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Actualising the Sustainable Development Goals with the Vertical Tower Farm

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ABSTRACT

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Civilisation requires food security, food security depends on agriculture, and agriculture depends on the environment and climate. Unsustainable food production practices threaten ecosystems, biodiversity, climate, and global food security. Increases in urbanisation, the growing global population, and ageing populations are also factors that must be considered in long-term oriented urban planning strategies to confront food security. While the Sustainable Development Goals offer a map to prosperity, the vertical tower farm (VTF) is a possible path in actualising these goals.

A VTF is an agricultural operation in a tower, with its height greater than its width, and consisting of 10 or more levels. It minimises horizontal land use and maximises the utility of vertical space. Essentially, a VTF is the combination of a modern greenhouse and tower which utilises state-of-the-art technology and food production practices. A VTF mimics natural processes that can transform waste streams into valuable resources. It utilises freely available natural phenomena, energy-efficient technology, and renewable energy to cut long term operational costs to compensate for high start-up costs while reaching sustainability goals. The VTF revolutionises food production offering local, fresh, and healthy food produced sustainably, while also supporting food security, and is a long term investment for future generations. However, the VTF remains in its conceptual stage.

This research aimed to develop a more comprehensive VTF understanding and holistic view of its systems to build an updated perception. By gathering 53 VTF publications representing the last 15 years of VTF thought, this research identified domains and categories of its systems. A SWOT analysis was used to go

Key words: Vertical Tower Farm, Sustainable Development Goals, Sustainability, Food Security, Agriculture.

deeper and discover the opportunities and challenges of the VTF. Next, the weaknesses and threats from the SWOT analysis were addressed with its strengths and opportunities. The results of the VTF domains and SWOT analysis led to the development of a meta-level model describing the dimensions, modes, and drivers of success for the VTF. Afterwards, there was a more profound discussion updating current VTF thought and establishing a foundation to guide future research, development, and innovation projects.

This research contributes to the emergence of the VTF field while also approaching the Sustainable Development Goals through an updated holistic viewpoint offering direction for future research. The findings suggest that it is essential for future work to explore in greater detail the synergies that link the VTF business model and its structural design. The meta-model framework "A Sustainable Organisation: The Dimensions, Modes, and Drivers of Success" (see Figure 20) and the 4 domains of the VTF could work as a guiding tool for future researchers to use and improve on. Finally, future work would benefit from collaborative multidisciplinary research, development, and innovation projects.

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1 INTRODUCTION

Civilisation requires food security, food security depends on agriculture, and agriculture depends on the environment and climate. Unsustainable food production practices threaten ecosystems, biodiversity, climate, and global food security. Increases in urbanisation, the growing global population, and ageing populations are also factors that must be considered in long-term oriented urban planning strategies to confront food security. These are some of the most demanding sustainable development challenges of modern times. Modern capabilities must be employed to shift away from food dependency on unsustainable practices. Nations, urban planners, industries, and stakeholders need long-term oriented sustainable alternatives to conventional agriculture to address food security. Failure to do so will jeopardise the life on this planet and the wellbeing of future generations.

Currently, agriculture typically relies on tremendous amounts of land. Land use comes at a price, and it is a trade-off with the environment. Therefore, a major design challenge of modern agriculture is an innovation in the usage of space. Historically, land use has been principally reliant on the horizontal space. Utilising vertical space has become a new frontier in agriculture. In current times, the feasibility of indoor agriculture has advanced in knowledge and technology. Now is the time to merge the theoretical and the practical in addressing an immense threat to food security and sustainability.

1.1 The Vertical Tower Farm

Towers can maximise capacity while minimising land use by benefiting from vertical space. The vertical tower farm (VTF) concept could be a viable means of addressing modern food security and sustainable development challenges while also addressing their future implications. The VTF could be part of a long-term oriented urban planning strategy. Essentially, a VTF is the combination of a modern greenhouse and tower, utilising state-of-the-art technology and food production practices. A VTF mimics natural processes that can transform waste streams into valuable resources. It utilises freely available natural phenomena, energy-efficient technology, and renewable energy to cut long term operational costs to compensate for high start-up costs while reaching sustainability goals. The VTF revolutionises food production offering local, fresh, and healthy food, produced

sustainably, while also supporting food security, and is a long term investment for future generations. The materials, technologies, knowledge, and capacities that are required currently exist that can transform this concept into a reality. Through sustainable practices, a VTF could intensively produce an enormous amount of food on a limited amount of land, both above and below ground. A VTF takes agriculture from its two-dimensional application to three-dimensions, activating volume space (see figure 1).

With a tower, it would be possible to compress the equivalent of 1 square kilometre on 1 hectare of land. For example, if a tower were to have an area of 1 hectare and a height of 100 meters, this makes for a volume-space equivalent to 100 hectares or 1 square kilometre. A VTF of these dimensions could conceivably compensate 99 hectares of natural lands from destruction (Stewart Jr, 2020.) In contrast, the average farm size in the US is 179 hectares (USDA, 2019), in Brazil 63 (Bento & Eduardo, 2016), in France 54.5 (Momagri, 2012), in Estonia 48 (AS SEB Pank, 2013), and Finland 36 (eurostat, 2018). Although in practice, these farm sizes will vary, they still give an impression of the situation. As in the mentioned example, the VTF would account for about 0.6% of the average farmland in the US, 1.6% in Brazil, 1.9% in France, 2.1% in Estonia, and 2.8% in Finland.

Figure 1. Artists rendition of an urban VTF.

1.2 The Sustainable Development Goals

Implementing the VTF concept could support the world in reaching the Sustainable Development Goals (SDGs). The SDGs were adopted in 2015 by the United Nations and are an initiative to advance global prosperity and environmental protection by 2030. The 17 SDGs are a framework intended to guide decision-making towards shaping a better world for both people and nature. The SDGs recognise that reaching these goals requires a holistic approach, addressing the economic, social, and environmental dimensions of sustainability (United Nations, 2020.)

