food security in the 21st century. As time is running out for global governments to reach their communal SDGs, VF can become a crucial driver in the process, with less than ten years remaining to achieve these goals.

Many educational institutions are actively investigating the opportunities offered by urban farming. Gobble and Headrick (2019) bring to our attention the partnerships between various universities to establish a new agriculture research centre that can investigate how smart cities can be made more sustainable while producing food innovatively. Due to the nature and potential of indoor farming projects, Benke and Tomkins (2017) expect much future attention in the field from the government, the industry itself, and tertiary education institutions.

Indoor food production can be undertaken in or near urban areas while eliminating problems such as seasonality, using a controlled indoor environment that requires small footprints and delivers high yields (Pinstrup-Andersen, 2018). Linked to the advantage of controlling seasonality in the food supply, VF allows producers to forecast market conditions and produce output based on the anticipated volatility and perceived market timing (Benke & Tomkins, 2017).

This research aims to contribute to the already existing research in the field under the leadership of the University of Cape Town while advocating how South Africa can implement such technologies. There is a lack of academic literature that evaluates the effect that technology's absorptive capacity has on productive efficiency (Danquah, Ouattara & Quartey, 2018).

2.2. INTRODUCTION TO SUSTAINABILITY

Even though the rest of the world mainly started gaining interest in sustainable development with the introduction of the 2030 SDGs, the Republic of South Africa has already commenced the process with its 'Reconstruction and Development Programme' (RDP), which was launched in 1994 (Stats SA, 2019). This was when a Post-Apartheid government administration took over. It is important to note that some SDGs have trade-off relationships (Pradhan et al., 2017), meaning that although one parameter will benefit from an improvement, another parameter will be negatively impacted by the same progress.

The National Development Plan (NDP), which followed the RDP a few years later, further expanded the programme and focused on nine areas of improvement (Stats SA, 2019): Creating employment; Infrastructure expansion; Reduced pollution and transitioning to a low-carbon economy; Transforming of urban and rural communities; Improving education and training; Ensuring quality healthcare; Building a capable state; Encouraging accountability; fighting corruption and reinforcing social cohesion.

With reference to the above government programmes, the researcher conveys that the South African government has continuously been attempting to drive sustainable development even before it became a global agenda. For the first time in many decades, city growth has outperformed suburban growth (Hersh, 2018). Africa's growing young population can result in uncontrollable urbanisation that will compel the fresh and clean water systems and place individuals' food security at risk (Ramutsindela & Mickler, 2019). At the same time, inequalities in cities could escalate due to people trying to escape their realities (Ramutsindela & Mickler, 2019). The water issue is further challenged by South Africa being a drought-stricken country comprised of different types of farming (Mdungela, Bahta & Jordaan, 2017).

The importance of economic activities is seen in some of the functions that economic development serves. For example, economic growth creates jobs while residents' income increases, and entrepreneurship is motivated by business start-ups (Hersh, 2018). At the same time, economic activities increase the tax base while people's quality of life is improved; stability and opportunities for the middle-class societal group are created, and poverty is reduced, according to Hersh (2018). A decline in agricultural production increases unemployment rates (Mdungela, Bahta & Jordaan, 2017), while the built environment explains the social and economic activities that influence sustainable development (Forsberg & von Malmborg, 2004).

2.3. THE FARMING ARENA UNDER CURRENT CIRCUMSTANCES

According to Stats SA (2019), the South African Government's support for sustainable farming practices is seen in the following National policies: the Agricultural Policy Action Plan (2015–2019), the Integrated Growth and Development Plan (2012), and the Strategic Plan for the Department of Agriculture Forestry and Fisheries (2015–2020).

Some factors that threaten community farming include access to resources, unemployment, price sensitivity of products, credit risk, food insecurity, market access, diversification, financial safety nets, and alternative land options (Mdungela, Bahta & Jordaan, 2017:1051). Though these factors are listed under community farming, they are closely related to the issues that large-scale farmers face in South Africa. Further limitations linked to the land-related problem include overusing

communal land (OECD, 2015). At the same time, there is a reduced interest in investment incentives for big-scale competitive farming due to the uncertainty about property rights (OECD, 2015). This is where this research comes in, as rural areas, where traditional farmland is located, are seeing a reduced interest in the agricultural sector (White, 2015), and therefore promotes other farming alternatives (such as concepts related to urban farming, where more labour is available).

2.4. VF: REDEFINING THE AGRICULTURAL SECTOR BY INCORPORATING THE BUILT ENVIRONMENT

The globally struggling construction industry can be rejuvenated by infrastructure developments that result from increased demand in the number of structures required to accommodate indoor farming activities (Benke & Tomkins, 2017). The incorporation of the built environment to include VF is supported by the National Framework for Sustainable Development (NFSD), which strives to achieve the following (Stats SA, 2019:143): 1): To enhance systems for integrated planning and implementation thereof; 2) Promote the use of natural resources efficiently with focus on sustaining the country's ecosystems; 3) Drive growth towards a green economy; 4) Motivate the building of sustainable communities, and 5) An active approach to climate change.

The term 'indoor farming' is an original product developed from conventional greenhouse farming systems, though its designs today deviate radically (Prescott, 2016:107). The Urban Farming description has many variations, but one of the most suited is described by Gobble & Headrick (2019) as systems that are often called 'vertical farming' that allow food to be grown under climate-controlled indoor environments. The term "plantscraper" is used by Gobble and Headrick (2019:8) to define buildings specifically designed to produce food. Benke and Tomkins (2017:15) describe vertical farming as an indoor farm based on a high-rise, multi-level factory design.

There are two indoor food production methods: aeroponics and aquaponics (Pinstrup-Andersen, 2018). Both of these only require the sheltering of the structure that accommodates the production facility, without the need for soil and production land (Pinstrup-Andersen, 2018). The utilisation of new technologies such as urban farming can rearrange who the leaders in the agricultural industry are (Benke & Tomkins, 2017). Indoor farming can assist in reducing micronutrient deficiencies and health problems, with the primary beneficiary being poor countries who experience an increase in urbanisation and can now provide fresh, nutrient-rich food (Pinstrup-Andersen, 2018). Even though the number of persons living below the international poverty line of $1.9 per day has decreased by 6.6% to be 18.8% in South Africa, there is still a lot of work that needs to be done to improve the poverty measure rate (Stats SA, 2019). Globally all countries are challenged by the successful implementation of SDGs, regardless of their income and development levels (OECD, 2019).

2.5. SUSTAINABLE FOOD PRODUCTION

With more than half of the world's population in developing countries currently residing in urban areas, a continuously growing world population suggests that 50% more food will be required by the year 2050 (Pinstrup-Andersen, 2018). The increased future food consumption will likely be from these emerging, urbanising countries. During the 2007-2008 recession, the price of food products experienced a spike, with commodities such as rice and wheat experiencing a triple factor increase in international monetary terms, resulting in food riots in certain parts of the world (Benke & Tomkins, 2017). Data analysed in Stats SA (2019) suggests that the 2008 financial crisis placed the South African government's attempts in addressing hunger in the country in a bad light. At the time of writing, the world is experiencing the Coronavirus pandemic, resulting in many economies experiencing crippling effects.

A country's budget can be used as a yardstick to measure a government's performance and long-term commitment to achieving SDGs, and it helps civilians to evaluate the performance of governments (OECD, 2019). By aligning national expenditure with climate and other environmental goals, environmental objectives can be achieved through "green budgeting". Some of these targets include climate change mitigation, pollution reduction, biodiversity protection, and the promotion of sustainable production and consumption patterns (OECD, 2019).

'Precision farming' promotes the desires of consumers to support environmentally friendly and high-tech production practices (Prescott, 2016). Indoor farms can be seen as precision farms, considering that the plants are grown using only water and the nutrients needed (Pinstrup-Andersen, 2018). The millennial generation tests the urban redevelopment projects' feasibility with their preference for urban, historic, and sustainable places (Hersh, 2018). Xiang, Yang and Li (2020) suggest combining Nature-Based Solutions with Society Based solutions to represent local socio-economic problems and guide urban planning practitioners.

Pinstrup-Andersen (2018) says that indoor farming provides lower environmental costs than traditional farming, especially when renewable energy sources are used, as it has a reduced impact on water sources and related water and soil pollution. Land and the fauna and flora biodiversity of the ecosystem reduced greenhouse gas emissions, use less pesticide control as there are fewer pests present, while fertilisers can be used more efficiently and the growth cycle time is reduced (Pinstrup-Andersen, 2018). It is expected that the (traditional) agricultural sector will, in the future, be charged for discharging polluted water (OECD, 2015). There is continuously new technology being added to remediate environmental damage (Hersh, 2018). Indoor farming solutions are driven by

developments in crop science, energy-related technologies, climate change, and population growth (Gobble & Headrick, 2019).

The National Policy on Food and Nutrition Security addresses food security in South Africa and is interested in solving the following challenges (Stats SA, 2019:54): 1). Creating a reliable data collection and analysis process; 2). Reinforcing current strategies and policies that relate to food security; 3). Advancing market accessibility for smallholder farmers; and 4) Raising awareness on agro-ecological approaches to farming. It is especially under SDG 2, which approaches food security and zero hunger as its primary objective, that Stats SA (2019) draws our attention to target 2.3 that concentrates explicitly on increasing agricultural productivity and is quoted as follows: "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment". Although it is clear that the intention is to increase agricultural productivity, how it will be achieved is not outlined.

SDG Target 2.4 builds on the theme of food production by emphasising the need for sustainable food production systems to protect biodiversity and against natural disasters (Stats SA, 2019). Simpson (2019) believes that local governments should select certain farming activities that they would like to include under the urban agriculture framework. Food security refers to the availability of food and the quality thereof; as Dalby et al. (2019) point out, there is an increasing rate of obesity and diabetes, with low and middle-income countries showing an even higher surge. Future food security and sustainability are threatened globally by climate change and declining land and water resources (Benke & Tomkins, 2017), while indoor farming is not influenced by one of these (Pinstrup-Andersen, 2018; Dalby et al., 2019).

Under target 2.a, of the SDGs, the goal is to attract investment to the agricultural research field and related extension services to increase agricultural productivity (Stats SA, 2019). One of the real estate development and economic incentives listed by Hersh (2018) includes real estate tax abatements, which are often related to job creation during the construction period as well as thereafter. Simpson (2019) says that tax incentives can create additional interests to participate in urban farming activities, as tax exemptions will lower start-up costs and enable the payment of labour, materials, property taxes, and other legal related compliances during initial years of uncertainty. The importance of policy, planning and management is realised in investment incentives and the environmental impacts of such decisions (Forsberg & von Malmborg, 2004).

2.6. SUPPLY CHAIN MANAGEMENT

According to Pinstrup-Andersen (2018), the production of fresh vegetables does not guarantee consumption, but it is a step in the right direction. In the same sense, VF will not directly ensure the consumption of the foods produced but can assist governments in providing the opportunity to gain access to freshly grown consumables regularly. Hersh (2018) believes that many cities today are struggling to find their economic drivers of the future. Hersh believes that many cities replicate solutions incorporated by other cities with the hopes that solutions used by others will solve their problems.

Operational plans represent the government's commitment and ambitions in achieving its SDGs (OECD, 2019). European countries are more likely to achieve their SDGs than African countries, as economic symmetries exist between member states while not neglecting the presence of cultural homogeneity (Ramutsindela & Mickler, 2019). Access to fresh vegetables is often limited in urban areas by supply chains that perform poorly, the seasonality of certain vegetables, and volatility in production while being accelerated by high prices and other supply factors that make these basic nutrients out of both economic and physical reach (Pinstrup-Andersen, 2018).

The number and duration of driving trips undertaken today have taken a downturn (Hersh, 2018). In contrast, Hersh (2018) says that many young people today are interested in walking, taking bike rides, or using independent commuting services to work. Hersh says that it is likely a result of their parents who spent hours commuting to work daily. VFs located in cities will accommodate the fewer driving trips taking place and further re-evaluate how cities are designed.

Shorter travel distances between supply networks mean that food can reach consumers quicker while reducing the carbon damage caused by long-distance transport pollution (Benke & Tomkins, 2017; Gobble & Headrick, 2019). Key modes of transportation for consideration impacting urban farms include big and smaller pick-up trucks (Hersh, 2018). Hersh refers to the big trucks as "over-the-road tractor-trailers" and mentions their manoeuvring areas and the need for loading/unloading space as a key consideration for the impact that these vehicles will have on regular traffic flow, not neglecting their access times. Though the pickup vans require less space, these are more frequent (Hersh, 2018).

Table 1 below analyses the relationship between economics, environmental and social factors with VF.

Table 2.1: SDG Relationships with VF

ECONOMICS	ENVIRONMENTAL	SOCIAL
• Improved Productivity • Reduced Cost Base for fertilisers, herbicides, and pesticides • No losses due to floods, droughts, or sun damage • Reduced Transportation cost • No requirement for farm rolling stock • Production can be programmed to match demand because of no seasonality issues	• Export potential of clean, green, and food • No soil is required if hydroponics is used • Reduces fossil fuel use by employing renewable energy source • Reduction in carbon levels • Rejuvenation of the ecosystem • Environmental sustainability	• Provides employment in regional areas • Addresses social isolation in remote rural communities by providing jobs in towns • Increases demand for trade workers in construction, renovation, and ongoing maintenance • Provides new jobs in engineering, biochemistry, biotechnology, construction and maintenance, and research and development • Encourages a more holistic lifestyle where apartments and food production are localised and therefore reduces the need for vehicles and transport

(Benke & Tomkins, 2017:23)

2.7. WATER PRESERVATION & HYDROPONICS

According to Gobble and Headrick (2019), the nutrient-rich water solution used to feed the roots is circulated to feed the suspended plant roots (Hersh, 2018). This closed system allows for water containing nutrients that were not absorbed the first time around, to be recycled instead of being lost (Benke & Tomkins, 2017). From a nature preservation and restoration perspective, VF supports environmental sustainability as the ecological water system is restored while rural land returns to its former glory (Benke & Tomkins, 2017). The not using of soil mentioned in the table above might become an important consideration when undertaking regeneration projects, as it reduces the structural load that conventional soil farming techniques would have had on buildings.

The reduced water usage of hydroponics mentioned by Pinstrup-Andersen (2018) becomes important for areas such as South Africa, which are classified as drought-stricken countries. Stats SA (2019) points out that South Africa's water stress level (which measures withdrawal from freshwater sources) was 41% in 2018 and is high for a country dependant on freshwater sources. Benke and Tomkins (2017) mention a few applications where VF is likely to be taken up at a quicker rate.

Some of the places mentioned include desert and drought-struck areas such as Arabian and African countries. Smaller, densely populated countries such as Israel, Japan, and the Netherlands will also stand in line and are followed by countries such as China who struggle with pollution and soil depletion (Benke & Tomkins, 2017). Mdungela, Bahta and Jordaan (2017) proved that although

various conventional farmers had the same exposure to droughts, their vulnerability and ability to cope with the droughts differed.

There are numerous programmes highlighted by Stats SA (2019:27), which are run by the Department of Environmental Affairs (DEA), which closely relate to VF and reflect the government's ambitions to achieve, among others, water-related SDGs. Some of these listed programmes include:

- **Working for Water (WfW)** strives to protect freshwater sources, protect biodiversity and enhance ecosystem services;
- **Working for Forests (WfF)** encourages the development and management of new forestation while utilising alien invaded plant regions and degraded forests into perusable land;
- **Working for Wetlands** addresses lost and, or degraded wetlands;
- **Working for Ecosystems (WfE)** relates to land-related problems and environmental degradation in SA;
- **Working for Energy (WfE)** promotes using biomass materials for the production of energy for various applications;
- **Working for Land (WfL)** strives to improve land degradation caused by reduced soil qualities;

2.8. CHALLENGES, COSTS, AND MINDSETS FACED BY VF

Some of the challenges faced by city farms listed by Gobble and Headrick (2019) include high energy costs, high associated labour costs, and the high costs of urban properties, and are some of the main reasons new start-ups fail. Benke and Tomkins (2017) reaffirm that start-up costs are excessively high in many cities due to high real estate prices compared to rural land prices. If the output production yield that is obtainable from indoor farming is much more than conventional outdoor farming in rural areas, then the initial cost of land will with certainty be recouped in the future, while VF input costs are further reduced by no need for traditional farming machinery input and related maintenance costs (Benke & Tomkins, 2017).

The two main cost factors of indoor farming include energy and capital outlay and are why renewable energy, more efficient lighting, and solar power reduce the energy-related cost component (Pinstrup-Andersen, 2018). Hersh (2018) believes that money is the cornerstone of real estate, as the goal is always to make more money than it costs and is, therefore, that the highest and best use value' of a property is crucial for making real estate decisions (Hersh, 2018). In contrast, the achievement of the 2030 SDGs is often opposed by the capitalist economy (Ramutsindela & Mickler, 2019). Benke and Tomkins (2017) believe that growing low-value field crops indoors is not financially viable under the current economic conditions. Yet they are hopeful that it might change in the future

as the impacts of climate change increase and the availability of arable land declines, while water source concerns remain present.

The clientele's response to indoor-grown products is one of the primary considerations, bearing in mind that in Europe and the United States of America, the term 'organic food' does not include products that were not grown in soil, with the price being the final determinant (Pinstrup-Andersen, 2018). Certain indoor producers might not market their products as indoor grown. Benke and Tomkins (2017) say that this is due to some consumers viewing these indoor-grown foods as unnatural and might cause them to be uninterested in purchasing such products. Chang (2014) says that the aesthetical aspects of building structures can favour higher capital returns from a supply-side and a demand perspective. Chang believes that this is due to many consumers being eager to be associated with such unique character-built environments. An increased uptake rate of new technology results in higher efficiency-enhancing techniques (Danquah, Ouattara & Quartey, 2018).

Today, many governments are challenged by corruption, resulting in public resources being used inefficiently (OECD, 2019). Corruption is a direct cause of economies not achieving their full potential of SDG 8, which addresses the market entry barriers, and SDG 9, which relates to technology and uptake thereof (OECD, 2019). 'Technical efficiency' is the explanation used by Danquah, Ouattara and Quartey (2018) to describe the ability of individual economies to adopt and adapt technologies that already exist in other countries and apply them locally.

In terms of SDGs, indoor farming meets the requirements of all-year-round sustainable food production and mitigates the risks of natural disasters such as floods, droughts, and pest attacks (Benke & Tomkins, 2017). These physical challenges are more controllable indoors than outdoors (Pinstrup-Andersen, 2018). South Africa's battle with these disasters causes damage to ecosystems, water supply systems, and food security (Stats SA, 2019). Although traditional energy costs are high, the advantages of a guaranteed disaster-free harvest as a risk mitigation strategy re-evaluate the cost of such technologies (Benke & Tomkins, 2017; Dalby et al., 2019).

2.9. TECHNOLOGY

VF produces authentic organic food which is healthy and not contaminated by chemicals (Benke & Tomkins, 2017). The nutritional products that are harvested contribute positively to the local community by proposing health and social benefits (Hersh, 2018). The crop returns per area are much higher in indoor farms than conventional outdoor farming (Gobble & Headrick, 2019) and resultantly implies higher capital returns.

The development of software that incorporates machine learning can adjust the growing conditions according to the changing growth requirements of each plant in the producing facility (Gobble & Headrick, 2019). Benke and Tomkins (2017) suggest a more factual investigation into computer simulation software and its commercial application to indoor farming. The indoor controlled environment provides an opportunity for technology to monitor essential variables such as the air quality, illumination, humidity, temperature, O3, O3, NO2, and other visually noticeable growth elements by creating a traceable record to refer to in the future, thereby enabling the improvement of future productivity (Yang et al., 2018:195). Advancements in the fields of lighting, sensors, temperature control, and nutrient monitoring bring costs down while providing VF opportunities with trackable growing cycles (Gobble & Headrick, 2019; Benke & Tomkins, 2017). The figure below serves as an example of how the integration of various technological aspects can be combined in an encompassing manner to monitor the growth process.

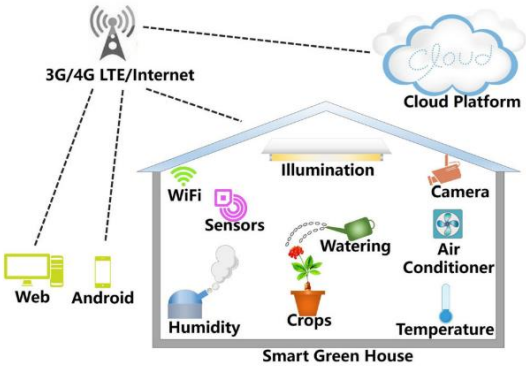


Figure 2.1: How the integration of technology can be used to enhance indoor farming

(Illustration by Yang et al. (2018:190)

Data analysis forms an integral function of indoor farming (Gobble & Headrick, 2019). The technological basis of indoor farms manages the perfect climate, lighting, irrigation, and plant nutrient requirements by integrating sensors and control systems (Gobble & Headrick, 2019). Air conditioning that replenishes current air with carbon dioxide (CO2) assists with the growing process further, while controlling variables such as temperature, humidity, and CO2 levels can lead to increased crop yields (Benke & Tomkins, 2017).

Benke and Tomkins (2017) suggest that more concrete research is required regarding the impact of different intensities and time durations of lightning exposure on the production process. This is due to plants reacting differently when absorbing different wavelengths and intensities of the LED light through their 'photoreceptors' (which perform the function of photosynthesis) (Benke & Tomkins, 2017).

There are numerous already existing environmental assessment tools to analyse the built environment and, inter alia, include a review of energy usage, climate control and health conditions inside buildings, the use of green building materials, and others (Forsberg & von Malmborg, 2004).

2.10. LEGAL ASPECTS

Designers involved in urban designs can only work with what is allowable under current regulations or with what has been permitted by authorities (Hersh, 2018). Even though the purpose of this document is not to investigate the provisions and adequacies made in South African legislation to accommodate urban farming, the result would be incomplete if no mention was made of it. Having a clear definition of what is included in urban farming will remove ambiguities and clarify the requirements for the use and height restrictions created by current usage categories (Simpson, 2019). To achieve the SDGs, the government must strategically apply their budgets, procurement, and regulatory tools, including local policies (OECD, 2019).

The two main types of legislature applicable to indoor urban agriculture include zoning ordinances (land parcel usage) and building codes (Simpson, 2019). Zoning refers to physical and functional controls within a municipal master plan that determines the permissible uses of land and is an integral part of urban design (Hersh, 2018). Building codes primarily fail for three reasons, according to Simpson (2019:8). The reasons include the ambiguity in the description, exemption conditions that are impractical and impossible to comply with, and cases where the public's welfare can be placed at risk from a human and economic standpoint when large buildings are exempted from such regulations. Zhang et al. (2020:1915) suggest three parameters to analyse governance in public participation of urban redevelopment projects: the policy and its contents, the features of the different actors, and the institutional features.