The VTF concept directly addresses 10 of the 17 SDGs, which accounts for almost 60%, and includes the following:

- Goal 2, Zero Hunger

Currently, there has been an increase in global hunger, malnutrition of millions of children, and a global decrease in agricultural investments. There is an urgent need to expand investments in infrastructure and technology that would support sustainable agriculture (United Nations, 2019a.)

- Goal 6, Clean Water and Sanitation

Water is rising in demand globally. At current efforts, it is unpromising that most nations will reach this SDG by 2030. Therefore, it is crucial to address threats to water security by improving water resource management (United Nations, 2019b.)

- Goal 7, Affordable and Clean Energy

This goal aims to expand infrastructure and support investment in renewable and efficient energy. Accelerated development and enhanced enthusiasm are required to reach this SDG and its climate goals (United Nations. 2019c.)

- Goal 8, Decent Work and Economic Growth

With global economic growth slowing, expanding employment opportunities requires further improvement. Economic growth must be inclusive and sustainable, this can incentivize advancements in reaching the SDGs (United Nations, 2019d.)

- Goal 9, Industry, Innovation, & Infrastructure

This goal aims to support innovation in all industrial sectors globally by the development of sustainable infrastructure to promote the publics wellbeing and economic growth, that is affordable and accessible (United Nations, 2019e).

- Goal 11, Sustainable Cities and Communities

This goal aims to enhance nationwide and territorial planning on the economic, environmental, and social dimension by promoting relationships among urban, rural, and hybrid landscape locations to shape more sustainable communities (United Nations, 2019f).

- Goal 12, Responsible Consumption and Production

Globally, resource consumption has considerably grown and is a threat to reach the SDGs. The situation is urgent and requires sustainable extraction practices and environmental protection. Approaches must minimise waste, increase resource efficiency, and perform sustainable methods extensively throughout all industries and the economy (United Nations, 2019g.)

- Goal 13, Climate Action

The increases in GHG emissions have accelerated climate change. The situation requires urgency in developing more ambitious projects, with rapid steps initiated towards mitigating and adjusting to climate change. This goal aims to confront climate change and its consequences (United Nations, 2019h.)

- Goal 14, Life Below Water

This goal aims to promote the sustainable use and protection of marine resources from pollution, especially those originating on land (United Nations, 2019i).

- Goal 15, Life On Land

Due to human activity, such as with urbanisation and agriculture, over one-fifth of land on the planet has been degraded between 2005 and 2015. This goals aims to support sustainable land use, land protection, and the restoration of damaged ecosystems (United Nations, 2019j.)

The purpose of this thesis is to address food security and sustainable development challenges by the combination of structure, technology, systems, and business through the VTF concept. Firstly, the VTF is an answer to the trade-off between land use and the environment, with the efficient use of space. Secondly, the VTF can also use biomimicry to take advantage of natural processes that would aid in shifting agriculture off of harmful chemicals. Thirdly, the VTF can eliminate agricultural-environmental contamination by eliminating products associated with such contamination, and containing and managing its by-products on-site. Fourthly, renewable, energy-efficient, and automation technologies could further support its sustainable operations. Fifthly, the distance food must travel to reach the consumer could be dramatically reduced with VTF installations near or even within a city. Finally, while most agriculture is constrained by seasonality, the VTF would be capable of year-round production, supporting continual access to local, healthy, and fresh food.

1.3 Thesis Goals and Structure

Implementing VTFs as part of a long-term oriented urban planning strategy can significantly support reaching the SDGs by 2030. Although, the construction and successful business operation of a VTF have yet to be actualised. With previous publications adding much to the development of the VTF, they are also growing diverse in their focus. The VTF concept requires an updated holistic approach to

refocus the direction of subsequent research. This thesis aims to explore the body of VTF literature to support its development towards practical application by compiling the literature into an updated and holistic version of the VTF. To do this, the research will address the following questions:

1. What are the systems of a VTF?
2. What are the possible challenges and opportunities to the wide-scale implementation of the VTF?
3. What improvements could advance the current VTF theoretical model?
4. What actions must be recognised to actualise the VTF concept?

To reach these objectives, the thesis is structured as followed:
Chapter 2 will begin by establishing for the reader the severity of the situation and the need for urgent action which the VTF could address. This chapter will explore the global situation concerning food security vulnerabilities and sustainability challenges by focusing in on the following areas:

- Population growth, urbanisation, and ageing societies
- Globalisation and supply chain vulnerabilities
- Climate change
- Global agriculture.

Chapter 3 will begin by presenting the history and evolution of the VTF concept. Then a distinction will be made between vertical farming and the VTF concept by defining the term and describing what is meant by it in this research.

Chapter 4 will begin by presenting the theoretical framework underlying this research. Next, the systems of the VTF will be described.

Chapter 5 will explain the choices in the methodology of this thesis, for example, why a content analysis of the literature, SWOT analysis of the literature, and a thematic analysis of the SWOT analysis was determined, how they were conducted, and these methods limitations.

Chapter 6 will present the results of the VTF systems content analysis showing the effort how the VTF domains and their systems saturate the literature. Comparisons charts will be displayed showing the state of VTF thought.

Chapter 7 will present the results of the SWOT analysis of the VTF literature. And then, the weaknesses and threats of the SWOT analysis by using its strengths and opportunities.
Chapter 8 will present the thematic analysis of the SWOT analysis and the resulting meta-model of the VTF.

Chapter 9 will discuss the results of this research, for example, the interpretations of the findings, their implications, and limitations. The researcher will also identify gaps in the findings and give suggestions on how to improve the VTF concept. Finally, the researcher will give recommendations on the direction further research should be conducted, and what actions could be followed to advance the actualisation of the VTF concept.

This thesis will conclude by reflecting on the implications and the bigger picture of this research, and finally, a call to action for expanded support and continuation of VTF research, development, and innovation projects.

2 GLOBAL FOOD SECURITY & SUSTAINABILITY

This section presents the severity of the situation and the urgent action required, that could be addressed by implementing the VTF concept. This section will explore the background of the global situation concerning food security vulnerabilities and sustainability challenges by approaching the following areas: population growth, urbanisation, and ageing societies; globalisation and supply chain vulnerabilities; climate change, and global agriculture.

2.1 Population Growth, Urbanisation, and Ageing Societies

According to the United Nations Food and Agriculture Organization (FAO, 1996), food security was described as the circumstance in which healthy food options are accessible and affordable at any time for everyone, and that food meets safety standards and dietary requirements supporting the public's wellbeing. Today there are over 7.7 billion people on this planet (Worldometer, 2020). By 2030, the United Nations estimated the world will reach 8.5 billion people and by 2050, 9.7 billion (UN News, 2015). The wellbeing of individuals that make up societies depends on the nutrition that they receive from their food. According to several United Nations programmes, the amount of undernourishment had increased by 4%, from a record low in 2015 from 785 million people to 820 million in 2018. Further, between 2011 and 2017, of the 77 countries reported having increased malnutrition, 65 of these countries also had experienced an economic slowdown or downturn while also being characterized as highly dependent on the import and export of commodities (FAO, WFP & UNICEF, 2019.) Global urbanisation has increased by a tremendous amount expressing a demographic transformation from country to the city. From 1960 to 2018, the global urban population increased by 64%, from 33% to 55% (United Nations Population Division, 2019.) Currently, the population living in cities has become larger than that of the country. Urbanisation is anticipated to increase with population growth. The dietary patterns following urbanisation have considerably reshaped the food system. Additionally, the global population is ageing (FAO, 2017.) The elderly are especially vulnerable to malnutrition. Although it has been found that a healthy diet could decrease the risk of certain diseases, food price has been a discouraging factor to its consumption (WHO, 2020.) Agriculture and rural communities will encounter

significant effects due to urbanisation and ageing. For the progression of sustainable development to guarantee global food security, these population dynamics must be appreciated (FAO, 2017.)

2.2 Globalisation & Supply Chain Vulnerabilities

Globalisation has increased the interdependencies among nations. It is becoming more observable to the world how the conflicting interest and irresponsible actions of a few individuals, groups, and organisations can work counter to global wellbeing and have consequences affecting global food security. For example, in the United States, subprime loans were the content of toxic assets which caused mortgage-based securities to fail, although there had been plenty of evidence indicated that the loans were based on fraud, there have been no major prosecutions to date, and the consequences of which had resulted in the massive global economic recession of 2008 (Pontell, Black & Geis, 2014). Due to these irresponsible lending practices and corruption on Wall Street the consequences rippled through the world. A clear example could be seen in the price of rice, which increased by 300% within a year (Future Earth, 2020). Another source influencing uncertainty on food prices resulted from international power struggles. Such an example could be seen in the trade war between the United States and China since the past several years which resulted in the price volatility of soy (Future Earth, 2020).

The global economy plays a significant role in the business environment and society, of which the supply chain could be viewed as its foundation (van der Vegt et al., 2015). The supply chain is a part of all organisations as well as nearly all transactional activities. Globalisation has influenced improvements in numerous business areas as well as satisfying consumer demands (Scholten & Fynes, 2017). Although, the complexity of the supply chain and its interdependencies have also expanded along with increased competition and uncertainty (Mentzer et al., 2001). Supply chain disruptions are an annual occurrence and according to the fifth annual Supply Chain Resilience survey conducted in 2013, with 519 valid responses, as many as 75% of businesses faced a single disruption while 15% faced a single event totalling 1 million Euros or more in losses (Business

Continuity Institute 2013.) Consequences of unforeseen supply chain interruptions are a risk to all businesses that could result in monetary loss or bankruptcy (Skipper and Hanna, 2009).

The world is currently experiencing a significant threat to the public's wellbeing with the novel Coronavirus (COVID-19). Due to this global pandemic, global supply chains and manufacturers are becoming disrupted. For example, Chinese ports have decreased activity by 20%, while across the world in a major European port, Le Havre of France has decreased its activity by 30% (Haren & Simchi-Levi, 2020). The global food system has a complex network of interdependencies of actors. This supply chain includes producers, processing plants, and its logistics. Due to this pandemic, restrictions and quarantine regulations are expected to interrupt farmers access to markets, such as with inputs and outputs needed for agricultural processes. This would limit their operational capacity and constrain locations for sales. The restrictions to logistical routes could have consequences on the fresh food supply which could result in the spoilage and wasting of produce. This situation could be a significant challenge to nations dependent on imports (FAO, 2020.) As globalisation has increased the interdependencies between nations, situations like these remind the world of its hidden interconnections that supply chain disruptions will bring to light. These disruptions can threaten the food security of import-dependent nations.

2.3 Climate Change

Food comes from agriculture and agriculture is dependent on appropriate climatic conditions. Changes in weather patterns threaten agriculture. Food security is dependent on the climate and climate change poses a serious risk to disruptions of the food market and supply (Lipper et al, 2014.) Through the recording of weather patterns over the last century there have been the emerging signs of a changing global climate. For example, there has been a marked increase in extreme weather events such as droughts, cyclones, and floods. The United Nations had predicted in 2019 that the consequences of such extreme weather events in Southern Africa could leave 45 million people of 16 nations with severe food insecurity (Future Earth, 2020.) Another marked example is in the United States, according to statistics recorded by the National Oceanic and Atmospheric

Administration, known as NOAA (2020a), billion-dollar weather and climate disasters are on the rise, from a mere 3.4 on average between 1980 to 2000 and up to about 14 on average annually between 2011 and 2019. Billion-dollar severe storms accounted for part of these trends and have seen a significant increase in frequency over the years. For example, there was a total of 31 of these type of severe storms recorded between 1980 and 2005, averaging 1.24 severe storms per year. After 2005, these events significantly increased within the following 13-years. From 2006 to 2019 billion-dollar severe storms averaged 6.54 per year, and between 2010 to 2019, in just 9 years, this average increased to 7.1 a year. Compared to the 25-year average from 1980 to 2005 and the 9 years between 2010 and 2019, billion-dollar severe storm events in the US have seen a 472.6% increase in frequency. Other signs of the changing climate include the changes in global temperature. NOAA recorded 2019 as the second warmest year in 140 years, with October and November being some of the warmest on record globally, such as in Europe, Asia, the Caribbean, South America, Australia, and New Zealand. It was also recorded that the sea ice in Antarctica was 12.8% lower than the average between 1981 and 2010 (NOAA, 2020b.) In 2020, NOAA recorded that January the global land and ocean surface temperature was at its highest in 141 years. Signs of this increase were seen around the world. Europe experienced its second warmest January on record. Even in its most northern countries, known for their long cold winters, countries such as Finland and Norway also experienced their second warmest January, with 60% of Finland experiencing their warmest January. While across the world Asia and South America experienced their second warmest January, and Oceania their third warmest (NOAA, 2020c.) Signs of a changing climate are increasing along with substantial consequences. The situation requires a global sense of urgency and collective response.