Building use restrictions discourage interest in urban farming practices due to no or a lack of provisions made in local laws (Simpson, 2019). In contrast, a clear legal definition of what is included under the term ‘vertical farming’ can clarify all ambiguities and make the application much easier (Simpson, 2019). Current RSA building laws and land ordinances do not allow urban farming to be incorporated into the urban planning network. For example, not one of the *SANS 10400* (2008) regulations mentions agricultural activities. Neither is there any mention made of urban farming or commercial-scale food production. A solution to include agrarianism in urban planning would be to update zoning codes without neglecting the importance of considering the relevant building codes (Simpson, 2019) as zoning sets the standard of what is permissible and what not in terms of land usage (Hersh, 2018).

Because no reference is made to indoor farms, one cannot clarify other regulatory design requirements set out by *SANS 10400* (2008), as some areas are more problematic than others. For example, Part O – Lightning and Ventilation; Part P – Drainage; Part N – Glazing and Ventilation requirements and Part T – Fire Protection. Other issues are concerned with how the treatment of wastewater produced by irrigation and the washing of the products will be handled as well as the air quality requirements inside the buildings. It is unclear if it will be permissible to discharge wastewater into municipal lines or if the buildings would, in any way, not have any waste due to water purifying and recycling systems. Table 2 proves that South African building codes do not recognise VF as an occupation type yet, let alone describe the required design standards. Forsberg and von Malmborg (2004) raise the question of whether one can segregate buildings from their environment and then still provide objective feedback about the environmental performance of such areas. The public sector's responsibility is to motivate private sector investments for a community's economic development (Hersh, 2018).

Table 2.2: Different Building Occupancies and Classifications

Class of Occupancy or Building	**Occupancy**	**Description**
A1	Entertainment and Public Assembly	Occupancy where persons gather to eat, drink, dance, or participate in other recreation.
A2	Theatrical and Indoor Sport	Occupancy where persons gather for the viewing of theatrical, operatic, orchestral, choral cinematographic, or sports performances.
A3	Places of Instruction	Occupancy where school children, students, or other persons assemble for the purpose of tuition or learning.
A4	Worship	Occupancy where persons assemble to worship.
A5	Outdoor Sport	Occupancy where persons view outdoor sports.
B1	High-Risk Commercial Service	Occupancy where a non-industrial process is carried out and where either the material handled or the process carried out is liable, in the event of a fire, to cause combustion with moderate rapidity but is not likely to give rise to poisonous fumes or cause explosions.
B2	Moderate Risk Commercial Service	Occupancy where a non-industrial process is carried out and where either the material handled or the process carried out is liable, in the event of a fire, to cause combustion with moderate rapidity but is not likely to give rise to poisonous fumes or cause explosions.
B3	Low-Risk Commercial Service	Occupancy where a non-industrial process is carried out and where neither the material handled nor the process carried out, falls into the high or moderate risk category.
C1	Exhibition Hall	Occupancy where goods are displayed primarily for viewing by the public.
C2	Museum	Occupancy comprising a museum, art gallery, or library.

D1	High-Risk Industrial	Occupancy where an industrial process is carried out and where either the material handled or the process carried out is liable, in the event of a fire, to cause combustion with extreme rapidity or give rise to poisonous fumes, or cause explosions.
D2	Moderate Risk Industrial	Occupancy where an industrial process is carried out and where either the material handled or the process carried out is liable, in the event of a fire, to cause combustion with moderate rapidity or give rise to poisonous fumes, or cause explosions.
D3	Low-Risk Industrial	Occupancy where an industrial process is carried out and where neither the material handled nor the process carried out, falls into the high or moderate risk category.
D4	Plant Room	Occupancy comprising usually unattended mechanical or electrical services necessary for the running of a building.
E1	Place of Detention	Occupancy where people are detained for punitive or corrective reasons or because of their mental condition.
E2	Hospital	Occupancy where people are cared for or treated because of physical or mental disabilities and where they are generally bed-ridden.
E3	Other Institutional (residential)	Occupancy where groups of people who either are not fully fit or who are restricted in their movements or their ability to make decisions reside and are cared for.
F1	Large Shop	Occupancy where merchandise is displayed and offered for sale to the public and the floor area exceeds $250m^2$.
F2	Small Shop	Occupancy, where merchandise is displayed and offered for sale to the public and the floor area, does not exceed $250m^2$.
F3	Wholesalers' Store	Occupancy where goods are displayed and stored and where only a limited selected group of persons be present at any one time.
G1	Offices	Occupancy comprising offices, banks, consulting rooms, and other similar usages.
H1	Hotel	Occupancy where persons rent furnished rooms, not being dwelling units.
H2	Dormitory	Occupancy where groups of people are accommodated in one room.
H3	Domestic Residence	Occupancy consisting of two or more dwelling units on a single site.
H4	Dwelling House	Occupancy consisting of a dwelling unit on its own site, including a garage and other domestic outbuildings, if any.
J1	High-Risk Storage	Occupancy where material is stored and where the stored material is liable, in the event of a fire, to cause combustion with extreme rapidity or give rise to poisonous fumes, or cause explosions.
J2	Moderate Risk Storage	Occupancy where material is stored and where the stored material is liable, in the event of a fire, to cause combustion with moderate rapidity or give rise to poisonous fumes, or cause explosions.
J3	Low-Risk Storage	Occupancy where material stored does not fall into the high or moderate risk category.
J4	Parking Garage	Occupancy used for storing or parking of more than 10 motor vehicles.

(SANS 10400, 2008:(3)(A)(20))

2.11. DESIGN CONSIDERATIONS

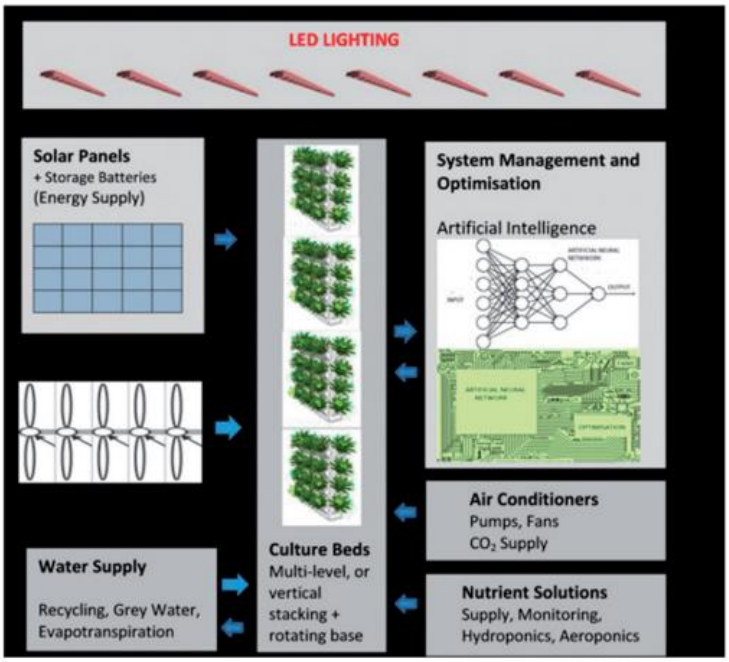
The millennials, the next generation followed by the baby boomers, are opposite in many ways and prefer lively, mixed-use, and transit-oriented urban environments and is a clear shift from the baby boomers' suburban preference (Hersh, 2018). Some of the deciding factors on whether to redevelop a property or not are described by Munneke and Womack (2015) to include the age and size of the structure, nearby amenities, the quality and density of the neighbourhood, demographical changes,

and new space requirements arising. Redevelopment designs must often incorporate a series of inflexible systems into their design, such as existing infrastructure, site conditions, and transportation networks which must be brought up to current and future performance standards (Hersh, 2018). Commercial urban regeneration is generally a result of new problems and market demands and often leads to new policies (Yiannakou, 2020).

The suitability of crops that are to be grown under indoor environments can be altered through genetic engineering (Benke & Tomkins, 2017). The quantity of these crops to be produced in terms of economic viability, says Gobble & Headrick (2019), is determined by economies of scale play an essential role in defining the success of an indoor farming facility. The main items affecting the success are the building and facility's design and are linked to the potential receivable income from the market catchment area (Gobble & Headrick, 2019). One of the main drivers of vertical farming is the need for agricultural land, which is only obtainable by building upwards (Benke & Tomkins, 2017). The demand for land is why densely populated cities, such as Singapore, use high-rise vertical buildings, which constitute more space per area than horizontal surfaces such as roofs (Kosorić et al., 2019). Singapore is one example of where farming land is scarce, and new developments further reduce the area (Tablada & Zhao, 2016). One of the challenges faced by rapid urban developing countries, such as China, is that the government has the responsibility to ensure sustainable food security by protecting agricultural land (Zhang et al., 2020). The motion to successfully achieve SDGs must be reflected in the national and regional levels of government's undertakings (OECD, 2019). A vertical governance hierarchy provides a more controlled mechanism of ensuring authoritative SDG achievement (OECD, 2019). It is unknown whether consumers of the era we live in will prefer fast-foods that were processed, or nutrient-dense, freshly grown non-rivals (Pinstrup-Andersen, 2018). Physical access and product prices result in the opportunity cost according to which individuals choose and respond to their needs (Pinstrup-Andersen, 2018).

Tablada and Zhao (2016) analysed 57 different buildings by considering the impact that the availability of sunlight and the building's three-dimensional and other geometry-related factors of plot ratio, site coverage, and structure height have on its performance. The plot ratio and building's height proved to be the significant characteristics that influenced food and energy self-sufficiency in buildings. Figure 2 shows an example of the typical components that can be found in a VF.

Figure 2.3: Typical components in a VF and the integration thereof



(Benke & Tomkins, 2017:16)

2.12. CURRENT URBAN FARMS

Pinstrup-Andersen (2018) says that the initial costs of new innovations and technologies are high, with an elevated risk of failure. Pinstrup-Andersen (2018) compares this concept of elevated risk to failure to the first computer developed without neglecting all the initiatives that failed before succeeding. SDG Target 2.c is concerned with the functioning of the food market, related market information, and the associated accessibility thereof to limit food price volatilities (Stats SA, 2019). The financial performance data of the successful indoor companies are regarded as valuable intellectual property and is therefore not made available to the public (Pinstrup-Andersen, 2018). As a result of companies not making their financial data available publicly, one cannot ascertain the 'life-cycle analysis' of indoor farming, as suggested by (Benke & Tomkins, 2017). It also makes it difficult to accurately determine the Return on Investment (ROI) and compare costs with traditional farming.

Gobble and Headrick (2019) mention two vertical farm start-ups that went bankrupt, namely FarmedHere in Illinois, USA, and Podponics in Georgia, USA. FarmedHere was one of the start-ups that failed due to high energy costs, while Podponics went insolvent in 2016 after successfully raising $15 million at the establishment (Gobble & Headrick, 2019). This is while others, including Urban Produce and Plenty in California, USA, Plantagon in Sweden, and Aerofarm in New Jersey, USA, continue their existence and presumably make a profit as they would otherwise not be operational (Pinstrup-Andersen, 2018). 'Aerofarms' is an example of a company that focuses on urban

regeneration and combines various techniques such as: using innovative land usage, adapting historic buildings for reuse, creating public-private partnerships for financing, and creating jobs and skills development through training programs (Hersh, 2018). Bigger and more complex growing facilities are often taken up by companies that strive to increase their business performance to target a client market that includes densely populated centres (Gobble & Headrick, 2019). These hubs are usually comprised of institutions, corporate campuses institutions, and universities (Gobble & Headrick, 2019).

The Plantagon building in Sweden was launched in 2012 and is described by Gobble and Headrick (2019) as a "plantscraper" that consists of 16 storeys, with a South facing glass façade. This Swedish-designed building uses excess heat and CO2 gasses from nearby industrial plants to drive a closed-loop process that can grow 550 tons of vegetables annually to feed 5500 people per year (Gobble & Headrick, 2019). This happens while the north of the building houses office space where workers can work in the cool North (Northern hemisphere), but is scheduled to open by 2021 (Gobble & Headrick, 2019).

A Boston-based headquarter firm called Freight Farms converts shipping containers into "fully equipped, self-contained, automated growing units" that are portable and only have a level surface as a requirement (Gobble & Headrick, 2019:8). These containers provide an opportunity for entrepreneurs to supply local markets (Gobble & Headrick, 2019). A focal focusing point throughout all the urban redevelopment projects analysed by (Hersh, 2018), found that most urban redevelopment developers focused on maintaining the area's character while considering the sustainability of their projects. The application of technology can assist economies in enhancing competitiveness, productivity, and growth (Danquah, Ouattara & Quartey, 2018). Resultantly, one cannot ignore VF's economic export opportunities (Benke & Tomkins, 2017).

Another noteworthy competitor in the indoor farming race is Crop One Holdings, based in the San Francisco Bay area, which aims to become the world's largest vertical farming facility in Dubai, United Arab Emirates (Gobble & Headrick, 2019). This joint venture with the emirates is mutually funded by Emirates Flight Catering and will use 99% less water than outdoor farming while hosted in a $40 million facility (Gobble & Headrick, 2019). This group will target a niche market of 100 airlines and 25 airport lounges (Gobble & Headrick, 2019).

Another Singaporean example of VF includes the Sky Green group and is also home to 120 growing towers in the CBD (Benke & Tomkins, 2017). Singapore's Sky Green group towers supply 10% of the vegetable market in Singapore, at an approximate 10% higher cost than imported products (Benke &

Tomkins, 2017:17). The Valcent Company in North America exports its products to worldwide customers (Benke & Tomkins, 2017).

Some of the obstacles that Australian industries face are related to uncertainty in the climate arena; water supply; pests invading; reduced soil qualities, and transportation-related costs (Benke & Tomkins, 2017:13). Reduced transportation results in less fossil fuel being burnt (Benke & Tomkins, 2017). Climate change reduction attempts to support the implementation of VF due to reduced greenhouse gas emissions caused by trucks not driving so far (Benke & Tomkins, 2017).

Mirai Company in Japan is one of the VF start-ups expanding exponentially and is planning to implement robots for the harvesting process in the future while using fast-growing leafy vegetables with a fast turnaround time as its strategy (Benke & Tomkins, 2017). Some of the largest known indoor food-producing units are Japan, Singapore, South Korea, Taiwan, and the United States of America. It is unclear why some of these indoor farming initiatives failed while others are operating successfully without the need for government interference and subsidy support (Pinstrup-Andersen, 2018).

To a certain degree, the total amount of food grown from urban agriculture is limited, making it expensive to undertake commercially (Hersh, 2018). Critics argue that lightning costs are too expensive and artificial lightning is unnatural, as the name suggests – while promoting conventional soil and natural light methods (Pinstrup-Andersen, 2018). Even though the indoor growing process is manipulated, the cultivation process undertaken with the plants supplies the same nutrients compared to traditional farming (Benke & Tomkins, 2017). Deficiencies that individuals suffer from are argued by critics to be caused by a lack of demand rather than being related to supply or access (Pinstrup-Andersen, 2018).

2.13. EDUCATIONAL SHIFT

The historical element of a city is appreciated by creative entrepreneurs (Chang, 2014). Much of the previous urban regeneration literature focused on the relationship between ‘culture’ and ‘regeneration’, limiting the thinking to cultural institutions such as galleries and museums - leaving one to disregard any interest in other spaces (Lugosi, Bell & Lugosi, 2010). The involvement of higher education institutions is a strategic approach to achieving SDGs (Ramutsindela & Mickler, 2019), as these institutions are closely associated with the state self. The role that the state plays in culture-led gentrification is important (Chang, 2014).

Hersh (2018) says that the economic drivers changed after the 2007 financial crisis, as many of the millennial generation now live in a live-work-play urban environment and are employed by sectors

such as technology, media, education, art, and health care. In the meantime, private developers now drive redevelopment while working with communities and the public sector (Hersh, 2018). Some of the careers that are expected to arise out of VF include specialist technologists, project managers; maintenance workers; marketing, and retail staff (Benke & Tomkins, 2017). More technical career opportunities will likely be related to HVAC, water reticulation, illumination and growth process control positions, new opportunities for software and robotics engineers (Benke & Tomkins, 2017).

The agricultural sector's perceived representation can be improved through general education and the assistance of the media, including social media (White, 2015). One of the main channels of exposing developing countries to foreign technologies includes academia and the media (Danquah, Ouattara & Quartey, 2018). Even though the indoor farming field falls under the agricultural sector, it opens an entirely new study field that includes professional disciplines such as biological and material sciences, though it will likely influence a range of study fields (Gobble & Headrick, 2019). The urban farming field requires a higher-skilled workforce, likely increasing the total employment in the food production sector (Benke & Tomkins, 2017). Designers must be aware of the latest market developments, considering the current financial resources available (Hersh, 2018).

Education is addressed under SDG 4, with target 4.7 being concerned with sustainable development knowledge and introducing the idea of transferring knowledge and skills to promote sustainable development and lifestyle choices (Stats SA, 2019). Goal 4 speaks of transferring knowledge and having educators who can contribute to this research and the body of knowledge to achieve sustainable development, food security, and urban regeneration.

VF research can assist in developing education to inform government officials and farmers about the new technologies and guide the infrastructure development process (Benke & Tomkins, 2017). The constant renewal of knowledge, skills, and understandings is vital for responding to changing circumstances (Ramutsindela & Mickler, 2019). A few steps in the redevelopment process entails site analysis and acquisition, land re-use approvals, market analysis, financing, remediation works, redevelopment and liability protection, project organisation and sequencing, design, regulatory, and community reviews (Hersh, 2018:18).

2.14. COMBINING URBAN FARMING WITH EXISTING STRUCTURES

The availability of buildings for remodelling into indoor farming units is one of the key drivers of indoor farming (Pinstrup-Andersen, 2018). Benke and Tomkins (2017) say that infrastructure costs are reduced when single-level, high ceiling storeys are stacked with multiple levels of planting space. The reduction in arable land per capita is an international concern, with the following items further contributing to the existing concern: climate change; a reduction in the number of fisheries, which

shifts the burden to land-based products; increases in urbanisation; increases in agriculture-related costs such as fertiliser, fuel, and pesticides; a growing global population and reduced soil quality as a result of depletion and degradation caused by over farming and poor production practices (Benke & Tomkins, 2017:13). Governments' intervention to relocate subsidies that go to wheat, maize, and rice-related products towards supporting indoor-grown products and farmers can help with the uptake of controlled environment farming (Pinstrup-Andersen, 2018). The reasoning is that one's economic vulnerability is increased when access to resources is limited (Mdungela, Bahta & Jordaan, 2017).

2.15. HERITAGE

One must not neglect the importance of the Heritage Act with specific applicability to many of the dilapidated buildings and urban decaying structures. Heritage resources must "contribute to the social and economic development" of South Africa (*National Heritage Resources Act No. 25 of 1999*, 1999:(5)(7)(d)). Public engagement helps to protect cultural and heritage sites (Zhang et al., 2020). As the heritage aspect can often discourage regeneration projects, Yiannakou (2020) believes that partnerships between the public, private sector, and different stakeholders are among the most effective ways to overcome uncertainties and externalities that often challenge large-scale regeneration projects. Stakeholder participation can assist in achieving SDGs and includes various parties such as "international and regional organisations, local authorities, business and industry civil society, science and academia" with duties ranging from resource mobilisation to providing solutions and innovations, the adjustment of production patterns and lifestyle choices, advocacy, and accountability (OECD, 2019:30). South Africa is described as a "middle-income developing country" by Stats SA (2019:148), who says that the country is regarded as a recipient of global support in striving to achieve SDG 17, which deals with building partnerships.

Although the lives of many can be improved by new buildings that create more jobs, it goes without saying that not each person's life will be impacted (Hersh, 2018). Historic preservationists often oppose redevelopment projects in China, where for example, many cultural heritage sites and old urban fabrics were destroyed with past regeneration projects (Zhang et al., 2020:1904). An adaptive approach to redevelopment allows for buildings to be reused by remodelling the buildings to fit changing needs while preserving the historic character and embracing growth for new opportunities (Hersh, 2018). Structures that are older than 60 years cannot be demolished or altered without a permit issued by the relevant provincial heritage resource authority (*National Heritage Resources Act No. 25 of 1999*, 1999:(34)(31)).

Three different overview levels for attracting investments for redevelopment projects include the strategic spatial planning, governance, and administrative levels (Yiannakou, 2020) and explain it as follows. The strategic planning level is concerned with communicating shared agendas and priorities for possible urban regeneration projects. The governance level is aimed at partnerships and implementing other tools between various stakeholders. Lastly, the administrative level refers to the systems and competence therein that local government enjoys in facilitating redevelopment projects. In the event of uncertainty (such as the case of urban vertical farming), it is the responsibility of SAHRA to guide what is permissible what is not in terms of the *National Heritage Resources Act No. 25 of 1999* (1999:(13)(11)(d)).

The following development activities that change the character of a site, are governed by the *National Heritage Resources Act No. 25 of 1999* (1999:(38)) and requires special permission: (1)(i) Exceeding 5 000 m2 in extent, or; (1)(ii) Involving three or more existing erven or subdivisions thereof, or; (1)(iii) Involving three or more erven or divisions thereof which have been consolidated within the past five years, or; (1)(iv) The costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resource authority, or; The re-zoning of a site exceeding 10 000m2 in extent.

To ensure that stakeholders abide by (re)development policies, local governments can use instruments such as permits and incentives such as compensation and fines (Zhang et al., 2020:1907). It is pioneer developers who incorporate innovative models and experimental concepts of urban regeneration that can be used to educate future developers (Hersh, 2018). One must consider that converting buildings that fall under the heritage act may require structural engineering due to the increased loads induced by the crops.

2.16. THE CAUSES OF URBAN DECAY

Hersh (2018) says that redevelopment differs from traditional development from the outset, considering that conventional developments are usually driven by business principles, with profit being the primary motive. In contrast, Hersh (2018) says that redevelopments generally involve the community and government from the beginning, with shared goals as the main priority, not neglecting the importance of compensation. The impacts of semigration cannot be ignored. This comes as Xiang, Yang and Li (2020) say that numerous communities often suffer from semigration, as South African individuals and businesses migrate from central urban areas to suburban areas, with many other countries, too, experiencing this phenomenon since World War II. In the meantime, Planning systems and provisions in places such as Greece act as a barricade to persons wishing to undertake development activities in dilapidated urban regions (Yiannakou, 2020). Since 2010, the

focus has been on larger-scale developments, with little consideration for urban regeneration (Yiannakou, 2020). One of the reasons for the Central Business District (CBD) being neglected is that the money that would have been invested there is now making its way to neighbourhood-based retail projects (Hersh, 2018). Some of the main challenges faced by urban regeneration projects include the project's inherently complex nature, financing needs, the long-term commitment (which also relates to SDGs) of the various stakeholders involved, and meeting general responsibilities (Yiannakou, 2020:100).