2.4 Global Agriculture

Feeding the worlds growing population is the tremendous task of nations to satisfy food security, while in modern times the food system struggles to meet all needs, these factors will amplify if sustainable solutions and innovations fail to keep pace. For example, by 2030, given present trends, nearly 45 countries will not meet a level characterized by the Global Hunger Index Severity Scale as low hunger (GHI, 2019). Additionally, the increasing complexity of global supply

chains increases uncertainty that threatens the food security of import-dependent nations, while the actors and international relationships of nations can influence food prices on the global market place. Although underneath the trade and consumption of food is its production. Agriculture is the source of food production. It is dependent on environmental resources and conditions, such as land, water, and the climate. As well, it has an impact on these factors. Agriculture is essential to civilisation and the underlying element to its sustainability and food security.

Globalisation allows for the mass scale international trade of food between nations. On the global marketplace, agriculture influences the choices of buyers, whereas buyer and consumer demand influence the profitability of certain crops. For example, the global increase in demand for soy resulted in its increased production. Although production aimed to keep pace with demand, the results were seen in more dimensions than only economic. As a consequence, increased deforestation of the Brazilian Amazon has been influenced by soy demand (Fearnside, 2001.) Additionally, the environment and climate are circularly connected, what happens to the environment affects the climate and what happens to the climate affects the environment, including human activity. Significant concerns globally have emerged due to the signs of climate change. One of the factors that can impact the climate is due to gases which can trap heat in the atmosphere, such gases are termed greenhouse gases (GHG's). Excessive GHG emissions could have harmful consequences to climate stability. Carbon dioxide is a commonly produced GHG as a byproduct of human activity, such as with the combustion of fossil fuels, a significant emission source (EPA 2017.) Another source of GHG's is from deforestation. For example, it was estimated that between 2000 and 2005 around 3,292 million hectares of forest were cleared in Brazil producing about 340 tetragrams (340,000,000 tonnes) of carbon emissions (Harris et al. 2012).

The term carbon sequestration refers to the removal of atmospheric carbon dioxide (Forestry and Timber, UNECE, 2019). Forests are made of plants, and plants perform valuable ecosystem services. In a process called photosynthesis, plants transform light and carbon dioxide (a GHG) into the chemical energy they require to grow. Oxygen is a byproduct of this gaseous exchange which plants release into the atmosphere (Vidyasagar, 2018.) The contribution to the global carbon

cycle of a forest can vary in their net carbon sequestration or emission, which can depend on local factors such as forest disturbances (Forestry and Timber, UNECE, 2019.)

Land clearing also threatens biodiversity, but not all consequences are always seen immediately after habitat destruction, whereas time lags can occur, this is where the concept of an extinction debt comes from, the accumulation of factors and there impacts not fully to become realised until a later time (Wearn, Reuman, & Ewers, 2012). Agriculture has become vast, covering approximately 40% of the earth's surface land, and represents an enormous terrestrial biome (Ramankutty & Foley, 1999; Asner et al., 2004). In the last 300 years, the environment has been drastically changed due to land clearing for agricultural development (Ramankutty & Foley, 1999). A primary sustainable development challenge is protecting forests and their valuable ecosystem services while strengthening the production of food. The global demand for cropland and its decreasing availability has stimulated deforestation, which has been a challenging issue confronting developing nations (Wearn, Reuman & Ewers, 2012.)

Traditionally, agriculture was dependent on natural processes and had far less of an impact on the environment. After World War II, this has all changed. In industrial nations, the amount of land used for agriculture has become enormous while held by fewer people. Conventional agriculture has become mechanized and dependent on chemical fertilizers and pesticides (e.g. herbicide and insecticides) (Conway & Pretty, 2013.) Pollutants that accumulate in the soil can be carried to bodies of water through the flow and drainage of water on the surface subsurface layers (Boxall, 2012). The pure conditions of freshwater systems are threatened greatly by agriculture. While the EU had responded to water conditions by adopting The Water Framework Directive 2000/60/EC (WFD) which could be an inferable response to the issue with the agenda to restore bodies of water in the Europe Union to better conditions (Moss, 2008.) Although, there have been many challenges and delays in its application after fifteen years, and it has failed to reach its primary goal of restoring water to good quality throughout the EU (Voulvoulis, Arpon & Giakoumis, 2017). Aquatic ecosystems and their biodiversity are increasingly threatened by the drainage from agricultural activities that alter natural conditions (Blann, Anderson, Sands & Vondracek, 2009). In a first of