Possible reasons for developers being cautious about urban renewal projects include that special skills are required for historic preservation, together with specific professional team members such as architects and building contractors who are knowledgeable in this specialist field (Hersh, 2018). Other reasons listed include that the professional team needs to be swiftly creative, which comes at a cost for the developer. Thirdly, authentic restoration comes with its challenges. It can be difficult to source original materials used in the construction, and other or newer techniques might have developed in the interim (Hersh, 2018).

Persons who reside in lower-quality neighbourhoods and earn below-average incomes are less educated, have fewer children, and tend to be less willing to invest in regeneration projects, resulting in them moving away from such areas (Vigdor, 2010). According to Munneke and Womack (2015), investors pay little attention to the value of existing structures on properties when the intention is to remodel such sites. The property's price will indicate the value of the land as if vacant (Munneke & Womack, 2015). Modern thinking strives to conserve and protect structures, landscapes, historical and cultural artefacts of archaeological nature, whereas former urban developments demolished structures and their character (Hersh, 2018).

Swanepoel and Smallwood (2019:4) list 13 characteristics that make buildings uninhabitable and contribute to buildings being left vacant. These include electrical supply and wiring; hot and cold water supply; security; quality of paintwork; floor structure and covering; general cleanliness; roof covering and structure; building structure; proper ventilation; adequacy of illumination; sanitation; plasterwork, and the building envelope. A simple initial assessment to analyse the character decline of a neighbourhood is to determine whether nearby buildings have window bars installed, whether repair work is needed to the streets and whether there are waste lying around in the streets and sidewalks (Vigdor, 2010:278). Places with a reputation for high crime rates and places known for their lack of security are often areas where urban redevelopment occurs and is why both the reality and the perceived image of such neighbourhoods need to be changed (Hersh, 2018).

It appears that demolition projects are undertaken in non-overlapping areas, separate from those undergoing renovation projects (Munneke & Womack, 2015).

Properties that are bought to renovate can be picked up below their intrinsic value when compared to properties sold without the need for redevelopment (Munneke & Womack, 2015). Major renovation and demolition properties suggest a further reduction in price to a level where one only pays for the value of the land (Munneke & Womack, 2015). From an environmental perspective, less waste ends on landfills when buildings are not demolished, while less energy is used instead of building a new building with new materials (Hersh, 2018).

The probability of a redevelopment (renovation or teardown) increases as the relationship between the land to property value increases and the value of improvements declines (Munneke & Womack, 2015). Renovation projects are undertaken to improve existing space layouts instead of increasing existing space, while demolition decisions are based on the fact that the interior space is inadequate for the intended purpose (Munneke & Womack, 2015). The five most noteworthy items that the management of an area must consider for preventing urban decay includes safety and security; waste removal; proper working and adequate street illumination; the adherence to bylaws and regulations; and including local persons in the local suburb management (Swanepoel & Smallwood, 2019:4). The 'Business Improvement District' approach is used in commercial areas where property owners and tenants agree to pay higher real estate taxes (Hersh, 2018). These taxes are used to provide additional marketing, keep streets clean, host special events, improve signage, and provide safety patrols.

Demolition projects tend to be geographically concentrated, while Renovation projects occur where previous renovation and demolition activities have already been undertaken (Munneke & Womack, 2015). Swanepoel and Smallwood (2019:5) believe that a relationship exists between the occupation of a building and the urban decay occurring in such areas. One of the reasons for urban inner-city centres decaying is as a result of the development of highways which led to the radical expansion of cities outward (Hersh, 2018).

2.17. SUMMARY

Whether consumers are for or against VF, the reality is that alternative means of food production to increase supply will inevitably be required. Using the words of Hersh (2018:62): "It's about transforming what we already have to get what we actually want". The allowable usage and number of storeys, building height, and zoning of a structure are guided by its occupancy group (Simpson, 2019). To realise the full potential of indoor farming, universities, governments, and various industries will have to work together and show support in terms of funding and investment (Benke &

Tomkins, 2017). SDG integration with VF should not be regarded as individual components, and the cumulative number of goals should be viewed together in obtaining a sustainable result (Pradhan et al., 2017).

When people, at first, hear about the idea of growing food in a dense urban city centre area, they might come across as distorted. It becomes evident that this contribution by the creative generation (or whichever way you want to refer to this non-textbook, millennial generation) is nothing but impossible, considering there are already a few known companies undertaking such activities. The investment growth experienced by the indoor farming market suggests a 37% increase over five years from 2017 ($25.4 billion) to 2022 ($40.25 billion) and concludes an increasing interest therein (Gobble & Headrick, 2019:7). Globally, the increase in farmland prices attracts corporate investors and large-scale commercial farmers and acts as a barrier for young persons interested in farming to gain entry into the market (White, 2015). Indoor farming does not intend to replace traditional agriculture but complement it (Pinstrup-Andersen, 2018). Society will not value environmentally responsible farmers, and as a result, the actual cost of such techniques cannot be accurately determined (Pinstrup-Andersen, 2018). Similar to SDGs, VF should be seen as a reinforcement system of synergy to enhance global development (Pradhan et al., 2017).

“Ambiguous and underdeveloped building codes” are two of the most significant barriers to vertical urban farming (Simpson, 2019:6). Building structures can provide VFs with climate-controlled environments, resulting in reduced transport costs, increased food- and biosecurity while lowering input costs related to water, pesticide and herbicides control, and fertilisers (Benke & Tomkins, 2017:14). Urban Agriculture can safeguard genetic diversity and support international relationships and research (Dalby et al., 2019).

Urban Farming has the potential to re-develop traditional land use parcels as defined by land use laws (Simpson, 2019:1). The cohortative impact of all the factors, including the location; financing options; designs; community engagement; transportation; remediation; resilience; market; infrastructure; preservation, and amenities should be considered all-encompassingly (Hersh, 2018:149). Updating the national legislature that applies to all provinces is a much simpler solution instead of waiting for each province to establish its own legislature, making it only applicable to the province in such a case (Simpson, 2019).

The same poor countries whose citizens often battle with the sourcing of nutritious vegetables are also constantly challenged with water management difficulties and can benefit from the 95% water usage reduction (Pinstrup-Andersen, 2018:233). Pinstrup-Andersen (2018:234) believes that more evidence is required to determine the economic feasibility of vertical indoor vegetable production in

urban areas in low-income countries. Reduced real estate taxes are one option that municipalities can apply to encourage redevelopment (Hersh, 2018). Tax abatements are usually for a specific time and can reduce over the period that the reduction is granted until it reaches a zero value (Hersh, 2018:132). Offering tax abatement incentives rewards developers for undertaking redevelopment projects instead of punishing the development with higher taxes (Hersh, 2018:133).

Preservation is often concerned with preserving one or two buildings, but it is multiple buildings that contribute to the district's character (Hersh, 2018). Though this research started with the view of regenerating individual buildings, one cannot help but wonder how feasible this is. Is it possible to only focus on the individual buildings when the character of the entire neighbourhood requires attention? This is likely why (Zhang et al., 2020) refers to the concept of urban renewal, where the whole neighbourhood is redeveloped. Though this does not fit in with the research objective of finding uses for existing buildings, it instead suggests demolishing the building(s) and starting over, bearing in mind that one of the economic development strategies often takes on the form of urban redevelopment (Hersh, 2018). Ramutsindela and Mickler (2019) acknowledge that synergy exists between the United Nation’s 2030 agenda and the African Union’s 2063 agenda, and raise the question about the actual time frame in which the SDGs will be reached in Africa and, more specifically, in South Africa. Even though most countries have an SDG monitoring framework established to assess the successful implementation of SDGs, not many countries have a method of evaluation to review SDG achievements (OECD, 2019). Stats SA (2019) acknowledges that South Africa is experiencing some difficulty with the availability and validation of data for some SDG indicators. The advancement in one or more SDGs might limit some other SDGs in achieving their end goal (Pradhan et al., 2017).

The following chapter documents the research methodology employed in this study.

CHAPTER 3 - RESEARCH METHODOLOGY

3.1. INTRODUCTION

How do you quantify something that there is little knowledge about? This question forms the underlying reasoning for not selecting a quantitative approach for conducting this study, as a knowledge base first needs to be created. Even though there is existing literature, the researcher was not convinced that sufficient literature directly relates to the research topic to conduct a quantitative study. At the same time, the limited literature available restricted the literature review chapter.

3.2. RESEARCH APPROACH

According to Flick (2018), the credibility of a qualitative researcher is improved in refining the research methodology. Therefore, this chapter is dedicated to understanding the research methodology followed in this study and forms the basis of explaining the researcher's thoughts. Hammersley (2013) elaborates further about the importance of this chapter by saying that in-depth investigations that are undertaken by qualitative researchers investigate the problem by verifying the understanding of the person being interviewed while defining the interviewee's understanding more clearly. Leatherdale (2019) says that in certain research fields, such as public health, there is insufficient information available about the decisions that need to be made, and the same seems to be true for VF. Qualitative studies are generally interested in finding the causes and influences of the problem and thereby identify how change can be brought about (Hammersley, 2013).

3.3. RESEARCH PHILOSOPHY

As part of the aim of this research, the potential of VF is explored, while the method utilised to find these answers is chosen based on its appropriateness to the situation (Amaratunga et al., 2002). There was a stage that the researcher considered using the experimental research method. It was soon decided against as the experimental route is known for controlling certain variables (Hammersley, 2013). The researcher's objective is to create an understanding of the potential of VF as opposed to enforcing the implementation thereof by manipulating the environment. The final convincing piece for selecting a qualitative research method is owed to Flick (2018), who said that qualitative research is more interested in theoretical generalisations than numeracies. This aligns with the researcher's objectives.

Amaratunga et al. (2002:29) add to Flick by saying that specific research's contribution to the body of knowledge is determined by items such as the "reliability, generalisability and validity", with the latter two parameters being closely related. The researcher applied critical thinking throughout the research

process to avoid biasedness. However, this does not result in ‘critical research’, as critical research is more interested in a global perspective framework than localised thinking (Hammersley, 2013).

3.4. SAMPLE SELECTION

Amaratunga et al. (2002) described the 'Research Interview' method as the most frequently used quantitative research method used in the Built Environment. This study will entail interviews with knowledgeable persons in the field or persons who can transfer their knowledge from other fields. These interviews enable researchers to understand the problem from the interviewees' perspective while understanding their knowledge and perspective and are sometimes referred to as the ‘descriptive survey method’ (Amaratunga et al., 2002). Semi-structured interviews were held with the selected persons. The reason for choosing semi-structured interviews is that it left the researcher with some freedom in asking questions that were not necessarily directly related to the research topic but were identified in the responses.

Leatherdale (2019) believes that study participants who are not randomised should not be seen as unworthy. In contrast, Flick (2018) believes that random sampling can avoid bias and improve the validity of the reported data. This study includes a wide array of participants whose professional background is expected to contribute to the study. Candidates interviewed had some knowledge or background about the VF concept.

As a result of the complexity that qualitative studies investigate, such studies are often focused on smaller sample sizes to create a complete encompassing understanding of the problem (Hammersley, 2013). This is in favour of the research problem, as the reduced sample size increased the executability of the study. There probably would not have been enough people who possessed the knowledge to undertake quantitative research while achieving reasonable data validity. A quantitative approach would have required a predetermined sample size for the data to be credible, while this does not hold for qualitative studies.

Other studies, such as Grebitus et al. (2020), who followed an exploratory research approach to investigate urban farming, concentrated on residents from a major metropolitan area as respondents. Such studies are easier to undertake as the availability of research subjects is more readily available in the specified area. This research is analysing VF from a business and entrepreneurial perspective and requires more ‘research-specific knowledge’. Even though researchers should always strive to follow a robust research design, the final selection is regulated by the availability of different types of data (Leatherdale, 2019).

The transferral of knowledge from other fields to this study can be seen as part of the risk mitigation strategy. It can avoid biasedness that can be imposed by persons who are already knowledgeable in the field.

3.5. DIFFERENT INTERVIEWEES AND THEIR BACKGROUNDS

In understanding the background of the different interviewees, the following information can help the reader to better understand the research approach followed. It was interesting to see how many people had something to do with vertical farming in the past and could contribute to this research through insightful conversations. The list below contains the key role players that were interviewed in this study:

I001 – A qualified industrial engineer who spent the initial years of his career as a consultant. He then developed an interest in supply chain management, which he specialises in today. He was selected as an interviewee for this reason. His knowledge of distribution centres, logistics, and appreciation for space is a welcome contribution to the study.

I002 - This person owns a project management company that operates internationally. His vast skillset owed to the versatility of the projects on which he works assisted in the heterogeneous conversation had.

I003 – Someone who works for the City of Cape Town Municipality and understands the urban agriculture landscape due to his involvement in Cape Town's City Garden projects. His knowledge and experience became transparent in explaining the urban farming setting, not neglecting the insight provided in terms of the process to be followed when embarking on urban farming projects.

I004 – An international fruit and vegetable quality control consultant and specialist who lives in Cape Town, although she predominantly operates in the United Arab Emirates.

I005 – A fruit and vegetable import and export boffin who previously worked for a high-end retailer as a fruit and vegetable buyer.

I006 – Employed by a non-profit organisation, this person offered meaningful insight into applying green technologies in the South African economy. This NGO specialises in finding green ways around agricultural, waste management, and electricity usage issues. The persons work in a space where government, academia, business, and civil society come together.

3.6. VALIDITY OF DATA

Flick (2018) differentiates between data validity and validating data and suggests that one way of validating data is to ensure that persons who were interviewed agree with the statements recorded

from the conversations. A criticism of qualitative research is that it is up to the researcher to convey the info extracted from the discussions held without bias or skewing the answers to accommodate the researcher's view (Hammersley, 2013).

The data saturation was reached after six interviews. It is not possible to predict beforehand at what stage this would occur. This point of 'saturation' is described by ten Have (2004) as a point in qualitative research where the addition of new data will not influence the research outcome; in other words, the responses start repeating themselves. As part of the data validity, a background check of the participants was conducted prior to the interview, as Flick (2018) recommends that doing a background and diversity check further reinforces the findings. It is only after the research results were obtained that one can review the actual contribution made by this research, as Flick (2018) mentions. Any recommendations made, are based on these findings.

Most of the questions asked (refer to annexure 4 for a comprehensive list) during the interview were related to the research literature review. Evidential areas of interest included questions relating to energy consumption, structural functionality, supply chain management; technology related questions, legislation, as well as participants' general understanding of VF.

3.7. INTERVIEW DESIGN / APPROACH

Amaratunga et al. (2002) describe research as a process of inquiry and investigation that follows a systematic and methodical approach to increase knowledge. This made the researcher realise that whether or not the implementation of VF proved to be plausible or not, as long as the correct procedure was followed, then this study could be seen as successful - regardless of the research findings, as new knowledge would be added to the field. It is crucial to consider how a person asks questions in an interview, as these questions determine how respondents reply. For example, ten Have (2004) says that questions that are phrased as statements will often get a confirmation or denial response. Such responses can then be analysed by questions such as "why" or "why not" to obtain an in-depth understanding of the person's reasoning.

Flick (2018) suggests that reviewing the reasons for selecting the research method is a good starting point in assessing whether 'good practise' was used in the research. One of the main reasons for choosing a qualitative method aligns with the reasoning followed by Amaratunga et al. (2002) and includes that qualitative studies are more subjective and endeavours to understand human behaviour and perspectives. Qualitative research uses words and observations to narrate people's reactions in real life and usually explains the observations thoroughly by depicting the research's complicatedness while providing flexibility in the research method (Amaratunga et al., 2002). The strong affiliation that 'interpretivism' shares with exploratory research and this study are formed by the mutual goal: to

explain that what comes first comes across as abstract (such as VF, for example) (Hammersley, 2013). Therefore, the 'interpretivism' approach forms part of the research method as the researcher relies on the info and opinions that interviewees supply (Hammersley, 2013).

A dangerous area with interviews is where people do not answer the questions asked honestly, as they might feel that it can influence how they are seen or would like to be seen (Hammersley, 2013). That being said, the order in which interview questions are asked will follow a logical sequence of build-up, with the interviewer playing the role of an "interested listener" while also being the person who ignites the conversation (ten Have, 2004).

Tests conducted in other, non-qualitative approaches provide persons interested in such research findings with the serenity of knowing that the research is reliable, valid, and credible – though it is unfortunately not applicable to qualitative studies (Flick, 2018). The researcher will continue promoting the 'funnel shaped' research design followed in the whole research project. This shaped layout is also applied to the interview questions and the data collection reporting. An overview level discussion of VF is the first point of discussion in the interview, followed by more in-depth questions and conversations that are adjusted to be more relevant to the particular interviewer's knowledge and expertise. Amaratunga et al. (2002) describe the narrowing down of research data as a continuous process throughout the research undertaking, with some of the first narrowing-down stages being related to the drafting of the proposal, followed by the literature review, then the drafting of the questions to be asked to the interviewees. Introduction conversations can, for example, relate to the agricultural build-up over the historical period, which led to the current developments, as Hammersley (2013) notes, with reference to the positivist approach.

Qualitative research usually incorporates interviews in a more informal environment to gain optimum insight into the interviewee's opinion/knowledge related to the research field (Hammersley, 2013). It is the interviewer's responsibility to interpret the responses gained from interviews while the interviewer should verify any uncertainties only at the end of the interview, thus giving the person being interviewed free reign to speak (ten Have, 2004).

Constructionists are an example of critics who argue that understanding oneself and other people is not possible and therefore questions qualitative research as a whole (Hammersley, 2013). The researcher believes that it is not about the individuals but rather about these persons' knowledge. As a result of no data credibility tests being available for qualitative research. Flick (2018) suggests that criteria or checklists should be incorporated as an alternative reliability measure. Some of the criteria that the researcher will consider in the interviews include the seamlessness with which the interview

conversation topic and sub-topics are held, the relevance of the conversations, time consciousness, and general transparency in conversations.

It is important that researchers undertaking qualitative studies are interested in the actual data collection and the analysis process and do not follow biasedness in the approach (ten Have, 2004). The researcher is more interested in the interviewees' 'way of thinking' than in the individuals themselves. Choosing the correct research methodology is one part of the equation, with the other part constituting the relevance of the research questions.

Interviews must be undertaken in environments that allow the interviewees to be relaxed enough to freely and comfortably speak (Hammersley, 2013). Food production in urban areas might be opposed for the dirt, noise, odours, and pollution caused by pesticides and fertilisers, which pollute the air and the local water sources and air breathed (Grebitus et al., 2020:2). Interviewees misunderstood none of these misconceptions associated with VF and did not require any clarification in terms thereof.

The structure of the interview design followed a funnel approach. Initial questions were broad to create an understanding of the interviewee's perception of VF. These initial questions also aimed to develop a platform for the questions to follow regarding how much information was expected per question response and generally set the interviewee at ease. The questions that followed were more knowledge specific, based on the interviewee's personal knowledge and experience. The reader can view Annexure 4 for the full list of interview questions. It should be noted that this annexure was an initial guideline and that conversations often diverged, depending on where they were led. See an example hereof in the randomly selected interview, Annexure 7. All discussions were closed in the same manner. The interviewer thanked them for their time and asked whether the interviewee had any additional persons they felt needed to be interviewed for this research.

3.8. INTERPRETING THE DATA

To comment on two points mentioned by Amaratunga et al. (2002): Firstly, the researcher in this instance has undertaken a quantitative study in the past and did not select the qualitative method for this study as a result of not being familiar with statistics, but purely because it is believed to be in the best interest of the study to follow such a method. Secondly, the researcher notes that it might be easier at first to commence the qualitative method but recognises that the project close-out in terms of the written analyses might be harder to undertake and may require more effort towards the end of the project. Interview questions that were asked are referred to by ten Have (2004:13) as "forward looking conversation objects" as the questions asked literally guided the conversation.

Though many critics will argue that asking questions is not a reliable source of data, they often forget that doctors determine the initial assessment by asking patients questions; criminals are interrogated by police asking questions; persons applying for work are interviewed to determine their capabilities and the list continues (ten Have, 2004). Even though there is computer software available to speed up the data analysing process (Flick, 2018), this research is more dependent on the researcher's skill to ask the right questions and to analyse data effectively.

The data was analysed using thematic analysis and the *NVivo* software, which is made available to students of the UCT by the university to analyse the data. This software helped the researcher to analyse the data by grouping the same contents under one heading, which made writing the research analysis much easier. The emergent thematic node structure was derived using this software and can be found in Annexure 6. This forms the backbone of the schematic analysis, also being the whole chapter 4 – Data Analysis Chapter.

The data obtained from the various interviews are incorporated and arranged to show the links between the different interview conversations instead of reviewing each interview in separate isolation. The researcher is optimistic that the research results will lead to evidence-based research (see Flick (2018) for more about evidence-based research). Qualitative research explains the consequences of certain changes (Hammersley, 2013). In the case of this research, it will either support or reject the research objective of implementing VF while achieving SDGs.

Data reliability reduces errors and biasedness by assuming that the same findings can be expected if the same procedures are followed (Amaratunga et al., 2002). With a new topic such as VF, the perspective of persons might change over time, bearing in mind that this is a qualitative study. This increases the importance of having reliable, knowledgeable persons for interviews.

3.9. ETHICAL CONSIDERATIONS

After drafting the proposal, the document was submitted to the UCT Faculty of Engineering and the Built Environment Ethics in Research Committee who approved the research. The process of obtaining Ethical Clearance is an inevitable part of the research process, and a copy of the ethical clearance can be found in Annexure 5. Approval was given with the condition that the research supervisor must approve the research interview questions before starting with the data collection process. Ethics in qualitative research goes much further than an ethical clearance, as Flick (2018) highlights that output quality is part of the ethical considerations, considering that it is unfair to waste the time of persons with interviews and then provide sub-standard output from such conversations.

The researcher will, at all times, avoid being biased. Persons with whom interviews are held will be provided with complete anonymity. Although anonymity is an essential consideration in all research types, it becomes imperative in quantitative research, Flick (2018) emphasises.

This research is fortunate not to face any language and other communication barriers as experienced by some other studies investigating global problems, as Flick (2018) notes. The VF theme is internationally taking shape, and it would have been much more trying if the cross-border data had to be sourced.