its kind global scale study, it was found that concentrations of insecticides surpassed regulatory standards, indicating that agricultural pollution poses an enormous threat to aquatic life from its pesticide contamination to surface waters (Stehle & Schulz, 2015). Pesticide residues can leech into bodies of water. They have even made it as far as to be observed in trace amounts in marine life in Antarctica (Corsolini et al., 2002). Another factor is eutrophication, the consequence of excess nutrients in water bodies, causing the excessive growth of algae, after which bacterial consumption of its biomass can lead to water oxygen depletion. This can have devastating results, with the loss of biodiversity (Chislock, Doster, Zitomer & Wilson, 2013.) Fertilizers nitrogen and phosphorous have had a significant increase in agriculture since the 1960s and threaten aquatic life. Agriculture is responsible for the contamination of 57% of US lakes and 60% of lakes in the Netherlands with these nutrients. Agriculture runoff is a significant source of pollution which can further surface water eutrophication (Min, & Jiao, 2002.) In the US, it is estimated that eutrophication is responsible for around 2.2 billion dollars in damages annually (Dodds et al., 2009). Pesticide usage also threatens terrestrial biodiversity. Colony collapse disorder is affecting honey bees in North America. It was found that even with non-lethal pesticide doses, bees and their colonies are threatened, and implicates significant concern for other similar insects (Henry et al., 2012.) Animal pollinators support 87 of the world's primary food crops, delivering 35% of its food production capacity. The significant drop in pollinators trending throughout the last decades is a serious threat to species, ecosystems, and global food security (van der Sluijs, 2016.) Over a third of food crops globally depend on the wellbeing of pollinators such as bees, bats, butterflies, birds, and mosquitoes (UN News, 2008). Such issues suggest the need for a fundamental paradigm shift in agriculture.

In current times, the increasing complexity of the global food system has not matched pace with public comprehension. The distances are enormous between where food is produced and processed and where it is purchased by the consumer. There is a disconnect in public awareness and food prices concerning the external costs to the environment and community by food production, processing, storage, and transportation. For example, vast food travel distances require considerable amounts of fuel. In consequence, increased GHG emissions are reflected (Pirog, Van Pelt, Enshayan & Cook, 2001.) The energy that is consumed

in the process of production, transportation and distribution of a product is called its embodied energy (Tuladhar & Yin, 2019). The term 'food mile' reflects the concept of embodied energy in regards to food systems, including distance food travels, and its environmental impacts, such as by emissions produced in the process. For example, Canada imports nearly 30% of its agricultural and food commodities. The most significant contributors to this food mile were fruits and vegetables. Consequently, this produces 3.3 million metric tonnes of carbon dioxide emission annually from over 61 billion tonnes kilometres of food to consumer distance (Kissinger, 2012.)

While the population is estimated to reach around 10 billion people by 2050, it is also projected that the economy could also grow by 50% compared to 2013, and would result in the growth of low and middle-income nations, thus influencing consumption patterns away from cereals and towards an increase in meat, fruits, and vegetables. This would require an increase in agricultural production, subsequently increasing the strain on natural resources. Agriculture that is input and resource-heavy have resulted in extensive deforestation, soil exhaustion, water scarcities, and significant amounts of GHG emissions. Such practices are incapable of supplying sustainable food (FAO, 2017.) In the report Reaping the benefits: science and the sustainable intensification of global agriculture, it is concluded that due to population growth, climate change, and the increase in consumer demand by 2050, there will be an enormous strain on the global food system requiring an increase in food production of major crops by 50 to 100% (Baulcombe et al., 2009, 47). These challenges require technological advancements and significant reductions in fossil fuels to confront climate change (FAO, 2017.)

3 THE VERTICAL TOWER FARM

3.1 The Evolution of the VTF Concept

The evolution of the VTF concept goes back in history to the idea of maximising the use of space, particularly in dense urban locations where it is limited, by utilising vertical space more effectively, and blending elements of both country living and the urbanised structural approach. The following is a brief timeline of the history and evolution of the VTF concept.

In 1909, "Real Estate Number" published in Life Magazine, was an illustration that depicted housing and gardens, offering the possibility of countryside living in a tower within the city (Hidden Architecture, 2016). In 1922, illustration "Immeubles-Villas" presented a similar concept of countryside living in the city, with houses and gardens on stacked layers (Fondation Le Corbusier, 2020). By 1981, James Wine published the "Highrise of Homes" this was a revisiting of the earlier 1909 work published in Life Magazine, to create a vertical community, including housing, gardens, and countryside landscape in a tower within the city (Cline, 2002, 220; Hidden Architecture, 2016). In 1999, a professor at Columbia University, Dr Dickson Despommier, developed with a class of his, the concept of farming in towers within the city (Columbia University, 2019). In 2004, AeroFarms was founded, a vertical farming operation aiming to produce food closer to population centres, requiring 95% less water and annually producing 130 times the yield per square meter than traditional agriculture (AeroFarms, 2020a). In 2008, Plantagon an American-Swedish company had established its international enterprises, registered its initial patent, and feasibility tests its vertical greenhouse concept (Plantagon International, 2020). In 2009, the Paignton Zoo in England had initiated a vertical farming operation with Verticrop's high density modular growing system (Frediani, 2010). Also in 2009, founder of Sky Greens, Mr Jack Ng had begun prototyping concepts for vertical farming systems. By 2012, Sky Greens started commercial operations, becoming the first globally to develop a low carbon hydraulic water-driven system for vertical farming (Sky Greens, 2014.) In 2013, the Association for Vertical Farming was established, a non-profit international organisation aimed to support the sustainable advancement of the vertical farming movement (Association for Vertical Farming, 2020). In 2015, AeroFarms moved its headquarters to New Jersey, reclaiming an old steel mill, of about 0.65 ha, and started producing around 907 tonnes of food annually (AeroFarms, 2020b). In

2016, Sasaki Associates Inc. (2020) had completed its project design for the Sunqiao Urban Agricultural District, in Shanghai, China, which is home to almost 24 million people. Rapid loss of farmland in the region due to urbanisation had stimulated the need to innovate with space, which has led to this design for the development of 100-hectares of urban farmland by integrating vertical farming systems. In 2017, Oasis Biotech, a nearly 2-hectare vertical farm operation in Las Vegas, US, was established and backed by $30 million in foreign investments. Claiming it requires 50% less energy by using LEDs compared with previous commercial greenhouses, and 90% less water than conventional agriculture (Daniels, 2018; Oasis Biotech, 2020.) In 2019, vertical greenhouse company Plantagon, files for bankruptcy, stating the primary reason was its inability to become financially sustainable (AGFO, 2019a; AGFO, 2019b). Based on statistics collected by Google Trends (2020), from January 2004 to April 2020, globally, the search frequency of the term “vertical farming” had increased by 450% (see figure 2). Thus marking a significant growth of public awareness in this direction of agricultural evolution.

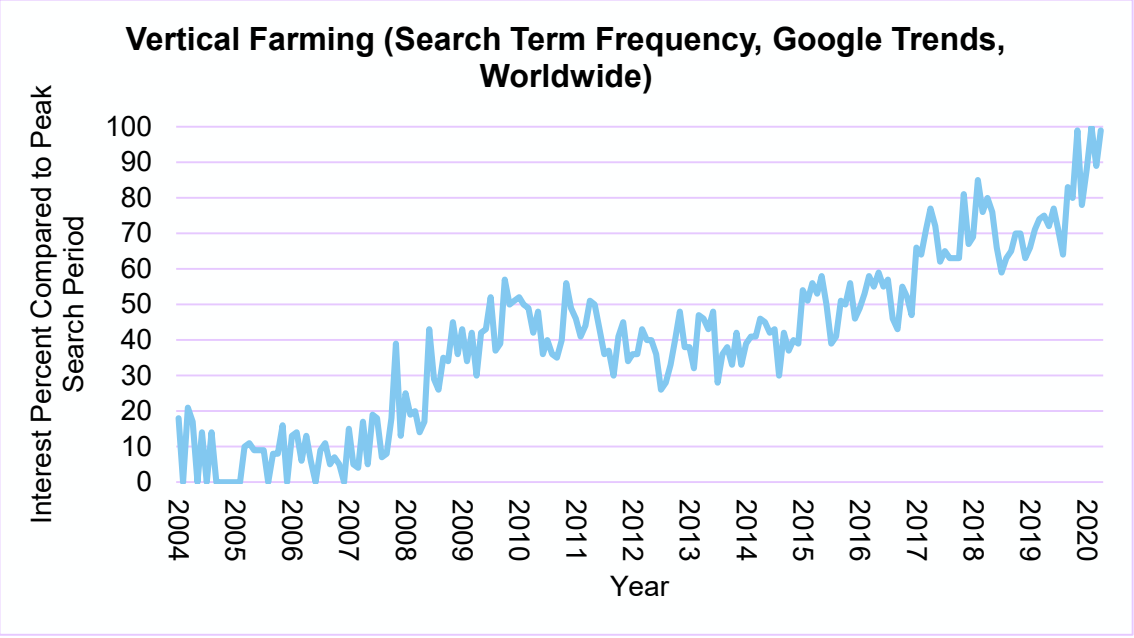

Figure 2. Search frequency of the term "vertical Farming" 2004-2020 (Google Trends, 2020).

3.2 VTF vs Vertical Farming

According to the "Dictionary of Architecture & Construction," a tower is defined as a structure which is taller than its width. Additionally, high-rise buildings are considered to be 10 to 12 levels or taller and typically built in response to expensive land (Harris, 2006, 508 & 1007.) Within the literature, there is a blur between

the terms VTFs and vertical farms, with these terms sometimes being used interchangeably. For these reasons, it is necessary to establish a distinction between the VTF and vertical farming. In this thesis, a VTF is defined as a tower specifically designed for agricultural operations, while this tower is characteristically defined by its height being greater than its width and consisting of 10 or more levels. Although vertical farms have made significant advancements in vertical space productivity, they differ from VTFs. Vertical farms are typically wider than they are tall and generally consist of one or a few levels. However, vertical farms are becoming widely implemented and represent an important intermediate evolutionary phase of the VTF concept. Whereas, addressing sustainability and food security challenges are common unifying goals leading this directional shift in the evolution of agriculture.

4 THE IMPORTANCE OF VTF SYSTEMS

General systems theory is a means to give systems a structure or framework to develop a logical architecture of knowledge. Systems theory can be used to approach organisational challenges by considering its systems workings and its environment to develop a holistic perspective. This understanding encourages decision-makers to observe challenges from a new perspective (Lai & Huili Lin, 2017.) Identifying and understanding the systems of the VTF could be essential in supporting further research, development, and innovation of the VTF concept. Therefore, forming a holistic perspective on the potential VTF systems is a support function of researchers that gives direction to the development of the emerging VTF field. The selection of the ideal combination of VTF systems continues to be a long term development that has been primarily aimed at best-achieving sustainability and operational goals. At the same time this may be its greatest barrier to implementation due to costs and complexity.

A strategy to deal with complexity is by minimising the unique elements of a system and grouping them into a smaller number of subsystems (Langlois, 2002). Modularization has many advantages for construction projects, such as enhancing the quality and accelerating construction while lowering cost and risk (Langlois, Burke & Miller, 1998). Since standardised parts for a VTF do not exist, many systems will have to be customised, while the increasing customisation could lead to a higher cost and complexity. Understanding the systems of the VTF gives further research, design, and innovation projects a holistic view, and guides their focus for the modularization of VTF systems, and could potentially enable the wide-scale implementation of VTFs.

The VTF is an organisation. For an organisation to be sustainable and develop its resource inputs must be transformed into some sort of value-added product or service that satisfies marketplace demand. Management of these processes is fundamental to business viability. Operations management is a discipline that provides an organisation guidance regarding its operations (Slack, Brandon-Jones, & Johnston, 2013, p. 4-31.) The operations management is an area of the VTF needed to develop its logical and productive operations. Effective VTF operations design requires the careful selection and understanding of systems, their resource transformation processes, and marketplace requirements. Making the

best use of low-cost inputs such as certain waste streams, such as bio-waste, or natural phenomena, such as sunlight, and transforming them through the VTF systems into value-added products and services could be a crucial enabler for the business viability of the VTF. In lean operations, elements in operations that do not add value are considered a wasteful use of time, energy, and resources, and therefore identified for elimination (Slack, Brandon-Jones, & Johnston, 2013, p. 644-490). Incorporating lean operations into further VTF research, development, and innovation could enhance achieving sustainability goals and business viability by eliminating waste and subsequently, cutting costs.