A copy of the ethical clearance document can be found in Annexure 5. Other related ethical documents include the research participation consent form and the anonymity measures found in Annexures 2 and 3. In applying Flick (2018) ethical requirements, this research does not relate directly to any financial questions being asked during interviews but might speculate about the financial performance of VFs if the conversation leads in such a direction.

3.10. BUDGET / FUNDING

From a funding perspective, the research method and proposal need to compare with other research proposals. The expected consistency and adequacy of the research outcome are two of the funding outcome determinants (Flick, 2018). At the time of writing the proposal, no funding was awarded for undertaking this research.

3.11. PRESENTATION OF THE RESEARCH FINDINGS

In many qualitative studies, it is acknowledged that the origin of the investigation is rooted in the researcher's perspective as the main source, though the possibility of applying the initial concept is clarified by the data collection and presentation thereof (ten Have, 2004). A full copy of the initial interview questions can be found in Annexure 4. As seen in the results in Chapter 4, the interviews often took the form of discourse. The research questions are set up with a specific interest in the City of Cape Town Metropole of Cape Town, South Africa. Flick (2018) brings to our attention that it has only recently been accepted that qualitative research can be generalised in its application, considering that this research is focused on the Cape Town area. The interviews transcripts assist in ascertaining the accuracy of the research interviews and the report findings. A randomly selected sample transcript is made available at the end of this report in Annexure 7. This allows the reader to review the recorded contents of conversations as part of the quality delivery.

3.12. SUMMARY

To reinforce, the limited literature available contributes to the difficulty of undertaking this study. As for the research method outlined in the chapter, the researcher is of the view that a qualitative

method is the best choice to undertake this study, as it is one of the preferred methods for discovering and exploring new research areas (Amaratunga et al., 2002). One of the advantages of qualitative research lies in the flexibility that the method provides researchers, while it also means that the content of this research methodology chapter needs to be updated continually throughout the data collection process, as changes might occur more naturally than when a quantitative method is selected (Hammersley, 2013). In applying Flick (2018) “internal needs and external challenges” approach to understanding the quality of qualitative research, it is realised early in the research process already that in new study fields such as VF, the perceived understanding by the research subjects is a major contributor to the success of the research outcome.

The following chapter analyses the data collected from the interviews and presents the emergent themes that can be found in Annexure 6.

CHAPTER 4 - AN ANALYSIS OF THE DATA

4.1. INTRODUCTION

This chapter will interrogate the data gathered using the research method described in the previous chapter. Also refer to chapter 3 for more information about the background of the persons interviewed. Five themes emerged from the data collection process that can be linked to the implementation of vertical farming. These are barriers to market entry; requirements for successful VF; financial implications; design requirements, and 'logistics'. These emergent themes were derived from the emergent tree node structure which can be found in Annexure 6. This tree node structure was established using the *NVivo* software mentioned in Chapter 3. Each of the respondents directly referred to items under these themes more than once during the interviews. Various interviewees had different first encounters with VF, such as I001, who saw it on the television for the first time. At the same time, I002 attempted his own aquaponic system, and I006 works in the sustainable agriculture industry. The knowledge and backgrounds of all the individuals make them relevant to this study.

It should be noted early in the chapter already that the different interviewees had different descriptions of what has been referred to as 'vertical farming' up to now. I006 refers to it as 'controlled indoor environments'. A new definition of VF coming out of this chapter is referred to as a 'production facility'.

Though expected, it stood out that most of the interviewees referred to the increase in productivity and density compared to traditional two-dimensional farming. I006 said that VF transfers to the three-dimensional quadrant by increasing the productivity of the production surface and therefore becomes a combination of optimizing the vertical and horizontal depth for optimal productivity.

Vertical farming is not necessarily something that has to be indoors but has different variations. For example, I006 mentioned that although some would see it as ultimately to do with indoor farming, others will include vertical stack production that can take the form of a tent, dome, or building and is then not limited to an indoor location. It can also make use of towers or A-frames, which are associated with NFT (Nutrient Film Technique) systems, though the majority of these associations are linked to keeping produces in a deep water culture system. I003 says that urban agriculture can include a wide array of farming activities, inter alia animal, fruit, vegetable farming, and more importantly, vertical farming. These VF activities have different descriptions and can take on production in different types of structures for various products:

I006: "So really, vertical farming for different people has a different style."

When asking the various interviewees about their understanding of VF, different responses were received while explaining their understanding of the concept. It is worth noting that everyone at least had some idea about the application of VF. Some of the more notable general answers included references to saving space, while others answered the question using the word 'vertical' in their response. I001 said "it is producing crops vertically" and that it is an alternative means of farming. I002 says that VF is interesting for its approach to saving space by farming vertically instead of horizontally, thereby saving space. An increased production area, while produces are planted in either regular soil or within tubes or bags at an elevated level, is noteworthy for I002. This corresponds with Gobble & Headrick (2019), who says that developments in crop science, energy-related technologies, climate change, and population growth are noteworthy in the VF industry.

Some of the advantages that came out of these responses are already known. I001, for example, mentioned items such as being able to produce foodstuffs closer to cities without the need for big land parcels and said that the land itself does not even have to be owned by the urban farmer. The opportunity to control seasonality in production once again proved one of the responses that all interviewees mentioned. These advantages correspond with those identified by (Benke & Tomkins, 2017) and can be linked to SDGs. People have different ways in which they perceived the incorporation of VF, with I001 being more pro to the option of having a local production facility in an apartment building that could supply the entire apartment block while contributing to the greenery of such structures.

4.2. RESULTS

Five emergent theme nodes were derived from the interviews. The emergent theme structure may be found in Appendix 6. These themes include: Barriers to VF market entry, requirements for successful VF, financial implications and costs, design requirements and logistics related factors. Each of these are discussed below.

4.3. EMERGENT THEME 1: BARRIERS TO VF MARKET ENTRY

4.3.1. LEGISLATION AND PERMISSIONS

As different countries have different regulations, the first interviewee (I001) raised the issue about legislation and uncertainty surrounding the question of whether legislation makes an allowance for the integration of VF into the South African economy:

I001: "Laws… what does the government permit and what do they not permit?"

The constant referral to growing marijuana indoors proved to be significant. This comes as I002 highlighted that marijuana is legal to produce but identified the lengthy application process for

obtaining a growing permit as a tedious process that can take up to two years. The growth of this green substance at new 'high' levels and under indoor environments is gaining popularity, as identified in the already existing and successful VFs which are in production in Cape Town, I006 reported.

Although there are current indoor farms, the time and input costs for even growing marijuana remain sky-high, according to I002. He believes that growing this product under indoor climates can be financially viable, though it is vital to first reach an agreement with the local government. I002, who said that the growing of medicinal marijuana could be economically feasible, has undertaken numerous cost analyses for the conversion and repurposing of other use buildings and has even undertaken financial feasibility studies for growing marijuana indoors.

Clarity could not be reached about whether local government will allow VF in buildings, but it was noted that the City of Cape Town Municipality is believed to be optimistic about incorporating green spaces into the urban setting and is already permitting roof gardens as indicated by I002, I005 & I006. I002, who said that the city should be pro-urban greening, also said that:

I002: "It's a positive environmental impact on people, health, carbon emissions, and all of that. So they're (the government) is definitely in support of supporting that idea. Whether your neighbours will be supporting when you rip out all the windows, and you do a vertical farm thing of 12 stories next to them, when they have paid three to four million ZAR for the apartment - that might be a different thing."

Arguments like these prove that persons will have opposing views about VF and that people do not always understand the full extent of VF as a production facility. I003 referred to VF as 'food gardens' located within or on top of a building. This description is likely more connected to the individual's perception of city gardens projects as he is involved with such projects.

I003 noted that the City of Cape Town has struggled to implement indoor and rooftop farming for about the past eight years. The main reason, according to him, is constraining by-laws and includes inter alia the by-law of spatial planning, the by-law of health conditions, the by-law of land use management, and the consideration of access to the building from the road. Road access to buildings especially becomes a big concern when operating at a commercial scale. Adding to the tediousness of the application process is the inter-departmental collaboration between city self when addressing these by-law requirements, while these by-laws are reviewed every 5th year, I003 says.

I003 recalls a person who wanted to apply for indoor farming in Woodstock about 6-8 years ago but decided against the application after seeing all the by-laws. In recent years, an inter-departmental collaboration stepped in, intending to speed up the application process for projects while creating an

integrative set of by-laws. All of the respondents said that VF would be implemented in the future, with most interviewees being hesitant whether it would be soon. I003, who works for the municipality, provided some hope that the implementation might be quicker than expected by some of the other interviewees. This comes as Canadian authorities helped draft the previous revision of the city's urban agricultural policy in 2014, with the specific introduction of rooftop gardens, highlighting the local municipality's open-mindedness. Furthermore, I003 says that the implementation of indoor farming has been discussed internally over the past three years, which gives further hope, bearing in mind that Canada is one of the prominent role players in vertical farming. Hopefully, Canada will again be involved in revising the urban agricultural policy for the City of Cape Town, which is set to be updated within the next two years (I003).

To comply with all the relevant regulations is a tedious process that generally takes about 18 months if everything goes smoothly (I003). During this period, all the departments involved in the specific project will comment on implementing such tasks. Although it relates more to urban farming than vertical farming in a building, I003 mentioned another individual interested in urban agriculture and wanted to put up a food production tunnel on a parking area in Loop Street. The community's disapproval led to the entrepreneur removing his production tunnel:

I006: "Controlled environments or indoor farms most likely would be situated in the urban setting, and the department that's in charge of those types of contexts would be your urban management department. However, it is still a farm and requires support at an agricultural level, but it wouldn't be able to receive that score. Rather the type of support that this kind of agriculture could provide would not be applicable for them. They wouldn't need extension offices. They wouldn't need cap funding, which would be primarily for paying for tractors and inputs like seeds and stuff like that. So because of that, it's one of the ways in which legislation is not ready yet."

The above quote by I006 determines who the leading role player is from a local government's side. It also addresses the description, which has been used up to now, to describe indoor vertical farms. I006, who researches different green technologies, suggests that VF should instead be referred to as 'controlled indoor environments' located in urban settings.

I001 believes that the government will support VFs if it can aid in growing the local economy, and describes VF production facilities as a "safe house". This can probably be seen for the financial support that it lends to building the economy and the food security it provides. Yet all public and private sector interviewees agree about the city's readiness to implement VF, namely that there is still some work. I001 says that all industries are "interconnected". Although cross-departmental co-working is taking place, I006 noted that it is unknown whether the required level of intersectional, inter-departmental

work needed to monitor and support urban farms is there yet. This comes from the observation that the department which supports urban farms don't really work with urban agriculture at a commercial scale and plays a more active role in programs such as school feeding schemes and community farms when interviewing I003, as mentioned by I006.

4.3.2. POOR MANAGEMENT

Forsberg & von Malmborg (2004) reiterate the importance of management. In one conversation held, the viability of vertical farming as a food solution was not as much under fire as the management of such farming projects:

I002: "I think in saying that it is viable and it is a definite way that the world is going. But I'm also saying that it doesn't come without its problems and challenges. You need to be aware of it. It's not something that you just pay the money, you get the system, and you make money for the rest of your life. It is like farming. You've got the same problems as what you have with farming in terms of pest control and water, supply issues, quality of water, not enough sunlight, and overfeeding. You need to be a farmer to actually be able to manage the system."

Persons whose interest will likely be attracted, such as traditional property developers, might not have the skillset to undertake and manage VF projects by themselves. But then again, developers do not handle the facilities management, and even before that, the actual construction management when undertaking developments. Instead, they use specialised persons such as consultants and contractors. However, the person driving the development usually understands the process to make the numbers work. Therefore persons interested in VF will need some holistic understanding of the process as a whole. I001 says that VF can bring advancement in knowledge, wisdom, and the way people think.

When asking the project management professional about the ease with which VF projects can be managed, he said that it is like any other project as the stages throughout all projects remain the same:

I002: "I think it's got the same elements of any project as it's, planning coordination and putting it together. It's got the same elements in terms of feasibility and all of that. There are very specifics in terms of the growing of whatever product you want to grow in, which obviously we wouldn't have the knowledge in, and we'll definitely approach someone with the correct knowledge and expertise related to that. But the same principles will apply. I think the same principle, also applying with regards to getting approval for whatever you want to do in the building. I've not checked the legislation from the council in terms of converting any type of building into a green building. And one, we'll have to check that out, whether that's actually legal to do that."

When asking I001 how easy it is for him as an industrial engineer to improve a process that he has not worked on before, he said that it is one of the things that he enjoys most about his work – being able to work on a vast array of projects, with diverse backgrounds. The only difficulty in something like VF is that I001 will not monitor an existing system that needs improvement, as VFs will require extensive planning from the beginning. I001 said that the primary method of improving a system is first to analyse the existing system, which does not exist yet at this stage. On a positive note, he believes that anything can be improved in life, as everything follows a systematic process. This way of thinking taught to engineering professionals enables them to work on miscellaneous projects.

I002 and I006 both stated that they are aware of firms in the City of Cape Town metropole which can assist in delivering turn-key VF projects by meeting individual expectations in terms of upfront cost, design layouts, and more:

I002: "They'll tell you what to farm with as well, and even be able to do a feasibility study for you on it. So they're already here. I think my understanding of the guys that I've spoken to is that they focus more towards people that want to invest in high-density growth. I don't think they specifically say vertical farming, but they can obviously do that. But it's more in high-density crop generation that they do. So they are out there."

Persons working in this specified, built environment field will contribute to the character of the environment and can cause clients to favour the demand for products grown in such areas, Chang (2014) says. Matters of concern for the implementation of VF mentioned by I001 included ground conditions, whether South Africa can build such buildings, and whether government restrictions will allow such activities, not neglecting the impact of politics. I002 alluded that typical team members will include persons with a keen interest in the landscaping field and said that these individuals are often referred to as "horticulturists" as it is becoming a more specialised field than general landscaping:

I002: "It's not your average garden or your average project manager that will play in that field."

4.3.3. WHY VF WON'T WORK

I001 stated that the increase of technology is beneficial and necessary for the future. He believes that one needs to consider the impact that it will have on the everyday living of persons employed in such fields, as highly advanced technological fields often don't offer as many employment opportunities. The government would consider activities based on how it impacts the community and employment numbers, I001 said. Although I002 believes that VF would be taking jobs from other traditional horizontal farming activities, I006 noted that it is not the case as VF will require more skilled labour, with possibly fewer labourers in general.

I002 is hesitant about implementing VF for everyday consumer products, as he undertook a feasibility study himself, which resulted in deciding against it. He even included a time frame and said he doesn't see it happening within the next 40 – 50 years. Two of the main reasons for deciding against VF are higher benchmark earning properties, such as accommodation, restaurant space, hotel space, and office space. Secondly, the high costs of electricity and rentals.

4.3.4. BARRIERS IN A LOCAL SA CONTEXT

I001 said one of the reasons for not seeing a more significant uptake of VF in RSA is that it is relatively new and that not many people have heard of it, adding to the uncertainty about whether it can work or not. Farmers who supposedly have heard about VF are likely to be extra cautious about it, as you require more intense infrastructure, which comes at a higher cost when compared to traditional farming, according to I001, I002, and I006. I005 says that it is essential to remember that suppliers are farmers at the end of the day and that they don't have 30 million ZAR to put into a vertical farm that may or may not work. Also, there is no guarantee how the customer will receive it, number one, and secondly, if they will be willing to pay for it. Pinstrup-Andersen (2018) says that the initial costs of new innovations and technologies are high and come with an elevated risk of failure.

I005 says that an upmarket retailer (who he worked for) in South Africa considered letting some suppliers implement VF about two years ago. High initial investments halted the implementation. He says that retailers are often placed in a difficult position when they don't have a product on the shelf, which leads to asking what the related reasons can be, with reasons generally being weather-related. Indoor farming is referred to by I006 as a "complete controlled environmental agriculture" and believes it significantly benefits countries with high volatility in weather patterns. She believes that some of the biggest drivers in the uptake of VF are extreme weather conditions and high water scarcity areas, such as in the United Arab Emirates, for example. Other drivers include land scarcity in places like Singapore or Thailand, where intensified production is required. This aligns with what Kosorić et al., (2019) said wherein densely populated cities, such as Singapore (the second-most densely populated country in the world) vertical high rise buildings constitute more space per area than horizontal surfaces such as roofs. Benke and Tomkins (2017) say that one of the main drivers of vertical farming is the need for agricultural land, which is only obtainable by building upwards. I005 and I006 mention places like Iceland, Norway, and Switzerland in their examples of sites where the sun hardly shines, and because they do not have a choice of production they use VF in these areas:

I006: "The sunlight that they do get is often not for long enough or very intense. In South Africa, we don't have that. Although our land is not very arable, there are ways to get around that, to get the productivity that you need either by putting in synthetic chemicals or by just adopting stainable

agriculture practices, which gets you to improve the carbon in your soil or to improve your soil self. So although there are limitations to how we grow, our context is not as dire as the bigger players in indoor farming."

The market of economies comes into play when you start producing different products indoors. I003 says that the department of agriculture is responsible for gardens sized between 500m2 to one hectare, while the urban agriculture department is responsible for gardens smaller than this. Following the interview with I003, it was noted that the focus of the smaller gardens is usually more community-oriented and takes the form of city food gardens. In comparison, the bigger gardens are more focused on business principles.

Items such as strawberries will make sense to be produced indoors according to I005, as they will not be costly. In contrast, producing something like baby leaf spinach becomes extraordinarily expensive. The reason being is that customers are not used to paying specific prices for certain products, while such prices are seen as the norm for other products. I005 compared the disposable income of RSA citizens to first world countries such as Hong Kong, Dubai, and some American cities in saying that the disposable income of South Africans is meagre when compared worldwide:

I005: "For example, the price of potatoes has been the price of potatoes for the last five years. It just doesn't increase. It doesn't increase because people don't feel it's worth paying for. So I think in a South African context, maybe the top 1% of the country would consider doing something like that. Here it's only really maybe a [company X] who can pull it off (in my view) and saying that I would say even at a store level - where they will have a small little something going on top of the roof or something like that, for some herbs or some strawberries or something like that.

When considering the labour supply, I006 says that indoor farming is a very specialised field that raises the question of whether South African can provide enough skilled labour for this possible new field. This comes as many current traditional farming employees are semi-skilled and do not possess the more technical skills required by VFs, which often relate to the ICT management side, electrical engineering, and process engineering according to I006:

I006: "People are more greatly trained with tractors and driving tractors than the budget. So basically, we just don't have the type of agriculture sector where indoor farming would not be a more costly endeavour than just producing on land."

I001 believes that it is important to consider how the implementation of VF will impact the community surrounding the production facility, in terms of various aspects, including logistics, noise, and pollution levels. I002 questions whether developing countries particularly will have the skills to adopt VF

practices. Stats SA (2019) refers to SDG 4, which is concerned with education and knowledge development and relates to creating the required skill for the implementation of VF. Although regulations were discussed as to their own topic above, they are duplicated as a requirement for VF's implementation heading.

4.4. EMERGENT THEME 2: REQUIREMENTS FOR SUCCESSFUL VF

A few of the requirements for the implementation of VF mentioned by I001 include the advancement of technology; the skills, knowledge expertise, and equipment to construct appropriate buildings. I001 was optimistic about the uptake of VF in South Africa and said the following when asked whether he thinks that VF can work in Cape Town:

I001: "Yes, I think I'm positive that it can if there's space. How far in the future? I don't know. I also don't know, as I've mentioned, about the restrictions and how the government sees it."

4.4.1. INFRASTRUCTURE

I001, I002, I003, and I006 referred to the importance of infrastructure in cities for incorporating VF technologies. The importance of infrastructure development is seen as a priority in the National Development Plan (NDP) as mentioned by Stats SA (2019). Specific items mentioned by I002 under this topic include resource-intense items such as water and electricity. I001 says that structural steelwork is also costly, and one needs to consider the commuting and up and down movement within buildings. Movement becomes an 'elevated' problem, with activity between the various storeys and between the vertical 'inter-levels' created on each floor level. Once the product has reached the level where it can be sold, the next consideration becomes transportation. I006 says that current urban infrastructure is not designed to accommodate VFs.

4.4.2. ORGANIC PRODUCTS

I001 says that there are persons such as quantitative analysts and marketers who can provide customers with ease of mind and proof that these indoor-grown substances are safe for human consumption. I001 believes that these persons can provide its target market with ease of mind regarding the pros and cons offered by such products. Persons who undertake VF can also be advised how the market will react, I001 said. He believes that if the product looks and tastes the same as the original product, it should sell similarly to regular products. The only time that such products will not sell is when you start altering the genetics; for example, if broccoli would be blue - I001 said jokingly.

I004 said that people would likely receive VF with an open mind, as it will probably be associated with organic products. The market's preference for organic products is confirmed by Pinstrup-Andersen (2018), who mentions that in places such as Europe and the United States of America, organically

grown products do not include products that were not grown in soil. The growth of organically produced products in the market is exponential, with I004 reporting a growth rate of about 150% year on year during her time of working as a buyer for a Canadian food retailer a few years ago. I005 said that people are conscious of having chemicals in their food. I004 said that parents today are looking at buying items that are not genetically modified or contain extra added hormones and, therefore, do not only look at what they purchase but also who they buy it from:

I004: "So to be able to provide a standard of food that people are used to without the chemicals, I think is where the future would be."

When asking I004 whether one will apply the same quality control tests to fruits and vegetables produced indoors, she said yes and that the quality should be much better than conventionally produced products:

I004: "I think the vegetables would be tastier and have more flavour because they don't have all the chemicals and pesticides in them as well. I think that they would in terms of quality, be better quality and would have a longer shelf life, but I'm not too sure on that one - but the quality would be better if that makes any sense to you. So quality better, shelf life - I don't know if it would be better."

I004 said that she is unsure how the shelf life of products produced in VFs will be influenced, while I005 said it should be longer as one controls what goes into it:

I004: "Well, organic fruit is not longer. Organic products has a shorter shelf life. If I look at strawberries, organic strawberries, or organic pepper -, the shelf life is not as long as on conventional products."

4.4.3. ADVANCEMENTS IN TECHNOLOGY

I001 suggests implementing controlling technology in VFs that can monitor the growing process and compares such systems to an alarm system that operates automatically at set times. The subject of managing technology was noted as noteworthy from the literature review.

I002 is concerned about the effectiveness at which VF buildings can be used as production facilities. He says that if mechanical systems are not employed in the production process, VFs become limited in planting space as a lot of sunlight is required. Planting space on the external façade, which includes balconies, rooftops, and areas close to the outside perimeter buildings, then becomes limited, I002 said. The ability to control pests and insects was mentioned by I004 and can, by itself, be seen as an advancement in technology.