For the VTF to become a viable business operation, its potential systems must be recognised early in its planning process to select the most optimal system combinations (see figure 3). Due to the gaps in the literature, and the diversity of focus throughout the publications, this section is a compilation of the VTF systems mentioned by the literature and organised into relevant thematic areas. The following are the primary domains and subdomains of the VTF concept:

1. **Biological Domain Systems**
    a. Food Production
    b. Bio-waste Management
2. **Lighting Domain Systems**
    a. Natural Lighting
    b. Artificial Lighting
3. **Control Domain Systems**
    a. Climate Control Systems
    b. Operational Control Systems
4. **Energy Domain Systems**
    a. Renewable Energy

The systems of each domain in this section is given a brief description. This compilation will be used as a foundation for the literature analysis to get an understanding of VTF fields general focus, for example, what systems may be emerging or fading, or may be prevailing in awareness, or under recognised. It is important to note that not all of these systems should necessarily be included in a

VTF. Systems selection is paramount to VTF design, construction, and operations. These choices will directly affect a VTF's business viability and require careful consideration.

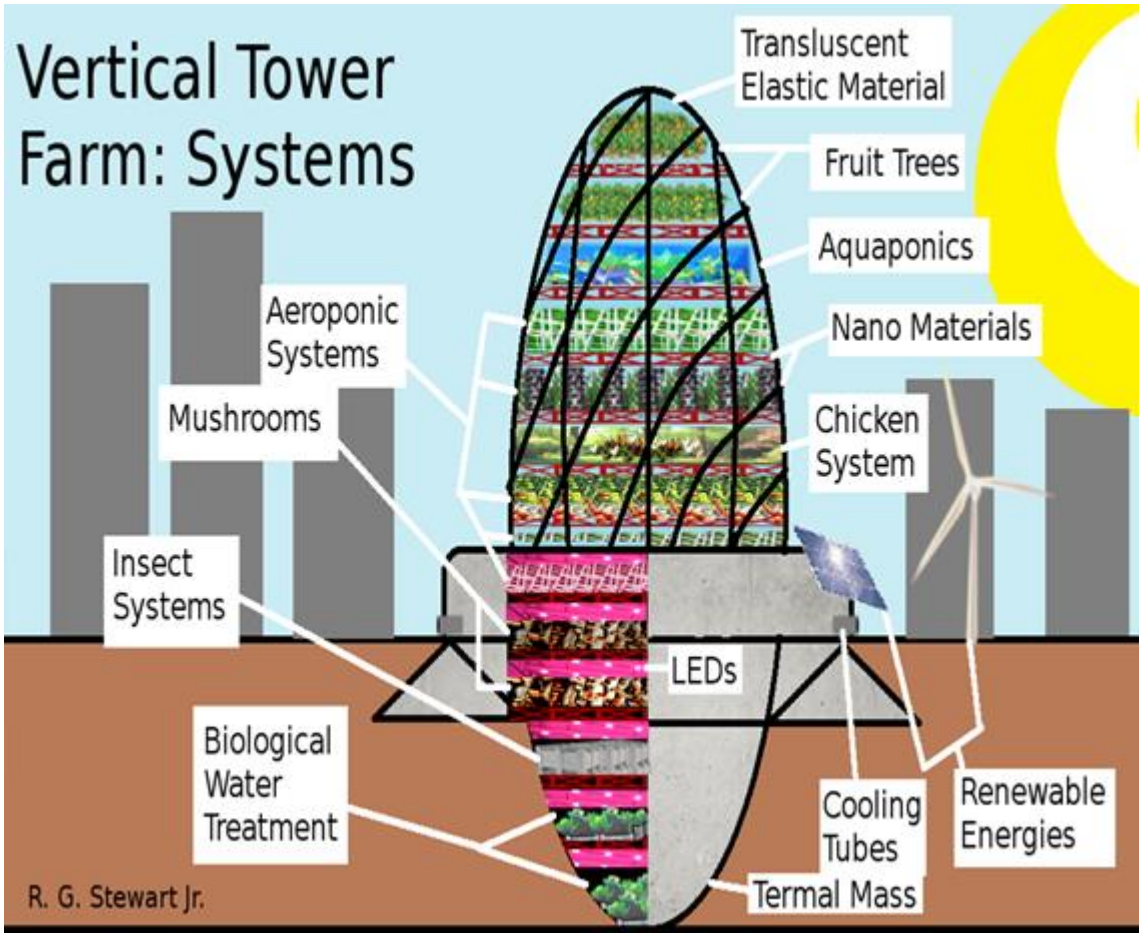

Figure 3. Diagram of hypothetical VTF systems (Stewart Jr, 2020).

4.1. Biological Domain Systems

The biological domain systems are the most extensive and central to VTFs sustainability and operations. The systems in this domain concern the utilisation and management of biological elements and processes. This domain is divided into 2 primary subsections: food production and bio-waste management.

4.1.1 Food Production

Food production is a central theme of agriculture. VTF food production has two subsections, plant production and animal production. The VTF food production systems aim at efficient usage of space and maximum production while reaching sustainability goals.

Plant Production

Plant production systems concern the operational systems of the VTF used for crop production.

Hydroponics

In a hydroponic system, instead of using soil to grow crops, they are grown in a nutrient solution (UMASS, 2020). Hydroponics is a very productive farming method that minimises water use (Jensen, 1999).

Aeroponics

In an aeroponic system, crops are grown by a nutrient solution that is misted on the plant roots (Christie & Nichols, 2004). Aeroponics increases plant growth due to the increased availability of oxygen to the plant's roots (AEssenseGrows, 2017). Compared to field agriculture, aeroponics can reduce water usage by 95%, whereas by 40% compared to hydroponics (AeroFarms, 2020c).

Rainwater Harvest

A rainwater harvest system takes advantage of the natural resource of rainfall by capturing and storing it within structures for its later use (Dhingra, Singh, Sharma & Parween, 2020). Rainwater harvest can be supplemental water-based VTF activities reliant on water while reducing grid dependency and related expenses.

Animal Production

Animal production systems concern the operational systems of the VTF used for animal production.