4.4.4. SUPPLEMENT, NOT SUBSTITUTE

I001 says that VFs can produce more than one product simultaneously and uses the example of having cucumbers in one area and tomatoes in another area. I001 also said that VFs are not meant to replace traditional farming but instead to supplement the existing supply. I001 elaborated by saying that if you, for example, have a conventional farm producing mushrooms in a specific location, then you won't need mushrooms in such a place but would instead plant something else that there is a shortage of in the area:

I006: "But more often than not, what you find is that you have farmers who want to add another aspect to their farm. So a farmer who may have been farming in soil but has a greenhouse will then want to then include hydroponics into their system, or they might be farming in tunnels, and then one might want to add up a poly roof structure to their production. And the idea behind that is that everyone is slowly but surely moving towards more controlled environment agriculture, but not everyone is going to get there at one time. So that's kind of us trying to figure out what are the business cases around that and what makes things for specific farmers and specific contexts."

I004 and I005 both reminded the researcher that VF uses less water, while I005 said that: "the natural environment will force you to go down that route" when asked about the implementation of VF. This not only refers to the outside natural environment but also refers to the shift in the consumer market's mindset when he later says that: "People don't want pesticides and they don't want to hear about GMO stuff."

I004 says that traditional farmland is over-farmed, with the soil decaying in quality, and I005 says that this over-farmed farmland has become very expensive. I006 mentioned a case study that they undertook for rooftop farms to be located on top of a mall's roof in Johannesburg. The idea is that these rooftop farms must supply the restaurants in the mall with fresh produce and is operated in partnership with one of the better-known start-up companies in this field in South Africa:

I001: "I mean then they can accommodate each other. It's not necessary that they affect the farmers negatively, locally."

4.4.5. GARDENS AS GATEWAY

I006 says that much of the urban farming uptake experienced has taken on the form of city gardens and believes that regulations serve an essential purpose and protect the urban authenticity of cities. When asking I006 whether she agrees that roof gardens are the beginning of VF in South Africa, she responded:

I006: "Yes, definitely". Once it becomes popularized and before people run out of space, but it's already starting with your more medicinal products. It really just is about making sure that the productions that are already produced remain productive and profitable and that will encourage people to enter into the space."

I003, who is involved in the urban garden farm programme at the City of Cape Town, said that a few of these gardens are located at schools, clinics, hospitals, police stations, hospitals, and community gardens. The food produced by the gardens located at the schools then goes to the school's food kitchens. The leftover produce is sold to the local community, and proceeds are returned to the NPO, which the community registered when starting the garden. This money is then used to finance the continuous operations of the NPO. These NPOs are then registered with the social department, which grants permission for five years to conduct activities and provide support to the NPO, according to I003.

I005 thinks that only one retailer in South Africa can get it right to establish a successful commercial food-producing VF in South Africa. He says that even this high-end retailer will only get it right at a store level to have something small on top of the roof with higher-end products. Although his belief does not refer to commercial single building VFs that this study investigates, it suggests that roof farms might be the beginning of indoor facility VFs.

4.4.6. A HEALTHY, GREEN SOLUTION

I004 says that people should not be hesitant about buying products produced in VFs. Clients will likely associate such produce with conventional hydroponic production, which is regarded as higher-end products in most cases. I005 agreed with this and said that though it should be explained to people, while the cleanliness in the production process further boosts the product's image. The ability to control what goes into the product during the production process will persuade a few more people to buy it, I005 said.

When asking I004 of what she thinks of VF, she responded with:

I004: "I think it's interesting. I think some countries and cities would benefit from it more than others. Like for instance, say a country like Dubai who cannot grow any of their own products and where everything is imported might benefit from something like this. Because they can then grow their own certain vegetables all year round themselves.

I004 says that she is not 100 per cent convinced that VF will be implemented in South Africa, as many products in South Africa, with specific reference to Cape Town, are grown locally. She also says, that South Africa will benefit from producing items that are not available all year round that are now being

made available, with the cost of production being the final item of persuasion. Even though VF is more expensive, one pays for the eliminated risk of weather-related damage, I004 said.

4.5. EMERGENT THEME 3: FINANCIAL IMPLICATIONS AND COSTS

Despite the newness of the VF field, I001 says that one can do calculations to determine the profit targets, space required, and the number of plants related to these parameters. He believes that traditional farmers can become a great asset in this regard. They are among a few professionals who can advise about the plant spacing and general design considerations:

I002: "Okay. Here's the question. Um, any type of farming is what is your, what is your cost versus what is your return on your investment. That is any business concept. So if you take a building and you are going to start adding up the cost of the building, if you're renting it, you've lost the plot. So if you add the cost of your rental, plus the cost of your water, plus the cost of your electricity to that equation, plus obviously your input cost and the return, then I've never been able to actually make those numbers work. You come out negative on whatever you look at."

I002 had a strong opinion of why people who invested in the VF business have done so, as he believes there is no money in it. One of the reasons is that people have done it is not for its financial benefit, but because they feel that it is the right thing to do, I002 said. His thinking manifests in people selling these VF systems online on second-hand websites and says that they would not be doing so if the systems were making money. I002 believes that another reason for people selling these systems is that they are required to play at a bigger commercial scale than they most likely thought would be necessary.

In I001, saying that one can determine the production facility size in square meters based on the specific product(s) that one intends to produce, one can also choose the optimum production product mix for optimal gain. Pinstrup-Andersen (2018) believes that more evidence is required to determine the economic feasibility of vertical indoor vegetable production in urban areas in low-income countries. I002 agree with him:

I002: "It's the feasibility of the project that I think throws it out often. And not just for vertical farming, but for any type of development."

4.5.1. INPUT COSTS

I002 believes that the success of VF is determined by the ratio of costs versus return on investment, with some of the main cost items, inter alia, being the planting self; the material required, the planting containers; the cost of the building and, or the land; the cost of electricity, the cost of water to mention a few obvious ones:

I002: "And if that cost is not less than what it is to farm outside on an open piece of land, and to bring that product from there, into wherever the product is needed, it's not going to take off. It needs to be commercially viable."

Although the initial start-up costs are excessive compared to traditional farming, the costs become more comparable once the VF is up and running, I005 said. Yet the initial cost for the establishment, which is mainly due to nitty-gritty items, must be incurred and paid for to enable the production cycle to start, with these costs reducing in the long run due to higher yields achieved according to I005. The use of green technologies such as solar power increases start-up costs even more, but the long-term benefits come at a much lower cost, I004 said.

4.5.2. WATER COSTS

One of the on-site considerations that I001 mentioned was the ability to store water on-site and the availability of space to store such tanks. I002 describes water as a secondary cost item which becomes especially problematic in the city centre.

I002 has a solution for the water problem and says that the water table is extremely high in the City of Cape Town city centre. He says that some people who do vertical farming tap into these underground water sources that form streams and rivers below the earth's natural surface to supply their VF production units. This free water is then set off against the electrical cost of extracting the water and pumping it to several heights within the vertical system. When asking I002 whether this is similar to a borehole, he said that it is not quite. This is because it is firstly not so deep and is closer to the earth's surface, and secondly, the water runs towards the sea in self-made channels within which it accumulates.

Even this water discovery proved that the costs do not yet allow for the implementation of VF. This idea was brought about by inner-city buildings having deep excavated foundations, which led to discovering this water source which then uses wells to pump the water out so that the buildings do not get flooded, I002 said. I002 says that basements are often 6, 7, and 8 storeys below ground level and in the way of the water, which naturally runs underground from Table Mountain towards the sea. Innovative gestures such as these can help fight the damage caused to ecosystems, water supply systems, and food security, mentioned by Stats SA (2019).

4.5.3. COST OF LOCATION

I002 says that the VF location is a significant cost factor, with I001 believing that there is a lot of uncertainty around where these production facilities need to be located. I001 says that an important

question is how far out of a city VFs can be in terms of the client market or, putting it differently, how close these farms need to be to the city?

I002: "Geographically, for instance, the further you go away from your city centre, the cheaper land becomes. If you look at, for instance, the cost of land, in Paarl and Stellenbosch areas which is relatively close to your market, versus places like Worcester, Robertson, Ashton, Swellendam. In those areas, land prices dramatically decrease. I mean, you can buy beautiful farms in Robertson, Ashton, and Swellendam for very little money. But if you look at your cost to get your product from them, in terms of anything that you grow to the market, that is actually what kills it - it becomes uneconomical."

I004 says that places like Dubai, which also happens to be big on organic products and where 90% of fresh produce is imported throughout the year, are an example of a place that will benefit more than others from VF. I004 also says that she does not see items produced in VFs being traded internationally as it would be too expensive, but instead says that each location will have its own production facility where it makes financial sense. Resultantly, one cannot ignore VF's economic export opportunities. Although Benke and Tomkins (2017) says that the potential of VF and imports and export cannot be overlooked, I004 says that each location would rather have its own production facility. I004 further disqualifies imports and exports by saying that air freight is expensive and unreliable in terms of fresh produce climate control requirements.

I002 says that where a piece of land is located, including its type of ownership, whether a leasehold or full ownership, influences the financial model. I001 noted that it becomes possible to contract the VF production facility for someone who has the required skill set to manage such projects. This then becomes an additional revenue income stream for the landowner, and tenants enjoy the benefit of having freshly grown substances available within immediate proximity, whether being within the building or on top of the building, by taking the form of a rooftop garden:

I002: "I think it's a factor of, you know, do they have roof space available? You know, again, if you look at your rental costs, I cannot see that you're going to at rentals now going anything from between 90 Rand and up to 250 Rand per square meter to farm that out of a farm, or to get that return on any plants that you do. It's just not possible."

4.5.4. ECONOMIC PRODUCTS

I006 says that indoor farming is much more expensive to produce per kilogram when compared to more familiar products such as spinach, cabbage, and carrots. Niche products like herbs, leafy greens, fancy lettuces, and frill lettuces grown under hydroponics will likely receive more attention by VF, I006

said. These niche products have started in the restaurant industry but spilt over to household consumption and are now stocked by the general retailers in South Africa. I006 admits that if everyone keeps entering the niche market, this market will experience constant crashes, implying high price volatilities as niche markets become saturated quickly. To answer Pinstrup-Andersen (2018) about why some VFs are financially successful and why others are not, it seems like the VFs producing niche market items are the ones prevailing their existence. I006 says that VF has the potential to bring down the prices of these niche products by increasing the local supply of these products - which is good for the South African economy:

I002: "Unless you really go in 'high'. I've actually looked at that unless you go into dagga (South African slang for Marijuana) - That's actually quite feasible. And then you can dagga is one of the many things. But again, with dagga, and we looked at a scheme where we actually did a costing for a client on that. It works. The numbers actually work quite well, but you need a market for it. You need a take-off agreement on dagga. And that's very difficult to come by."

I006 says that persons wanting to produce niche market products need to understand the nature of the process. I002 says that the application procedure for obtaining a permit to grow marijuana is a tedious process that can take up to two years, while it remains a costly exercise in terms of input costs. Although this is one of the few times that I002 said that VF could work under current market conditions, he highlighted that an agreement for growing is a critical item that can make or break the equation:

I006: "What we do know about indoor farms is that often they don't necessarily target your average produce or genuine market. They will tap into premium markets. So often, they will target restaurants. They will target outdoor markets that you see. They will target your hope home food delivery market, and those markets are always willing to pay."

I006 says that VF will likely focus on the higher-end market consumer. Even though VF will not create as many employment opportunities as traditional farming, I006 believes it will still boost the local economy. I006 believes that many knock-on benefits will come out of VF, such as an increase in the number of LED light suppliers:

I006: "There are opportunities for the just producing stuff, but there are also opportunities for getting into the production of components of vertical farms."

4.5.5. ENERGY COSTS

I001 mentioned that when companies consume a certain amount of electricity, they are billed at a specific rate. Although the cost of electricity remains expensive, one can project the costs thereof,

given that a constant amount of electricity is used according to I002. I002 says that persons dependent on the local Eskom electricity supplier must find alternative backup systems for the event of load shedding, possibly including generators and solar power. I006 says that the high electrical cost is related to lighting but mentions one indoor vertical farmer who got it right to reduce this cost drastically by implementing LED lights and is fortunate enough to have worked in the lighting industry before.

I002: "But putting those grow lights in is expensive and the running costs of it. I can almost be certain that if you do the numbers, you'll find that it will be cheaper to buy your fruit than to grow inside."

I003 believes that overcoming the high electricity costs by installing solar panels on the roof and writing it off over a certain period of years can overcome the issue of energy. I006 mentioned that indoor farming requires a lot of energy and a constant supply thereof. South Africa is burdened with high energy costs and is targeted by regular planned power outages in the form of load shedding. Producers are at risk of losing their harvest when the electricity goes off as the electricity is used to mimic the outdoor growing environment, I006 says. I006 believes that the cost of solar PV is very high at this stage and will put a few more investors off. According to I003, the application procedure to obtain the rights for VF is more of a concern than the high energy costs.

4.5.6. THE COST OF WASTAGE

Although the start-up costs are high, I005 believes that optimal production resulting from the controlled environment and less wastage are some of the benefits of VF:

I005: "And you don't lose anything. If you have the scale, it could be a lot more cost-effective because a lot goes to waste in farming, and I don't think that everyone quite realizes that."

One of the biggest causes of wastage, according to I004, is temperature control during transit. She says that airfreight has the least control over temperatures when compared to vessels:

I004: "The airlines don't necessarily have the facilities, or they ignore the facilities that they might have. And the product doesn't necessarily get put into the proper storage while it's at airports and everywhere else. So you can see a lot of issues because of that."

I006 believes that South Africa is quite productive in conventional farming as the Western Cape specifically: "is considered one of the most productive areas per hectare in the country". She also says that due to VFs being located closer to the consumer market, one would possibly not require the cold storage management that farmers located from afar would need:

I006 says that people do not always realise the amount of wastage involved in food production.

I001 and I002 asked the question about how waste and wastage will be handled, considering the odours in dense areas. I006 mentioned a farm in the Phillipi area of Cape Town that uses a bio-digester as an alternative means to reduce wastage:

I002: "So the limitations put on it (VF) may constrict its growth, but it is there because the wider users of that space require it."

It is crucial to be aware of general waste management regulations. I006 mentions that the greater City of Cape Town area requires such polluters to have a license when producing more than 10 tonnes of waste per day and comes at the cost of about ninety thousand rands, which is payable upfront. Hersh (2018) says that VF will result in less wastage than traditional farming. I006 says that this limitation is due to the city's waste treatment facilities not being prepared to treat more significant volumes and is determined in line with the EIA:

I006: "General regulations make it difficult, but at the same time, it's important to consider the fact that indoor farms happen inside a context, which is vastly dissimilar to what it is."

4.5.7. UNDERSTANDING THE FINANCIAL IMPLICATIONS OF SUPPLY AND DEMAND

I002 says that the reason for seeing vacant buildings in the Cape Town CBD and, in general, is often misunderstood. He reasons that many of these are government buildings that are in the process of either being sold or are/will be undergoing remodelling. Covid has caused an over-supply of commercial space as tenants moved out of their offices, and it will take a few years to fill, according to I002:

I005: "I don't think the world has a choice. I think we're running out of farmland."

A few steps in the redevelopment process entails site analysis and acquisition, land re-use approvals, market analysis, financing, remediation works, redevelopment and liability protection, project organisation and sequencing, design, regulatory, and community reviews (Hersh, 2018). I002 used an example of a project he worked on that had to be converted into a hotel. The building stood empty for four years and only had tenants on the ground floor, with nothing going on the remaining seven storeys. Then the building was sold, but the person who bought it miscalculated the feasibility study and ended up selling it after two years. The new owner took two years before commencing with the development:

I002: "So I think that building stood empty for about nine years before it eventually got an occupant. I think sometimes buildings are in the process of being developed. It just takes longer than what it should or what people actually anticipate it should take."

4.5.8. CONNECTIVITY COSTS

Other than electricity, I006 also mentioned connectivity cost as a considerable expense. This is due to everything being automated to control and monitor variables such as temperature, humidity, and luminaires, electronically - which requires constant connectivity. The cost of connectivity is high compared to other countries such as Europe and the United States (I006).

Another critical point made by I006 is that VFs will require higher-skilled labour that will require more training than conventional farming would, which comes at a high cost. More specialised employees will be employed than traditional farming, but fewer employees in quantity, I006 says.

4.5.9. COST OF LAND

I005 says that there is not any more or less farmland available than there used to be and that it is just a matter of who owns the land and how productive these farms are. The current prices of products are then, according to I005, not so much affected by the cost of the land self, but rather by changes brought about within the market self. He uses the example of the Limpopo province who had a lot of frost damage a week before the interview and says that this has already caused a 30% increase in the prices of certain products produced there, with tomatoes and baby spinach already seeing this price increase.

The demand for land is why densely populated cities, such as Singapore, use high-rise vertical buildings, which constitute more space per area than horizontal surfaces such as roofs (Kosorić et al., 2019). Singapore is one example of where farming land is scarce, and new developments further reduce the area (Tablada & Zhao, 2016). One of the challenges faced by rapid urban developing countries such as China is that the government has the responsibility to ensure sustainable food security by protecting agricultural land (Zhang et al., 2020). I002 said that the cost of producing fruit and vegetables in South Africa, especially in Cape Town, is still relatively cheap. This results from an abundance of traditional farmland, which is available at a relatively low cost:

I002: "If you look at other places like China and even in Europe, there are more places being taken by accommodation, and the land has become less and less. It's scarcer. It's also further away from where the product is needed. So now they are forced out further, which means that the transport becomes more expensive. It means that the produce being produced in the city centre can effectively demand a higher price for it; because it is already at the point of need."

I005 believes that the cost of the land itself has little to do with the feasibility equation in VF, as the other input cost items currently dominate the calculation. I005 worked for an upmarket retailer who considered the implementation of VF about three years ago as an alternative food production

method. He, unfortunately, left the company and could not comment on how far they were in the process. He, however, noted that the costs were prohibitive at the time and therefore stalled the process while he was there. I002 says that the high initial cost of the land is cannot be recouped in the higher production outputs obtained. I002 says that his VF investigations suggest that land is often given at a reduced price or even for free, which skews the equation. He refers to rooftop gardens as an example hereof:

I002: "So what I've seen is, (and we've done quite a lot of investigation into in-city farming) and there's a couple of projects that are currently running, where on top of existing roofs they do vertical farming, on top of old buildings and so on. But the cost of the land in most cases is given for free."

4.6. EMERGENT THEME 4: DESIGN REQUIREMENTS

There are numerous already existing environmental assessment tools to analyse the built environment. These, inter alia, include a review of energy usage, climate control and health conditions inside buildings, using green building materials, and others (Forsberg & von Malmborg, 2004). Factors disqualifying the functionality of a building are often related to its shape, size, and configuration, I002 says. He mentions the inner Woodstock area in Cape Town as an example by saying that this neighbourhood accommodates a lot of big, deep space buildings. These buildings would not fit residential conversions as people want windows and natural light in their inhabited spaces. Although these buildings become prime examples of structures that can be remodelled to accommodate VFs. I002 says that this will incur extensive electrical costs resulting from mimicking the natural growing environment of such produces. He argues that using only the outside perimeter of the building for production will disqualify the proposition at the beginning already:

I002 says that VF should perhaps not be referred to as vertical farming but rather be called "farming within buildings".

4.6.1. CONSIDERING CURRENT

One of the parameters I001 suggested for measuring possible support provided to farmers in urban agriculture can be seen in whether governments currently assist traditional farmers. Many of the respondents are hesitant about whether VF will be taken up soon. For example, I002 doubts whether VF will, within the next 40 to 50 years, be able to complete with traditional commercial farming, not even to mention the competition offered by other property income streams such as accommodation, restaurant space, hotel space, and office space. Some of the challenges faced by city farms listed by Gobble & Headrick (2019) include high energy costs, high associated labour costs, and the high costs of urban properties, which are some of the main reasons new start-ups fail. Benke & Tomkins (2017)

reaffirm that start-up costs are excessively high in many cities due to higher real estate prices than rural land prices.

I003 was not aware of any VFs within the Cape Town Metropole buildings at the time of the interview but only knew of tunnel structures in use in the city. I006 was the only interviewee who could provide an assertive “yes” answer when asking whether there are any VFs in and around Cape Town. She also said that it is essential to note that VFs do not necessarily produce for human consumption. I006 mentioned that these current VFs produce for human consumption, medicinal products, and animal feed products:

I006: “You can do indoor farming that doesn't necessarily deliver produce that is for human consumption.”

The only food-producing VF in the Cape Town metropole that I006 mentioned was a newly set-up farm at the time and is located in the Paarl area. This tomato farm did not produce a harvest yet at the time of the interview but was expected to deliver its first production in October 2021. Other farms mentioned, which are not in Cape Town, include a lettuce farm in Pretoria. Although this newly established Paarl VF has only existed since this year, I006 says that the person who helped establish this farm has been in the indoor farming industry for about ten years. His LED lighting background and skills assisted him in bringing down electrical costs dramatically and contributed to his success.

The current medicinal farms mentioned by I006 produce mushrooms and cannabis. The mushroom farm makes use of aeroponics, while the cannabis farm uses hydroponics as a means of production. The medicinal mushrooms contents are extracted in a way similarly applied to medicinal cannabis, I006 says. This mushroom farm has not been in existence for more than five years, according to I006. I006 also referred to an indoor VF company located in Pinelands, Cape Town who produces proteins used for medical tests, such as COVID tests.

The medicinal production in VFs will justify such investment costs, I006 says. She reasons that you can guarantee consistent quality as one can monitor all aspects of the production and plants, and secondly, the products can be kept contaminant-free. By tracking the production process, I006 says it is easier to identify where one has gone wrong if the desired quality is not achieved and also means that one can identify new ways of improving the production process.

One of the animal feed farming solutions, mentioned by I006, includes the production of ‘Black Soldier Flies’ indoors. The flies are used in animal feed products due to their high protein content. According to I006, a few Black Soldier Fly companies are established already, with one located in Philippi, Cape Town. These flies often feed on organic waste, making them an excellent protein replacement, not

only due to their reduced carbon footprint compared to fish meals and soya, for example, I006 says. This endomeal is then fed to fish, chickens, and pigs, I006 says. This Phillipi-based company has been operating on a pre-commercial scale for a long time before going over to commercial scale in 2019 and has recently taken over another company's business (who will remain unnamed for anonymity reasons), I006 says:

I006: "It is a great waste management tool because you're able to divert organic waste, which would have gone into a landfill into these types of farms and able to get really great protein products, using your indoor farming where you are testing and monitoring every aspect of the farm. You'll be able to guarantee the results consistently. And that's what we see with some of these companies, like 'X', where they have a premium protein meal, and they are battling to produce sufficient meal to keep up with the farming."

4.6.2. KNOWLEDGE SPECIFIC INDIVIDUALS

I001 says that essential services such as pipework and electrical supply will require specific knowledge from tradespersons such as electricians and plumbers. These persons, however, merely execute the drawn-up plan according to the specified design. I001 believes that persons with a background in engineering, architecture, and construction can contribute positively to the integration of VF practices. In fighting urban decay and providing urban regeneration alternative solutions, VF will put the people back in the community and equation while further preventing the semigration that Xiang, Yang & Li (2020) refers to.

The globalisation of supply chains has caused networks to become more interconnected and faster, which sometimes results in it being cheaper to import products than to produce them locally, I001 says. I006 says that several existing companies can guide the VF establishment process and provide customers with a turn-key product.

4.6.3. CURRENT VACANT BUILDINGS

I002 states that although many people tried to acquire vacant buildings owned by the government in the CBD, the government was not interested. I002 says that the list of government buildings made available to the public is public information and easily accessible. SDG Target 2.c is concerned with the functioning of the food market, related market information, and associated accessibility thereof to limit food price volatilities (Stats SA, 2019). Buildings are often vacant because they are 'in transit' as the process of a sale and placing it on tender takes time:

I002: "The landowners that have got undeveloped or empty buildings in Cape Town, I think, are few and far between. There are, but a lot of them have obviously bought properties and are in the process

of redefining it and, or repurposing it and so on. So a lot of people, if you do find it - you might find a short-term lease for it. Maybe a year and maybe with an option to extend it, which makes it difficult."

Some of the deciding factors on whether to redevelop a property or not, are described by Munneke and Womack (2015) to include the age and size of the structure, nearby amenities, the quality and density of the neighbourhood, demographical changes, and new space requirements arising. I002 mentioned a few repurposing projects that he undertook for clients. Some of these repurposing projects mentioned by I002 include office space into student accommodation. Though the numbers worked, the client on this specific project did not go ahead with it. Another example is where a building changed usage from an office building into a hotel. He says that there are a lot of CBD buildings that were remodelled into residential units:

I002: "It's the feasibility of the project that I think throws it out often. And not just for vertical farming, but for any type of development. Why does a lot of buildings not move from standing empty and it doesn't go from an office development through to a residential development? Sometimes the buildings are just not suited for that application. We've costed quite a few buildings where, after a couple of investigations, we told the client it's not going to work."

The legislature must be updated to make provision for old factory buildings to be converted into vertical farms, allowing for flexibility in height and number of storeys (Simpson, 2019). Although I002 believes that certain buildings will not be suited for indoor farming applications, he does not exclude all structures from such elimination and says that the location is one of the main disqualifying factors:

I006: "I think it's a viable food production system, as long as it can take into account the different agendas that may work against it."

The reason for vacant buildings is not necessarily a market-related factor, but sometimes is a result of the building simply not being suited for the application as I002 describes it and is often the reason for remodelling buildings. I002 speaks from experience and says that his company has costed a few buildings which the investor wanted to convert from office usage into a residential development or hotel space. The client then sometimes had to be informed that it was not going to work. Tablada and Zhao (2016) identified the availability of sunlight, a building's three-dimensional and other geometry-related factors of plot ratio, site coverage, and structure height as some of the main limiting factors in a building.

I006 believes that one of the reasons that local authorities in Cape Town might contest VF includes the extensive use shortages in the property sector in other segments. She refers to the big housing shortage in her example. She says that government officials might regard it as more important to

resolve the housing crisis than to promote green farming practices such as VF in a city. She adds by saying that it is primarily in the more densely populated commercial areas (CBDs) which are closer to work, where there is an increased housing problem. Therefore the plan for encouraging VF should consider targeting buildings and places that are not fit for housing (I004). Redevelopment designs must often incorporate a series of inflexible systems into their design, such as existing infrastructure, site conditions, and transportation networks which must be brought up to current and future performance standards (Hersh, 2018).

I002 says that the feasibility of a project needs to make sense on paper first. When asking I006 whether they ever considered VF, she said that an indoor context in buildings was not considered before:

I006: "We looked at already pre-fabricated container plants. So those were in shipping containers. And then we looked at overhead structures that would be tunnels and greenhouses and your hydroponic system that you could possibly use. So what we have focused on has been primarily because we don't necessarily go into a specific space. What we do is, we talk about the opportunity for people already in that space to adopt the technologies that could be of assistance to them."

4.6.4. COMMERCIAL SCALE

I002 says that VF can be economical on a commercial scale of production and believes that there are a lot of successful applications for it. According to Gobble & Headrick (2019), economies of scale play an essential role in defining the success of an indoor farming facility. VF can be expensive when undertaken on a commercial scale, not neglecting that 'the highest and best use value' of a property is a crucial consideration for making real estate decisions (Hersh, 2018). The figures will likely differ for each scenario, though there should be a general identifiable trend in terms of production facility size versus opportunity costs:

I001: "There probably needs to be a feasibility study or a benefit-cost study because you need to go a certain height for it to be feasible for you to have enough square meterage that you've gained."

When speaking about current VFs, I005 said that a few people in places like New York are doing it already. He also said that according to his knowledge, the Emirates airline has currently got the biggest VF in the world and said someone like them has the scale to undertake VF. As passengers, you are not given a choice but to eat what is offered. It, therefore, makes sense for Emirates to do this, and it enables them to grow clean and healthy produce without being reliant on producers, and they can then do it in-house. Although the initial investment remains huge, I005 believes that someone like Emirates must take the first step. Gobble & Headrick (2019) confirms that the Emirates airline has

taken the first step. I004 said that even someone like Amazon could drive VF. I005 says that it is essential to remember that Emirates does not have to profit from the harvest in the same way that a retailer must, as it is included in a traveller's air ticket and is already paid for. I001 reminds the reader that, in addition to the international competition, VFs must compete with traditional farms too:

I002: "These small systems are just not sustainable, and it actually requires more effort than what the outcome is of what you realize from them. So they need to be fairly large, and they need to be properly managed".

4.6.5. CONTAINERIZED

When telling I002 that there are already buildings being used to grow produce, he responded that those structures were designed to accommodate such plants and that those structures are cordoned off with sections. These are then, according to him, adequately waterproofed to protect the longevity of the building. Therefore, I002 suggests that buildings should incorporate containers in the growing of produces and refers to this design approach as 'containerising'. These containers will add additional weight to the structure and becomes especially significant in high rise buildings, I002 says:

I002: "You must understand if you take a concrete structure and you put a lot of water in it, and it starts leaking through the building, you are effectively deteriorating the quality of your building. And there are very few owners that would allow that."

I002 says that even if you use containers to plant in, the water still needs to circulate and have a definite entry and exit point, which opens the risk of leakages. I003 mentions pipes which are staggered vertically within a structure that can take on the form of a building, a wooden or steel frame, production tunnels, or something similar that can accommodate the temperature control and provide a protective encasement. An alternative to the pipe tubes is using plastic pots and bags, suspended from the top and irrigated from the top downwards, I003 says. Although the water is circulated and requires an entry and exit point through the circulation system, it should be noted that containers not only support the growth cycle but also help to protect the building structure - even if it means that it adds additional weight. The nutrient-rich water solution is circulated to feed the suspended plant roots (Gobble & Headrick, 2019; Hersh, 2018):

I002: "Yes, but ultimately I've never seen that they have used a building in its raw state to put soil on or to put any other...it's always containerized."

One of the problems with hydroponic systems identified by I002 is that the plants grow at such incredible speeds that it requires constant monitoring. I002, who used hydroponics for household usage, mentions a restaurant owner who experienced the same problem as him with hydroponics. The

plants grew so quickly that their roots are often not contained by the tubes in which they grow. Therefore, one could not leave the system for a weekend away as one would find that half of the water would be pushed out onto the ground upon returning (I002).

There are different interpretations of using hydroponics for production. I004 believes that VF is vastly similar to hydroponics, as VFs employ hydroponics as a means of production, with the sheltering structure being the main distinguishing factor.

4.6.6. STRUCTURAL LOAD-BEARING CAPACITY OF BUILDINGS & DESIGN REQUIREMENTS

I002 mentions another cost and design factor related to the structural loadbearing capacity of buildings and the design thereof. I001 says that a solid foundation and design specifications are key to the structural load-bearing capacity of the building. I001, an industrial engineer and supply chain specialist, says that when they do designs, they consider the load being placed on the floor and often measure it in terms of average weight per pallet.

According to I002, high-rise buildings are limited in loadbearing capacity, and the use of ordinary soil is often too heavy for typically designed buildings. Therefore, many horticulturists would use artificial substances such as 'organic balls' and 'lightweight soil' according to I002. Although these materials are more expensive than ordinary soil, one would use less thereof, I002 says.

When asking I002 about the success of producing indoors, he responded with: "It depends on what you want to grow and the medium that you want to grow it in. And there are alternatives to that."

I002: "An office building is traditionally designed for about three kilo Newtons per square meter, which means that you can put about 300 kilograms per square meter on the floor area. So you need to take that and work it back to what you want to do because she cannot exceed that. Some of the buildings are only designed for about 2.5 kilo Newtons. So it's 250 kilograms per square meter. So, whatever you do, you cannot exceed that."

I002 believes that one cannot simply put water tanks on top of a building's roof and expect it to work, as there are structural limitations. Many people would not be interested in allowing farming in their structures, as the spillage associated with VF will enter the building and cause decay to the building. This will result in a negative response from many owners (I002). In essence, not being able to use existing buildings for VF rejects the whole idea of revitalizing such buildings from the beginning and guides an answer to the research question early already.

4.6.7. MIXED-USE BUILDINGS

According to I001, VFs have the potential to redesign the whole concept of mixed-use developments. Some of the mixed-use operations found inside agricultural buildings include growing, washing, and selling produce (Simpson, 2019). The activity related to packaging and warehousing is not mentioned in the list but forms an integral part of the supply chain. I001 suggests that VFs can incorporate a food processing plant and even a food kitchen in the building to supply the local community with such products. One can even have other stores at the bottom of the building:

I006: "So really any sort of urban farming, I think has a lot of potential to really change the dynamic in city planning. And I also think it has a really big potential of changing the dynamic in agriculture that is not seen as something which is a low-profit margin business, but to something really dynamic and quite future resilient - be it climate change or price or an economic shock."

Forsberg & von Malmborg (2004) said in the literature review that the importance of policy, planning, and management is realised in investment incentives and the environmental impacts of such decisions.

4.7. EMERGENT THEME 5: LOGISTICS

4.7.1. SUPPLY CHAIN MANAGEMENT

In terms of the supply chain, I001 thinks that VF will naturally incorporate online ordering and delivering as it is likely to be located in or close to cities where there is not a lot of space. He believes that online shopping and speed of delivery are two of the primary supply chain considerations of the future. One of the immediate advantages of VF is that the production facility and distribution centre is already within relative proximity of the client and therefore already reduce the travelling time for deliveries. This aligns with Benke & Tomkins (2017) and Gobble & Headrick (2019), who said the shorter travel distances between supply networks mean that food can reach consumers quicker while reducing carbon damage.

I001 says that the retail store might be placed at the bottom level of the building, though many shoppers will likely not even go to the store and will instead order online. As part of the delivery service, I001 believes that one should also consider the ease of returning products should a client not be satisfied with a specific product delivered.

Another logistical consideration mentioned by I001 is whether seedlings will be produced within the VF self or be brought in from outside and then simply planted in the VF. In saying this, it opens another consideration of design in the building, where a specific section may be allocated to the production of seedlings only, as mentioned by I001.

I001 says the effective use of space can be enhanced in many ways. He mentions that planning and tracking capacities are essential to 'prioritize demand'. One method mentioned by I001 to increase space is by incorporating a mezzanine floor level or racking system, where one gains additional space by increasing space vertically. I001 says that another technique used is to move stock from distribution centre to distribution centre. Both of these methods will not work for VF, as VF is already incorporating the vertical space for optimum usage, and secondly, it would not make sense to relocate stock from DC to DC, as it is fresh produce. Therefore the only remaining way to control demand is by planning and prioritizing demand in products that are most likely not in current production.

I001 believes that VF can potentially relieve stress at ports but will probably increase urban pressure where the VFS is located. The can potentially free up containers for other industries and therefore has a macro impact, I001 says.

I001 further states that height aided the warehouse industry a lot, as racking systems were limited in the old days. He adds by saying that automation, narrow aisles, and technology generally redefine the optimum productivity and the speed at which goods can be moved. He says that storage space is a fixed cost that needs to be used wisely.

I002 was interviewed after I001, who said that the researcher should interview someone with a supply chain background as such individual not necessarily contribute to the building aspect of this research, but will more realistically analyse the executability of VF as a concept. I002 also suggested interviewing someone with a distribution and sales background, and it is therefore that I004 and I005 were both also appropriate interviewees:

I002: "But all of these things come together, and it forms a picture, and that picture will tell you whether you can or you can't. And I think we all have a dream sometimes of doing something like this or doing the right thing. Uh, but unfortunately, the numbers have to come together for it to work."

I004 says that during her time as a buyer for a big retailer in Canada, the retailer performed a test called "field to fork". This measured the shelf life of a product by considering the time it took for a product to get from the field where it is harvested to household usage. It was found that the prolonged period of products was before the retailer had it, which is not ideal, I004 adds.

The type of tests that I004 would do for fruits and vegetables will generally include looking for defects, whereby the shelf life and other issues are determined. If something is wrong, the cause of the problem is then identified and is often related to transit, the grower, or the packhouse, I004 says. VF reduces the source of the problem to be located in one location.

I005 says that one of VF's advantages is that the VF production unit can be located within the distribution centre, which brings down costs and results in products not having to travel 400km from a farm in the Free State, for example. In terms of this aspect, VF will bring down logistical costs, I005 says. I004 believes that VF has potential in terms of transportation, as freight is expensive and keeps going up. In addition, being close to the market increases shelf life further, as products don't have to travel for long on a truck or vessel before reaching the consumer:

I004: "I mean, sometimes before you get the product from to where it gets to somewhere, it's actually been 30, 40, 50 days on a boat. So to eliminate that is very good."

VF also brings down the cost of general risk, I004 says. She does not refer to the assured harvest production in this case but says that it eliminates the risk of quality issues caused by temperature control settings that were not set right or control issues during transit. She uses the example of vent settings that could be set wrong during transportation.

4.7.2. ACCESS TO THE MARKET

Access in VF becomes important in two ways: having access to the building and, secondly, access to the market. The main items affecting the success are the building and facility's design and are linked to the potential receivable income from the market catchment area (Gobble & Headrick, 2019). I002 says that it is interesting to see how the market has changed since the Covid pandemic as it caused a shift towards online shopping. I002 says that the market should receive VF well, while the distance to the consumer is reduced, with an online option increasing the uptake. Further, the developments in sales and distribution will create more opportunities, perhaps in the VF field even. Hersh (2018) notes that many of the successful redevelopments completed today are less vehicle-focused and more mixed-use and pedestrian orientated.

As the physical market is accessed from a building, I001 says that street access is an important consideration, relevant to both vehicles and pedestrians. The different types of movement in and out of the building is a crucial aspect, I001 said. This also includes the frequency at which movement takes place. For example, will there be enough space for big trucks to turn, or is it possible to have more frequent but lighter vehicles delivering and picking up items?

4.8. DISCUSSION OF FINDINGS

At the beginning of this research project, even before the drafting of the research proposal, it was a known risk that there might be insufficient interviewees to find for this study. This was due to numerous reasons, some related to the field's newness, the third world country which South Africa is

seen as, and the state of the economy, to mention a few. Data saturation was reached quickly, after six interviewees to be precise.

This study started by explicitly considering the production of fruits and vegetables. It was found that other consumables, which are not necessarily for human consumption, but often take on the form of medicinal products and animal feed, are alternative produces for controlled environment production. This aligns with numerous authors referenced in the literature review and includes Gobble & Headrick (2019) and Pinstrup-Andersen (2018). Perhaps the term VF should rather be seen as a production facility or, as I006 described it, a "controlled environment production facility". SDGs form part of the research field, with VF extending beyond food production-related SDGs. VF requires global collaboration, as seen with Canada assisting South Africa, specifically, the City of Cape Town. As noted by the U.N. (2020)'s SDGs, these relationships are forever and are supported by Dalby et al., (2019).

In taking a holistic view, without considering any numbers, it seems like VF is a viable solution, though the location and distance to the market will depend on the product being produced, as acknowledged by Benke & Tomkins (2017), and Gobble & Headrick (2019). This study started by considering CBDs as a possible location for VFs. However, it seems like more industrial and commercial areas will receive less opposition from society, seeing that future laws will more likely accommodate VF activities in such areas. This does not entirely align with Hersh (2018), one of the authors who support the work-live-play environment, saying that people want to drive less today. The suggested location will then be further out than the current shops but can still deliver to clients.

When analysing VF, all interviewees used an international conception which they funnelled to a local level when analysing VF in South Africa. There is a constant contradiction between producing at a commercial level and adhering to the economy of scale rule. The local economy's ability to afford a product can result in insufficient buying power to support commercial-scale production. Are people thinking too small and not investing big enough to actually see the full uptake potential of VF, or are the costs, legislation, etc., overwhelming? If a producer is too small, the production facility will not be economically viable, and if one is too big, the input costs become exorbitant. The importance of infrastructure was repeated numerous times and cannot be ignored. White (2015) says that high land prices are pushed up even further by investors and large-scale commercial farmers.

Many interviewees share I004's view that VF can be successfully implemented but requires some time as it is currently ahead of us. At least it is now known what the exorbitant input costs are, and one can alter the input variables until society, numbers, and legislation correspond in a local context. As I005 said, the quicker we get the costs down, the sooner we will see an increase in VF. Business principles remain the main governing item, with profit being required to exceed expenditures for continued

operations. The high investment costs will affect the cash flow in the initial stages of the project and are likely the answer to why many VFs fail to exist shortly after they were established, as seen identified in the literature review. Social and economic activities can explain the influence that the built environment has on sustainable development (Forsberg & von Malmborg, 2004).

Traditional farmers will play a big part in this knowledge era which we find ourselves in, as their knowledge of crop production and managing skills will become mandatory in producing food products indoors. Together with the farmers, some persons already specialise in establishing controlled environment food production facilities.

VF has forced people to think out of the box. For example, the exploration to possibly use natural underground water sources as a water supply. This kind of thinking, and much thereof, will be required in the future. In acknowledging VF as part of the built environment, one must understand that development is tedious. With city garden farms, the community plays a significant role in benefitting from such gardens. VF will support the local community with employment opportunities while growing the economy and contributing to the character of the area's built environment.

The cost of transportation will keep rising in the future, especially when considering the green-consciousness. Online shopping was bound to happen, but the Covid pandemic brought it forth quicker than anticipated. This confirms Danquah, Ouattara and Quartey (2018) who says that technology can assist economies in competitiveness, productivity, and growth.

People would not have investigated VF as a possible food supply system if they did not believe that they can improve traditional farming practices. This can result in commercial urban regeneration, that can solve new problems and market demands, while leading to new policies (Yiannakou, 2020). Benke and Tomkins (2017) state that crops grown in indoor environments can be altered through genetic engineering. These alterations will determine the success of VF, while ultimately still being regarded as organic.

All of the interviewees confirmed that the cost of producing food indoors does not come cheap. The two main cost factors of indoor farming include energy and capital outlay and is why renewable energy, more efficient lighting, and solar power reduce the energy-related cost component (Pinstrup-Andersen, 2018). Although traditional energy costs are high, the advantages of a guaranteed disaster-free harvest as a risk mitigation strategy re-evaluate the cost of such technologies (Benke & Tomkins, 2017; Dalby et al., 2019).

4.9. SUMMARY

A few key points were identified. These points relate to the five themes that emerged from the data collection process and can be linked as barriers to market entry, requirements for successful VF, financial implications, design requirements, and 'logistics'. Going forward, I006 says*: "There needs to be a plan around how indoor farming will be able to enter the market."*

VF is an option for land usage that must be documented in the local legislature, as this is currently the main barrier, following exorbitant input and running costs. The cost of the building is noteworthy but seems to not be the most significant cost item compared to the aforementioned costs. For now, VFs will produce niche, medicinal, and other specialised products. With the market gradually moving towards more controlled environment agriculture, the list will undeniably expand over time. In terms of designing, there are already persons who can assist with setting up such VF businesses. VF will likely become a much more specialised field in the future (especially from a professional services consultant viewpoint). In terms of logistics, VF makes sense, but there needs to be a balance between distance to the market in terms of market accessibility and travelling costs versus the price of properties. Although the price of properties is not seen as the most significant cost factor, this does not necessarily hold for CBD-located properties.

Throughout this study, it was noticed that there are different descriptions to what this study has referred to as VF. Others, interchangeably, refer to VF as urban farming, farming within cities, controlled environment farming, production facilities, high-density growth, depending on where the facility is located and in what type of structure the VF is accommodated in.

CHAPTER 5 - CONCLUSION AND RECOMMENDATIONS

5.1. INTRODUCTION

This chapter is dedicated to reviewing the research undertaken by comparing the research findings in line with Chapter 1's research proposal. The research aim, objectives, importance of the study, and recommendations are some of the items discussed in this chapter.

5.2. REVIEW OF RESEARCH QUESTION AND THE RESEARCH AIM

The research question was whether (existing) buildings can be used to accommodate urban vertical farms, while the research aim was to investigate whether or not existing buildings can be used to accommodate urban vertical farms.

To answer the research question: Can (existing) buildings be used to accommodate urban vertical farms? The short answer is yes, but it comes at a cost that does not necessarily justify the expenditure. Existing buildings need to be modified to accommodate the changing needs and cannot be used in their existing state. There are ways to reduce the long-term costs, but it increases the initial costs further. The main use of current buildings for VF takes on the form of a niche market produce production and products that are not necessarily for human consumption.

5.3. REVIEW OF THE RESEARCH OBJECTIVES ACHIEVED

The first objective was to review the current legislature in terms of provisions made for the implementation of VF. A few of the interviewees were uncertain whether VFs are permitted in urban planning policies. It was identified that VFs do not have the required land usage acknowledgement yet and that legislation vastly reduces interest in such undertakings.

The second objective was related to design considerations that are required to make VF building structures effective. Some persons currently specialise in advising how VFs should be designed.

Although not wholly related to the research topic, the third objective considered using VF as an urban regeneration tool. The option to implement VF as a possible solution to urban decay was identified in the research proposal stages and was indirectly answered from the interviews. The price of land is the primary consideration related to this parameter. Linked to objective number one, once legislation is updated; the financial aspect makes sense and if owners allow VF in their buildings, then VF might become a possible solution to fight urban decay.

Objective four, which was interested in global VF trends, was seen in the literature review and funnelling down process followed by interviewees to localise the VF concept. Global trends were more covered from a literature review context than the actual interview content.

Lastly, from an economic point of view, the researcher asked whether real estate developers would be interested in VF buildings. Other competitive land usage options overruled such possibilities under current conditions, while the possible decay to a building structure caused by water ingress might reduce interest.

5.4. PROPOSITION REVISITED

The proposition was that: "Vertical farming can create opportunities for developers to remodel existing buildings where fresh foods can be grown under indoor farming practices". The research findings support the proposition that existing buildings can be used for VF. The buildings might need some degree of remodelling and might not be suitable in their raw state. The financial aspects are discussed under the research question and research aim.

5.5. REVIEW OF THE IMPORTANCE OF THE STUDY

This study contributes to the body of knowledge in the relatively new field of VF farming. Locally, there are not any known studies that investigated VF in a South African context. Literature is even limited from an international point of view. Designers and legislators can be guided in terms of what VFs require. The relationship between VF and SDGs was summarised in-depth in Annexure 1 and can aid legislators further. The researcher answered the question about whether VF is realistic, what types of products can be produced, and where these production facilities will likely be located.

5.6. RECOMMENDATIONS

The availability of firms that specialises in indoor farming applications will be a good indicator of the current relative strength of the industry.

VF will only be successful if alternative energy sources can be found. It is important to keep the scale of operations in mind for a VF to succeed. Much more research and many more experiments are needed to determine the exact design requirements of VF buildings. The marketing strategy for crops produces indoors will likely follow a different marketing strategy compared to traditionally produced products.

Persons interested in establishing VF production facilities should not use this document as sole guidance in deciding whether or not to enter such markets but can use it as a guide in what steps need to happen next. These persons also need to ensure that their numbers work, as the literature review suggests that many start-ups got their numbers wrong initially and therefore fail to exist today.

5.7. FUTURE RESEARCH

A study focusing on land cost should provide valuable insight into the land price relationship between traditional horizontal land and VF production facilities when accounting for the vertical space per layer per floor level. It will also be meaningful to have a more defined list of products that are profitable enough to be grown indoors and those which are not. But then again, as someone said in the literature review, this is private information and determines which farms are successful and which are not.

5.8. FINAL CONCLUSION

VF is an alternative land usage of the future but will require much more developments, considerations, and collaborations before being profitable enough for everyday produce on a commercial scale.

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ANNEXURE 1 - SDG & KPI Relationship with VF

Goal	Description	Sustainable Development Target (SDG)	Key Performance Indicator (KPI)	SDG & KPI Relationship with VF (Researcher's comment)
Goal 1	No Poverty	**1.5** By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters	**1.5.2** Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)	South Africa is a drought struck country, and VF will reduce the impact of such natural disasters
			1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	VF will give SA more credibility for attempts in combating droughts and other natural disasters
			1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	VF is a food supply risk mitigation strategy
		1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions	**1.a.2** Proportion of total government spending on essential services (education, health, and social protection)	VF promotes the health and well-being of society while, with increased health benefits, making fresh nutrients accessible to everyone
Goal 2	Zero Hunger	**2.3** By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists, and	**2.3.1** Volume of production per labour unit by classes of farming/pastoral/forestry	VF produces higher yields per area than conventional farming

		fishers, including through secure and equal access to land, other productive resources, and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	enterprise size	
			2.3.2 Average income of small-scale food producers, by sex and indigenous status	VF can open access to the food production market to persons who cannot afford traditional farmland
		2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters, and that progressively improve land and soil quality	**2.4.1** Proportion of agricultural area under productive and sustainable agriculture	Crops that cannot be produced under VF conditions will still be planted at a commercial scale on open fields
		2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional, and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	**2.5.1** Number of plant and animal genetic resources for food and agriculture secured in either medium- or long term conservation facilities	VF creates conservation facilities that can be used for nature preservation

		2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development, and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular, least developed countries	**2.a.1** The agriculture orientation index for government Expenditures	An increasing interest in VF will contribute to this parameter
		2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	**2.c.1** Indicator of food price anomalies	VF can lead to a reduction in food price abnormalities
			2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector	Outsider's interest will require the co-operation and assistance from local governments
Goal 3	Good Health and Well-being			
Goal 4	Quality Education	**4.7** By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development	**4.7.1** Extent to which: (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	VF will not directly educate individuals but will contribute to the body of knowledge surrounding sustainable development
Goal 5	Gender Equality	**5.a** Undertake reforms to give women equal rights to economic resources, as well as access to ownership and	**5.a.1** (a) Proportion of total agricultural population with ownership or secure	VF has the ability to redesign the perceived public image of traditional farming and might

		control over land and other forms of property, financial services, inheritance, and natural resources, in accordance with national laws	rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure	attract the interests of women and younger generations.
Goal 6	Clean Water and Sanitation	**6.1** By 2030, achieve universal and equitable access to safe and affordable drinking water for all	**6.1.1** Proportion of population using safely managed drinking water services	VF reduces the strain on water supply systems
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally	**6.3.1** Proportion of domestic and industrial wastewater flows safely treated	VF Reduces the amount of water that needs to be treated, if these farms locate in industrial areas.
			6.3.2 Proportion of bodies of water with good ambient water quality	Water is likely to be re-used in VFs.
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	**6.4.1** Change in water-use efficiency over time	VF uses less water to produce a higher yield.
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	**6.4.2** Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Less water used in the food production process results in less stress on freshwater sources.

		6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	**6.5.1** Degree of integrated water resources management	If buildings can become self-sustaining, then existing rainwater resource is being stored on-site.
Goal 7	Affordable and Clean Energy	**7.1** By 2030, ensure universal access to affordable, reliable, and modern energy services	**7.1.2** Proportion of population with primary reliance on clean fuels and technology	VF reduces the number of buildings (which forms part of the population) which is dependent on the Eskom grid system.
		7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	**7.2.1** Renewable energy share in the total final energy consumption	If buildings are self-sustainable, then it implies that natural sources for electricity generation will be used.
		7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	**7.a.1** International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems	South Africa is a developing country and VF will reduce the carbon footprint of buildings.
		7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and landlocked developing countries, in accordance with their respective programmes of support	**7.b.1** Installed renewable energy-generating capacity in developing countries (in watts per capita)	Self-sufficiency in buildings will require an increased uptake rate of natural resources.

Goal 8	Decent Work and Economic Growth	**8.2** Achieve higher levels of economic productivity through diversification, technological upgrading, and innovation, including through a focus on high-value added and labour-intensive sectors	**8.2.1** Annual growth rate of real GDP per employed person	VF will create more employment opportunities and result in increased GDP per capita employed.
		8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	**8.3.1** Proportion of informal employment in total employment, by sector and sex	VF will not only open employment opportunities in formal sectors, where a higher level of skill is expected but will also require unskilled and semi-skilled labour.
		8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	**8.4.1** Material footprint, material footprint per capita, and material footprint per GDP	A lower carbon footprint is among other one of the advantages offered by VF

		8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	**8.4.2** Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	VF results in less pollution
		8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	**8.5.2** Unemployment rate, by sex, age, and persons with disabilities	Not all men and women will be provided with employment opportunities in South Africa. However, those who are employed in the industry are employable in a non-discriminatory manner.
		8.6 By 2020, substantially reduce the proportion of youth not in employment, education, or training	**8.6.1** Proportion of youth (aged 15–24 years) not in education, employment, or training	VF can possibly provide internships to school levers and graduates to gain some exposure to the VF field.
		8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	**8.8.2** Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status	VF can provide employment opportunities to minority groups
		8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through	**8.a.1** Aid for Trade commitments and disbursements	The RSA is one of the countries likely to receive funding and assistance from other countries

		the Enhanced Integrated Framework for Trade-related Technical Assistance to Least Developed Countries		
		8.b By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization	**8.b.1** Existence of a developed and operationalized national strategy for youth employment, as a distinct strategy or as part of a national employment strategy	VF can provide the youth and other school levers employment opportunities
Goal 9	Industry, Innovation and Infrastructure	**9.1** Develop quality, reliable, sustainable, and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	**9.1.2** Passenger and freight volumes, by mode of transport	Though the volume will be less, the frequency of travel will be higher.
		9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets	**9.3.1** Proportion of small-scale industries in total industry value added	VF can open new opportunities in cities
		9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	**9.4.1** CO2 emission per unit of value added	If VFs take up green energy, then CO2 emissions are further reduced in addition to reduced transport-related emissions

		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological, and technical support to African countries, least developed countries, landlocked developing countries, and small island developing States	**9.a.1** Total official international support (official development assistance plus other official flows) to infrastructure	Though South Africa will not directly promote development in developing countries, it is more on the receiving side. However, SA is one of the well-faring countries in Africa and can assist other countries on the continent with development.
		9.b Support domestic technology development, research, and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	**9.b.1** Proportion of medium and high-tech industry value added in total value added	Compared to first-world countries the tech industry in South Africa has a small market cap, but this can increase with the uptake of vertical farming as it results in the development and uptake of new technologies.
Goal 10	Reduced Inequality	**10.4** Adopt policies, especially fiscal, wage, and social protection policies, and progressively achieve greater equality	**10.4.1** Labour share of GDP	VF can promote minority groups while providing new employment opportunities
		10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations	**10.5.1** Financial Soundness Indicators	The affordability and long-term sustainability of food commodity prices will become more stable as a result of VF.
		10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States, and landlocked developing countries, in	**10.b.1** Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment, and other flows)	South Africa will be on the receiving end of attracting development assistance funds from countries higher up in the ranks, contributing to foreign investments receivable.

		accordance with their national plans and programmes		
Goal 11	Sustainable Cities and Communities	**11.3** By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	**11.3.1** Ratio of land consumption rate to population growth rate	In densely populated areas, VFs provide more space vertically than horizontally
			11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically	VF will require policies to accommodate such technologies
		11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	**11.4.1** Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural), and level of government (national, regional, and local/municipal)	Though VF will not contribute to the funding aspect of this parameter, it will enable the preservation of natural land.
		11.a Support positive economic, social and environmental links between urban, peri-urban, and rural areas by strengthening national and regional development planning	**11.a.1** Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and	RSA policies should be updated to accommodate VF

			(c) increase local fiscal space	
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	**11.b.1** Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	VF is an enabling risk mitigation strategy
			11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	VF policies will enable the government of the RSA to provide evidence of the risk mitigation introduced
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	No suitable replacement indicator was proposed. The global statistical community is encouraged to work to develop an indicator that could be proposed for the 2025 comprehensive review. See E/CN.3/2020/2, paragraph 23	VFs can be constructed from locally sourced materials
Goal 12	Responsible Consumption and Production	**12.2** By 2030, achieve the sustainable management and efficient use of natural resources	**12.2.1** Material footprint, material footprint per capita, and material footprint per GDP	The incorporation of green energy technologies will contribute to this parameter

		12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	**12.3.1** (a) Food loss index and (b) food waste index	The all-year availability of produces may lead to reduced food wastage
		12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water, and soil in order to minimize their adverse impacts on human health and the environment	**12.4.2** (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment	Less fertilizer and herbicides will result in less polluted packaging being discarded
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse	**12.5.1** National recycling rate, tons of material recycled	Fertilizers and herbicide packaging is not necessarily discarded on dumping sites where quantification thereof is possible, as many farmers get rid of these on the farm self
		12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	**12.6.1** Number of companies publishing sustainability reports	VF will naturally require companies to report on their sustainability, though it remains important info that not all companies will be willing to share as it creates a competitive distinction between success and failure.

		12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	**12.8.1** Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	VF contributes to the body of knowledge surrounding urban farming.
		12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	**12.a.1** Installed renewable energy-generating capacity in developing countries (in watts per capita)	Manifested in buildings becoming self-sufficient.
Goal 13	Climate Action	**13.1** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	**13.1.2** Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	The impact of natural disasters is less on VFs than traditional farms
			13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	It is expected that more governments will implement VF technologies

		13.2 Integrate climate change measures into national policies, strategies and planning	**13.2.1** Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications	If the RSA decides to integrate VF more actively, then it will place the country in line with the forerunners in the field
			13.2.2 Total greenhouse gas emissions per year	VF results in reduced greenhouse gas emissions
		13.3 Improve education, awareness-raising, and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning	**13.3.1** Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	VF opens a new field of study combined with sustainable development technologies
Goal 14	Life Below Water			
Goal 15	Life on Land	**15.2** By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	**15.2.1** Progress towards sustainable forest management	A result of VF not taking up as much horizontal space as compared to traditional horizontal farms.

		15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought, and floods, and strive to achieve a land degradation-neutral world	**15.3.1** Proportion of land that is degraded over total land area	A result of less traditional farmland being perused.
		15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, to enhance their capacity to provide benefits that are essential for sustainable development	**15.4.2** Mountain Green Cover Index	Less deforestation will be a result of VF.
		15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	**15.5.1** Red List Index	Even though the 2020 milestone has passed, UF can contribute to this target by not disturbing areas where Red Listed elements are presented.
Goal 16	Peace and Justice Strong Institutions			
Goal 17	Partnerships for the Goals	**17.1** Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	**17.1.2** Proportion of domestic budget funded by domestic taxes	New businesses arising will result in expanding the tax income/basket.
		17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge,	**17.16.1** Number of countries reporting progress in multi-stakeholder development effectiveness monitoring	VF provides the opportunity for new partnerships and information sharing to be formed

		expertise, technology, and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	frameworks that support the achievement of the SDGs	

(U.N., 2020:1 - 21)

ANNEXURE 2 - ANONYMITY MEASURES

ANONYMITY MEASURES RELEVANT TO THE STUDY

UNIVERSITY OF CAPE TOWN

Ethical Clearance Reference Number:

Research Title: Achieving SDGS through Urban Regeneration and Vertical Farming

The Researcher will undertake the following measures to ensure the anonymity of the participants in this study:

- The interviewee's identity will at all times be kept confidential; every attempt on the part of the researcher will be made to ensure the anonymity of the interviewee;
- Each interviewee shall be assigned a four-character code, consisting of two letters and two numbers, e.g. IN08. These codes shall be randomly assigned and have no relation to persons' personal information. Only the researcher and academic supervisor will have access to the information gathered and the file that relates the interviewee's code to their actual personal identity. This file will have restricted access, and no outside person will have access to it.
- No information regarding the time or place of the interview taking place shall be given out or posted on social media.
- Any personal information of the interviewee, including their contact details, will not be given out without the person's permission.
- No pictures of the person will be taken.
- The interviewee's privacy will be respected and no personal questions that have no relevance to the study will be asked. Non-essential questions which may reveal the identity of the person will be avoided.

Lafras Buchner

BCHLAF001

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ANNEXURE 3 - RESEARCH PARTICIPATION CONSENT FORM

CONSENT FORM TO PARTICIPATE IN A RESEARCH

UNIVERSITY OF CAPE TOWN

Ethical Clearance Reference Number:

Research Title: Achieving SDGS through Urban Regeneration and Vertical Farming

Dear potential participant,

You are being invited to participate in a research study conducted by BCHLAF001, a MSc Property Studies student at the University of Cape Town. The research is supervised by Prof Kathy Michell of the University of Cape Town. The study's results will be presented to the Department of Construction Economics and Management in fulfilment of the requirements for the degree of MSc Property Studies.

If you have any questions or concerns about the research, please feel free to contact me, at bchlaf001@myuct.ac.za. Alternatively, the research supervisor, Prof Kathy Michell, may also be contacted at kathy.michell@uct.ac.za.

Purpose of the study

The study's primary aim is to investigate whether or not existing buildings can be used to accommodate urban vertical farms.

Procedures

Your participation in this study is voluntary. If you volunteer to participate in the study, we will consult you to agree to a time suitable for a face-to-face or an online interview, whichever you prefer.

Potential benefits to participants

At your request, the anonymised research findings will be shared with you.

Confidentiality

Every effort will be made to ensure that interviewees are anonymous and safeguard any proprietary information. Confidentiality of all information gathered will be maintained. Each interviewee shall be assigned a four-character code, consisting of two letters and two numbers, e.g. IN01. These codes shall be randomly assigned and have no relation to your personal information or the company that you work for. The information gathered through the interview process will be used solely for this research purpose. The raw data of the interview will only be known to the student/researcher.

Participation and Withdrawal

You may choose to withdraw from this study at any time of your wish. You may also refuse to answer any question that you do not want to answer.

Rights of research participants

You may withdraw your consent at any time and discontinue participation without any penalty. This study has been reviewed and received ethics clearance from the University of Cape Town.

Signature of Research Participant/Legal Representative

I have read the information provided for the research as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Participant (please print)

_____

Company of Participant

_____

Signature of Participant

ANNEXURE 4 - BASELINE RESEARCH INTERVIEW QUESTIONS

POSSIBLE VERTICAL FARMING AND URBAN REGENERATION INTERVIEW QUESTIONS

GENERAL

1. Are you familiar with the concept of urban farming?
2. If so, please elaborate on your understanding;
3. Are you familiar with the concept of vertical farming?
4. If so, please elaborate on your understanding;
5. Do you believe that there is potential in implementing such technologies?
6. Are there any previous VF / Urban Farming projects that you are aware of?
7. Why do you think will VF not work in Cape Town?
8. What do you think will be some of the main challenges for the VF concept?
9. To what degree do you think that these challenges can be overcome?
10. What is currently barricading entry into the VF market in Cape Town?

ENERGY CONSUMPTION (PERSON-SPECIFIC)

11. Is it financially feasible to take buildings off the energy supplying grid system?
12. Are you limited by off-the-grid buildings in terms of production capacity?
13. How can rainwater be stored on-site and in large quantities during the summer months? (is it for example possible to install underground tanks in buildings that have been standing for many years already?)
14. Are there any ways in which energy costs can be reduced further, by for example alternative means of energy supply?
15. What are the downfalls of alternative energy supply systems?

CURRENT LEGISLATURE

16. Does the current legislature make provision for the implementation of VF in Cape Town?
17. If not, then which amendments are required to enact VF in Cape Town?
18. Do you believe that VF can combat urban decay from occurring?

STRUCTURALLY

19. Are existing buildings consisting of more than one floor level structurally able to bear the weight of crops being produced therein?
20. Can old buildings accommodate or be modified to accommodate the technological developments that are needed to accommodate VFs? (For example specialised lightning; specialised HVAC systems (incl. humidity control); Wi-Fi, etc.

TECHNOLOGY IN VF

21. To what degree can technological developments contribute to VF?
22. Do you believe that there are already sufficient technological advancements made to immediately implement VF?

SUPPLY CHAIN MANAGEMENT

23. What influence will it have if cities start producing crops indoors in terms of a supply chain management perspective?

LAST QUESTION

24. Is there anyone else who you feel I should interview that can contribute to this study?

ANNEXURE 5 - ETHICAL CLEARANCE

ETHICS APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Lafras Buchner
Department		Construction Economics and Management
Preferred email address of applicant:		bchlaf001@myuct.ac.za
If Student	Your Degree: e.g., MSc, PhD, etc.	MSc Property Studies
	Credit Value of Research: e.g., 60/120/180/360 etc.	60
	Name of Supervisor (if supervised):	Prof Kathy Michell
If this is a researchcontract, indicate the source of funding/sponsorship		self
Project Title		Achieving SDGs through Urban Regeneration and Vertical Farming

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

APPLICATION BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Lafras Buchner		15-5-2021
SUPPORTED BY	Full name	Signature	Date
Supervisor (where applicable)	Kathy Michell		17 May 2021

APPROVED BY	Full name	Signature	Date
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (Including Honours).	Dr. Frank K.Ametefe		04-06-2021
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the questions in Section 1.	Dr. Frank K. Ametefe		04-06-2021

ANNEXURE 6 - EMERGENT NODE STRUCTURE

	Name	Description
Tree Node Level 1	**Barriers to VF Market Entry**	
Tree Node Level 2	Barriers to VF Market Entry\Legislation and Permissions	Considers current legislature surrounding VF
Tree Node Level 2	Barriers to VF Market Entry\Management	Reviews how VFs are to be managed and who possible key persons will be
Tree Node Level 2	Barriers to VF Market Entry\Why VF won't work	Reviews the limitations in implementation of VF
Tree Node Level 2	Barriers to VF Market Entry\Why We have not seen uptake in RSA yet of VF	An Analysis of why VF has not seen an uptake in RSA
Tree Node Level 1	**Requirements for successful VF**	
Tree Node Level 2	Requirements for successful VF\Infrastructure	Highlights the importance of infrastructure development
Tree Node Level 2	Requirements for successful VF\Organic	VFs are often associated with organic farming practices
Tree Node Level 2	Requirements for successful VF\Advancements in technology	Without technology, VFs will not be viable
Tree Node Level 2	Requirements for successful VF\Supplement, not Substitute	VF is not meant to replace traditional farming and plays an important role in food security
Tree Node Level 2	Requirements for successful VF\Gardens as Gateway	Acknowledges the importance that gardens have in implementing VFs
Tree Node Level 2	Requirements for successful VF\Reasons for Implementation	Reviews why VF should be considered for implementation
Tree Node Level 1	**Financial Implications and Costs**	
Tree Node Level 2	Financial Implications and Costs\Input Costs	An analysis the different input costs
Tree Node Level 2	Financial Implications and Costs\Water Costs	Acknowledges the importance of water and cost thereof
Tree Node Level 2	Financial Implications and Costs\Location, Location, Location	Examines the importance of location as a parameter in VF
Tree Node Level 2	Financial Implications and Costs\Specific Products	Identifies the importance that niche market products play in the feasability
Tree Node Level 2	Financial Implications and Costs\Energy Costs	Considers the cost of energy and the impact that it has
Tree Node Level 2	Financial Implications and Costs\The Cost of Wastage	Looks at how wastage will be handled and the financial implications thereof
Tree Node Level 2	Financial Implications and Costs\Supply and Demand	Recognizes different supply and demand factors in buildings
Tree Node Level 2	Financial Implications and Costs\Connectivity Costs	The cost of internet connectivity is high, but a requirement for VF
Tree Node Level 2	Financial Implications and Costs\Cost of Land	The price of land and the impact that it has is reviewed under this heading
Tree Node Level 1	**Design Requirements**	
Tree Node Level 2	Design Requirements\Considering Current VFs	Inspects current VFs that are in operation, by considering what they produce
Tree Node Level 2	Design Requirements\Knowledge Specific Individuals	Identifies possible idividuals who will work in the VF field
Tree Node Level 2	Design Requirements\Current Vacant Buildings	Reviews possible reasons for why buildings are vacant
Tree Node Level 2	Design Requirements\Commercial Scale	Examines the scale at which VFs will likely operate
Tree Node Level 2	Design Requirements\Containerized	Considers how plants will be planted inside buildings
Tree Node Level 2	Design Requirements\Structural Load Bearing Capacity of Buildings & Design Requirements	Investigates how the structural integrity of a building can be protected while farming in it
Tree Node Level 2	Design Requirements\Mixed Use Buildings	Inspects new combined building usages
Tree Node Level 1	**Logistics**	
Tree Node Level 2	Logistics\Supply Chain Management	Identifies the impact that VF will have on the economy
Tree Node Level 2	Logistics\Access to the market	Reviews the importance of market access

ANNEXURE 7 - RANDOMLY SELECTED INTERVIEW (I002)

LB (00:01):

Okay, we're going to do this in English. Because then the transcription software can do it by itself, and then I don't have to do it. So, we had a brief discussion about vertical farming the last time. You said that you're familiar with the concept. Can you maybe elaborate a little bit more about what your understanding is of vertical farming?

I002 (00:23):

So there's many various, my understanding of it: I mean, I'm not a specialist on it, but vertical farming is instead of traditionally farming horizontally, where everything is planted on the ground, vertical farming is where you actually plant vertically within elements. Um, you know, whether it is within tubes or within bags. Uhm, sometimes they even plant within soil vertically, where they make mounts and then the plant on the mount. So it is to increase your production area, uh, significantly from the horizontal flat traditional way of farming.

LB (01:04):

So did you ever have anything to do with vertical farming before? I think you mentioned a feasibility study or something like that.

I002 (01:11):

Yeah, I've actually had my own aquaponics that I did at my own house, where we only found a standard concept of aquaponics. Where actually, you have, obviously you've got the fish, and obviously, you feed the fish and the water cycles through the system, and it was a quite a large set up for a house um that we did. And in the process of doing that, I had a very good friend that did it like that, which is a form of vertical farming. And so we had both, um, you know, 110-millimetre pipes that we grew in. I think ours was about (the house was about four meters long), and I think we had about 16 horizontal tubes. And then we had a lot of bigger trays in there, which was boxes with the bolts/vaults in it.

LB (02:14):

Do you think it's going to work on a commercial scale for food production?

I002 (02:20):

Um, it definitely works on the commercial scale of food production. I think there's a lot of very successful applications for it. The biggest challenge with it and any type of farming, and I have done quite a bit of research, is the distance to market, as it is one big, big costs. Geographically, for instance, the further you go away from your city centre, the cheaper land becomes. If you look at, for instance, the cost of land, in Paarl and Stellenbosch areas which is relatively close to your market, versus places like Worcester, Robertson, Ashton, Swellendam. In those areas, land prices dramatically decrease. I mean, you can buy beautiful farms in Robertson, Ashton and Swellendam for very little money. But if you look at your cost to get your product from them, in terms of anything that you grow to the market, that is actually what kills it - it becomes uneconomical. So what I've seen is (and we've done quite a lot of investigation into in-city farming), and there's a couple of projects that is currently running, where, on top of existing roofs, they do vertical farming. On top of old buildings and so on. But the cost of the land in most cases is given for free. The space is given for free. And in that concept, it works. So the guy brings his own soil. And very often the soil is quite expensive because they're not allowed to use soil because too heavy for the buildings. So, they use these organic balls and lightweight ground, which is expensive, but you use very little of it in the application.

LB (04:27):

So is that for high-rise buildings?

I002 (04:30):

Yes, it is for high-rise buildings.

LB (04:30):

So then you've got multiple layers of vertical farming stacks running in each story?

I002 (04:37):

No, the problem with anything that you grow is it needs sunlight, and then it' needs a hell of a lot of it. So there's very seldom that you find that people do it on deep spices in buildings. They will do it on the external facade, either on balconies or close to the outside of it. And predominantly on top of roofs.

LB (04:59):

What I've read now with the literature review was that a lot of people actually manipulate the climate inside with humidity control and with temperature control, and with specific lighting. Don't you think that changes the picture, that it can actually be applicable to having multiple layers in one story?

I002 (05:24):

Okay. Here's the question. Um, any type of farming is what is your cost versus what is your return on your investment. That is any business concept. So if you take a building and you are going to start adding up the cost of the building. If you're renting it, you've lost the plot. So if you add the cost of your rental, plus the cost of your water, plus the cost of your electricity to that equation, plus obviously your input cost and the return. Then I've never been able to actually make those numbers work. You come out negative on whatever you look at. Unless you really go in high. I've actually looked at that. Unless you go into dagga - that's actually quite feasible. And then dagga is one of the many things. But again, with dagga, and we looked at a scheme where we actually did a costing for a client on that -it works. The numbers actually work quite well, but you need a market for it. You need a take-off agreement on dagga. And that's very difficult to come by.

LB (06:32):

Is that for in Cape Town self?

I002 (06:32):

It was for Cape Town, yes.

LB (06:37):

Okay. Obviously, it wasn't legal back then?

I002 (06:39):

No, no, it is legal. It's even legal now. You make an application for a permit, and it's a long process. It can take you up to two years to legalise the whole system. And there's a lot of input costs that are needed because it's not a cheap thing to do. But if you can get the agreement to solve the problem, then it can work.

LB (07:01):

You said input costs. Can you maybe elaborate a little bit on what the main input costs are? Do you refer to what you said now-now with electricity, power, and water?

I002 (07:10):

If you look at any, whether it's vertical farming or dagga or anything that you want to: It's obviously about where your piece of land is, and what is the agreement on that? You need to buy it, or you need to rent it, or you need to make an agreement with the landowner to use it. And there are various models in that. That's very often one of the big costs; your secondary cost is your water. And that becomes quite a bit of a problem in the city centre. There's quite a lot of underground water in the city center, and we found that the guys who do vertical farming tap into those underground streams and rivers, and they then literally only have the pumping cost and electricity costs to get the water to the roof, or the plants. They don't then physically pay for that water.

LB (08:02):

So is that in the form of a borehole then?

I002 (08:06):

No, there's such a lot of water in Cape Town underground that there are actually channels running towards the sea. So there are these streams of water underneath, and it's surface water that runs underneath in channels and stuff and gets collected. If you look at the main buildings, the buildings that were dug out quite deep, they've all got wells that collect the water that they then pump out that so that the building doesn't get flooded. They use that water to actually then provide water, instead of buying municipal water. Also, the numbers we found don’t work.

LB (08:42):

So that's very interesting. I did not know about the wells in some of the buildings. So is it specifically in the CBD where the buildings have wells installed?

I002 (08:53):

Look, if you look at it geographically, you can do a little bit more studying, and I'm not an expert on it. But we know that there's a lot of water coming from Table Mountain - from the mountain running towards the sea underground. And obviously with these deep buildings that was built, you know, where the basement sometimes goes down 6, 7, 8 stories. They effectively are in the path of that water running towards the sea, and by digging around it, they need to get that water out. So they

create underground Wells or just catchment areas, and then the pump, the water. And that's the water that they traditionally use then.

LB (09:32):

So if a lot of buildings actually already have those wells, then that already brings down that one cost item - namely the water factor.

I002 (09:38):

I think it's a factor of, you know, do they have roof space available? You know, again, if you look at your rental costs, I cannot see that you're going to at rentals now going anything from between 90 Rand and up to 250 Rand per square meter to farm that out of a farm, or to get that return on any plants that you do. It's just not possible.

LB (10:11):

I also saw there's a few buildings that is actually vacant at the moment in the CBD - specifically, the CBD now...

I002 (10:19):

There are two problems with it. A lot of the buildings that are actually vacant at the moment are government buildings. And there's a lot of people that have tried to acquire those buildings, and the government is just not interested in it. So whether you're going to be able to get that is a very good question. I very much doubt that. There are people that are chasing those kinds of deals, and I very much doubt it. And the landowners that have got undeveloped or empty buildings in Cape Town I think are few and far between. There are, but a lot of them have obviously bought properties and are in the process of redefining it and, or repurposing it and so on. So a lot of people, if you do find it - you might find a short-term lease for it. Maybe a year and maybe with an option to extend it, which makes it difficult.

LB (11:18):

To what use are they remodelling it?

I002 (11:21):

It depends on what they're trying to repurpose it for. I mean, we worked with an owner in town that had office space, and they were trying to remodel it to student accommodation. It actually worked,

but he never went ahead with it. The other ones, uh, we've repurposed the building in town from an office complex to a hotel. We've done one of those. A lot of people convert office buildings to apartments. A lot of buildings have been converted in the CBD to residential developments.

LB (12:03):

That's interesting. I wonder...okay, we can speak about that one afterward. I just want to get back to vertical farming quickly. Another something that you said was the ability of the floor structure to carry the weight. So they use organic materials, or they use hydroponics, aquaponics, whatever. So you are saying that normal building can, or I'm asking: will it actually be able to take multiple layers, hypothetically, per storey, if you've got synthetic lighting inside.

I002 (12:39):

It depends on what you want to grow and the medium that you want to grow it in. And there are alternatives to that. I mean, I did on my own roof because my hydroponics was on the veranda's concrete roof, which wasn't very thick. And because of the weight, we actually had like this lava material. It's special, it's very light, but it's a special bowl that they use for that purpose. So it depends on what you're going to grow and what the market is for what you want to grow. But if you look at traditionally, an office building is traditionally designed for about three kiloNewtons per square meter, which means that you can put about 300 kilograms per square meter on the floor area. So you need to take that and work it back to what you want to do because she cannot exceed that. Some of the buildings are only designed for about 2.5 kiloNewton. So it's 250 kilograms per square meter. So, whatever you do, you cannot exceed that. You cannot put water tanks onto your roof and think it's going to work. Um, so as long as you stay within those parameters, I know that a lot of people are not keen for people to do farming in their buildings because there's a lot of water involved, and there's potentially a lot of spillages involved and that spillage obviously can go into your building and it could cause deterioration of the building itself. So I know a lot of owners will see it as a negative thing - the fact that you'd want to do farming in their buildings.

LB (14:21):

You said that there are a few buildings that are actually vacant at the moment. Why isn't the government doing anything about it or willing to negotiate the lease or something with regards to those buildings?

I002 (14:33):

I think there are various factors why. Some of them have been earmarked for public buildings, and they need to be renovated or restored. And it's a long process with the government. And often there isn't money, or when there is money, it gets canned or cancelled at number ninety-nine and so on. Some of the buildings can potentially be sold, but it takes very long for the process to be concluded to potentially put it out to tender. And there's also a political will, and it's not a simple process, unfortunately. So I can't really give you all the reasons why, but we do know that there is. It's actually public information. You can get a list of all the buildings that are available from the government. And they'll tell you which buildings and they are obviously earmarked for various uses in time.

LB (15:26):

So, you've said a lot now, but why do you think we have not seen an uptake in South Africa yet of vertical farming?

I002 (15:35):

I think the problem that we have here is that, or the challenge, not the problem. The challenge is that the costs of producing fruit and vegetables in South Africa, especially in Cape Town, is relatively still cheap. If you consider that there is still a lot of land available and people just take that land and they do it horizontally. If you look at other places like China and even in Europe, there are more places being taken by accommodation, and the land has become less and less. It's more scarce. It's also further away from where the product is needed. So now they are forced out further, which means that the transport becomes more expensive. It means that the products being produced in the city centre can effectively demand a higher price for it because it's at point of need.

LB (16:32):

Sorry, you're basically saying that Cape Town will first have to expand a little bit more to become a bigger city before it actually becomes really, really viable?

I002 (16:40):

It's all to do with what is your cost versus what is your return on your investment. It comes back to that point. So what is the cost to establish the system? Your planting, your material, your containers, whatever you want to do, the cost of the building or the land, the cost of electricity, the cost of your water, all those things together tells you what it's costing you to farm. And if that cost is not less

than what it is to farm outside on an open piece of land and to bring that product from there, into wherever the product is needed, it's not going to take off. It needs to be commercially viable.

LB (17:22):

You mentioned containers: just to clarify, the whole idea of this research is to focus on buildings and seeing how the built environment can actually incorporate existing buildings to include vertical farming.

I002 (17:34):

Yeah, but ultimately I've never seen that they have used a building in its raw state to put soil on or to put any other...it's always containerised.

LB (17:49):

There are.

I002 (17:49):

Yes, there are, but they were built like for that, or they use sections of it where they cordoned it off and then waterproofed it, because you must understand if you take a concrete structure and you put a lot of water in it, and it starts leaking through the building, you are effectively deteriorating the quality of your building. And there are very few owners that would allow that. So the safer way of doing it is to use containers in whatever form it is. Sometimes even concrete containers. Again, it adds weight onto your structure. So it's, it's the weight factor in high-rises that is significant.

LB (18:27):

With our weight factor, what if you can actually isolate the water in terms of hydroponics, for example, where you have tubes where the water is running through. It's just feeding the root system. It's not on the floor self.

I002 (18:39):

Yes, I agree, but you still need collection points, and how are you going to do that? Yes, you will feed it through the tubes, but at some point, the water has got to come in; it's going to circulate, and it has got to go back out. So yeah, you're a hundred per cent right.

LB (18:55):

Isn't that like normal plumbing or water supply in a house, or any building, for example, where you've got the water reticulation? And it's just running through? I'm not promoting it; I'm just asking?

I002 (19:08):

You're hundred per cent right. I think one of the reasons why I stopped, for instance, with my system, was, and that's the reason for all of these systems, and that's the big problem with all of these systems: On paper, it really looks great. And in theory, there shouldn't be an issue. But there is. I mean, I know that one of the guys in Cape Town. They had one of the restaurants with aquaponic systems outside their restaurant. They actually had a system on the roof as well. And they had the same problem as that we had, being that the roots grow so quickly that it actually blocked the tubes, and then the water spilt out of the tubes. Um, and sometimes, you know, I would leave the system on a Friday. We'll go away for the weekend and come back on Sunday, and half of the water is out onto the roof because it really grows very, very quickly because you either use the fish to feed it, or you use the material to feed the plants with. So they really grow very, very quickly, but managing the whole system and making sure that it's operational is like farming. It's constant supervision.

LB (20:25):

You know, it sounds like you saying, if we can get past the financials, it is a viable food solution?

I002 (20:32):

Yes, definitely. But also in saying that, I think in saying that it is viable and it is a definite way that the world is going. But I'm also saying it doesn't come without its problems and challenges. You need to be aware of it. It's not something that you just pay the money, you get the system, and you make money for the rest of your life. It is like farming. You've got the same problems as what you have with farming in terms of, uh, pest control and water, supply issues and quality of water, and not enough sunlight and overfeeding. And it's the same. You need to be a farmer to actually be able to manage the system.

LB (21:12):

Do you think that's one of the reasons why many developers haven’t embarked on such projects?

I002 (21:17):

I think it's one of the reasons. I think one of the problems that I see is that there's no money in it. The people that have done it so far haven't done it for the financial benefit of it. They've done it because I think a lot of them feel it's the right thing to do. A lot of them tested their hand at it. It's quite interesting when you go on second-hand websites; every now and again, you see a system that someone wants to sell. Why? Because they've tried it, and it didn't really work out the way that they planned it to work out. And also you need to go fairly big. These small systems are just not sustainable, and it actually requires more effort than what the outcome is of what you realise from them. So they need to be fairly large, and they need to be properly managed.

LB (22:07):

If we can get past those problems, do you think that a developer will, just like they do with other tenants, rent out the building as a vertical farm to a farmer? Or do you think they'll actually run the process themselves? Will it be actual companies who are interested therein?

I002 (22:29):

I very much doubt with the numbers that I have run that in my lifetime, I think. And I probably have another 40 or 50 years to go, but I very much doubt in my lifetime that we will see that as a viable solution that can compete with other traditional income streams, like accommodation, restaurant space, hotel space, office space. I very much doubt that it would even be in that league. I think yes, within the time it could potentially be, I'm not saying it can't be, but I think when you start adding up rental costs and electricity costs just to do lettuce, or to do beans or that kind of thing - I very much doubt that you would be able to, to make the numbers work.

LB (23:23):

From a project management perspective, because that's the field which you are in: who do you think will be responsible for the designing of such vertical farming buildings if we eventually reach that point?

I002 (23:36):

I think here in Cape Town alone, there are three or four companies that specialize in vertical farming. And they will actually go out and do a turn-key on it for you. They will calculate, obviously not just the upfront cost, but they'll do the layouts. They'll tell you what to farm with as well and even be able to do a feasibility study for you on it. So they're already here. I think my understanding of the guys that I've spoken to is that they focus more on people that want to invest in high-density

growth. I don't think they specifically say vertical farming, but they can obviously do that. But it's more in high-density crop generation that they do. So they are out there.

LB (24:34):

Can you or would you mind sharing a few names so that I can actually speak to them also?

I002 (24:38):

Yeah, sure. I'll have to look that up for you. Okay.

LB (24:42):

I made a note of that one. So it won't be your general architects and project management team?

I002 (24:48):

No, you'll find that, uh, they are called horticulturists, I think. The guys that I've spoken to are also guys that have got a keen eye for landscaping and that kind of thing. So we've seen some of them growing into that field as well, but it has become a specialized field. It's not your average garden or your average project manager that will play in that field.

LB (25:21):

So you're obviously aware of it that in the CBD, there are quite a few buildings vacant at the moment and even not only in the CBD but also in and around Cape Town. What do you think is the actual cause of it? Is it the economic times? Why aren't they being filled?

I002 (25:43):

I think it's what we've talked about before. I think, you know, some government buildings just take years to just come out of the ground. I think that's one, government buildings. I think at the moment there's a complete oversupply of office space because of COVID, that's played a significant role in that. So we know that a lot of tenants have moved out. A lot of buildings are standing empty because of COVID, and it will take some years for them to be filled again. I think the other thing is, as we mentioned, are buildings that are in the process of being developed or being sold to be developed. And that sometimes takes years. I mean, some of our projects we've worked on, I know the one building when we wanted to convert into a hotel, it stood empty for about four years and only had tenants on the ground, with nothing actually on the other seven storeys of the building. Then it was sold. Um, and then the guy that bought it didn't know what to do with it because he

didn't do the numbers right. He then held onto it for two years, then sold it again to another guy, and he took two years to develop it. So I think that building stood empty for about nine years before it eventually got an occupant. I think sometimes buildings are in the process of being developed. It just takes longer than, than what it should or what people actually anticipate it should take.

LB (27:12):

Just for interest sake, from a project management perspective, you obviously deal with a lot of project types, conventional residential - it's broad-based. How easy is it for you, or will it be for you to work on something such as vertical farming?

I002 (27:30):

I think it's got the same elements of any project it's, planning coordination and putting it together. It's got the same elements in terms of feasibility and all of that. There are very specifics in terms of the growing of whatever product you want to grow in, which obviously we wouldn't have the knowledge in, and we'll definitely approach someone with the correct knowledge and expertise related to that. Um, but the same principles will apply. I think the same principle also applies with regards to getting approval for whatever you want to do in the building. I've not checked the legislation from the council in terms of converting any type of building into a green building. And we'll have to check that out, whether that's actually legal to do that.

LB (28:25):

If there isn't anything in legislation, what do you do? Must you get special permission for that?

I002 (28:32):

I have unfortunately not researched that. I think the council is very positive about, you know, doing it on roofs or unutilised areas, because I think it greens and brings a lot of greening to the area. It's a positive environmental impact on people and health and carbon emissions, and all of that. So they're definitely in support of supporting that idea, whether your neighbours will be supporting when you rip out all the windows, and you do a vertical farm thing, 12 stories next to them, and they've paid three, four million for the apartment that might be a different thing. So one would have to test that. I have not looked at the legislation surrounding that.

LB (29:15):

We touched on the supply chain side now-now when you said it brings the product closer to the city. Have you got anything else that you want to add to that, to the supply side?

I002 (29:25):

It's quite interesting to see how the market has changed, especially with COVID, and how we see that. A lot of people in the past used to go to get things. You know, go to a market or go to a supermarket or go to a farm or whatever. Now we see a lot more things being delivered. It's become the norm, you know, you place your order via an app, on your phone or mail or whatever it is, and they deliver it to you. And that I think is very much in line with the growing of products in a city centre as well where the product is there, and it's quite easy to deliver products to people. So in that aspect, I think it is a positive move and will be well received.

LB (30:18):

Okay. We can go on. Um, just, you mentioned something about undertaking feasibility studies. Did you consider any other areas in your feasibility study, or which areas did you use? Or is that personal information?

I002 (30:36):

No, I've looked at a couple of places where you can actually grow. The thing is: It's the feasibility of the project that I think throws it out often. And not just for vertical farming, but for any type of development. Why does a lot of buildings not move from standing empty and it doesn't go from an office development through to a residential development? Sometimes the buildings are just not suited for that application. We've costed quite a few buildings where, after a couple of investigations, we told the client it's not going to work. We've looked at converting offices into hotels, and the building is not suited for it: the shape, the size, the configuration of it is not suited for it. And the same, I think when we get to vertical farming or farming within buildings, and maybe we shouldn't call it vertical farming, more, more just farming within buildings is maybe another word to describe it with. I think some buildings would not really be suited for that, maybe because of the location. Firstly, sometimes because of their shape. If you take, for instance, the inner Woodstock area, there is a lot of very big buildings with very deep space, and that deep space, for instance, wasn't very good for converting those buildings into residential complexes because of the internal depths of the thing - people want windows, they want outside. It just wasn't suited. And I think the same problem might have been happening with regards to the growing on the side. You've mentioned lights, but putting those grow lights in is expensive and the running costs of it. I can

almost be certain that if you do the numbers, you'll find that it will be cheaper to buy your fruit than to grow it inside.

LB (32:41):

Okay. Then you mentioned a few companies in Cape Town, which you'll send me later. Is there anyone else that you feel I need to interview that can contribute to this study?

I002 (33:07):

I think one of the guys that are out of practice is your supply chain. Any project has various facets. So if you look at what you're busy with, you're looking at establishing something in a location, but then you've got to, from that establishment, obviously do something. So you establish it, then you do something, and then you obviously have got a product that you need to sell. So, we've spoken a lot about the building itself and establishing it, but you've also got to meet with someone that can talk to you about what is your market, who's your market? Uh, how do you distribute into that market? And I think, and I'm not a specialist on that, I can't help you with that. But I think that is quite an important part of it. And there's been a lot of development in that regard, in terms of the distribution side and the sales. But all of these things come together, and it forms a picture, and that picture will tell you whether you can or you can't. And I think we all have a dream sometimes of doing something like this or doing the right thing. Uh, but unfortunately, the numbers have to come together for it to work.