Aquaponics

Aquaponics is the unification of aquaculture, the farming of fish, and hydroponics, the production of plant crops in a nutrient solution. The wastewater from the fish system contains nutrients which are supplied to the hydroponic plant crops. Plants utilise the nutrients from the fish wastewater while also filtering it before it returns into the fish production system (Rakocy, Bailey, Shultz, & Thoman, 2010.) Thus providing multiple yields, fish production, and from its wastewater, a fertilizer to supplement plant production while the plants also act as a natural filter of this wastewater, such operations maximise resource usage while cutting operational costs.

Chicken Farming

A chicken farming system provides the environment to support the production of chickens. Chickens are a type of bird common to agricultural food production, primarily for their meat and eggs, while their by-products, such as manure and feathers can supplement nutrients in composting operations.

Bee Farming

A bee farming system provides housing and support to maintain and develop colonies of bees for the production of honey and beeswax. Bees also add value by pollinating plants that support many lifeforms, including humans (The Bee Farmers' Association, 2020; Bradbear, 2009.)

4.1.2 Bio-waste Management

Bio-waste management systems concern the utilisation and transformation of biological forms of waste, solid and liquid, into value-added products and services. This is done through mimicking processes of natural ecosystem services. These systems can transform conventional waste streams into valuable resources for the VTF operations while achieving sustainable development goals.

Wastewater

Wastewater systems concern the utilisation of liquid waste streams, creating secondary uses for resources, and transforming them into value-added products or services.

Greywater

A greywater system collects and stores the byproduct water from showers, sinks, and washers for later reuse (Al-Jayyousi, 2003). Agriculture uses significant amounts of water. In regions where water is more scare of a resource, freshwater for public use should take precedence. Therefore, its reuse could provide a valuable for agriculture (Faruqui & Al-Jayyousi, 2002.) Ideally, greywater should be treated before its reuse to eliminate pollutants, or it should be sourced from negligible health impacting sources.

Blackwater

Blackwater is the wastewater from toilets. Phosphorous, from blackwater was found to be an effective fertilizer in numerous studies (Gell, 2011). Urine is an ideal soluble fertilizer because it contains nitrogen, phosphorus, and potassium, major plant nutrients, and additionally, a good balance of micronutrients. Collecting urine separate is the most effective way to recover this resource (Nagy, & Zseni, 2017.)

Living Machine

A living machine is an ecologically engineered system that emulates a wetland ecosystem for wastewater treatment (Ives-Halperin & Kangas, 2000).

Solid Waste

Solid waste systems concern the utilisation of solid waste streams, creating secondary uses for resources, and transforming them into a value-added product or service.

Composting

A composting system concerns the production of compost. Compost is a nutrient-rich soil product as a result of the microbe driven decomposition process of organic matter. Composting operations concern the intentional supporting conditions of microorganisms to enhance this process. Composting has the potential to transform organic waste into a valuable product (USDA, 2020.)

Vermiculture

A vermiculture system concerns the composting of organic matter by the use of worms. It has been shown to accelerate the composting time up to 60 to 80%, while their waste byproduct is an excellent organic fertilizer (Sinha, et al., 2002; Cotter, 2020.)

Mushrooms Farming

Mushrooms naturally decompose organic matter, which aids in the recycling of nutrients. In mushroom farming systems, certain mushrooms are grown for food and medicine (Stamets, 2011.)

4.2 Lighting Domain Systems

The lighting domain systems refer to VTF systems that act as a support function of food production, primarily plant crops, which depend on light for growth. Lighting can affect the growth rate and quality of crops, as well as the costs of operations. There are two subsections of this domain, natural lighting and artificial lighting.

4.2.1 Natural Lighting

Natural lighting systems refer to lighting systems that utilise naturally occurring light, particularly from the sun.

Sunlight

Natural lighting comes from the sunlight, its free to use, and has been used with great success since the dawn of agriculture. However, its use in agriculture can be constrained by objects blocking the light, and also due to the earth's cycles, such as day and night, weather, and seasonality.

Mirrors

Mirrors can reflect light, which can be angled to directs light towards locations that it had previously been blocked. For example, in a Norwegian village, that due to being in between two mountains, had a long dark period, and as a novel solution to this, they used mirrors to angle available sunlight into their village (Geddes, 2017).

Fibre Optics

While natural lighting is a free resource, it can be blocked from reaching deeper into a building. Fibre optics has offered a technological solution by capturing light where it is available and transferring it to places it is not (Parans Solar Lighting, 2020.)

4.2.2 Artificial Lighting

Artificial lighting systems refer to lighting systems that utilise artificially produced lighting, particularly from electricity.

Light-emitting diode (LED)

LEDs are an improved lighting solution due to their affordability, long life, energy efficiency, luminous efficiency, spectral variation, and low temperature, which has resulted in their adoption in numerous disciplines. LEDs are substituting traditional greenhouse lighting, such as high-pressure sodium lamps. Additionally, modifications to LED lighting can be used to improve crop quality, resulting in enhanced value (Kozai, 2016.)

Fluorescent

Fluorescent lighting is commonly in the form of a tube, used for lighting large areas, and more energy efficient than incandescent lighting (US Department of Energy, 2020). Fluorescent lighting was normally coupled with incandescent lighting to achieve crop growth similar to field agriculture (Downs and Hellmers, 1978.) It is expected that LEDs will replace fluorescent lighting systems in agriculture (Darko et al., 2014).

High Intensity Discharge (HID)

HIDs are composed of various mixtures of vaporized metals, they give off significant heat, and cannot be placed too close to plants. They have been one of the

most used lightings for indoor agriculture, accounting for 89% of lighting systems, while LEDs represented only 4% in 2017 (Stober, 2017.)

4.3. Control Domain Systems

The control domain systems refer to systems that regulate VTF conditions. This section is divided into two primary areas of VTF control, the climate control systems and the operational control systems. These systems support the VTF reaching equilibrium conditions that are optimum for production.

4.3.1 Climate Control Systems

The climate control domain systems refer to VTF systems that aim at regulating the VTF climate, a critical environmental support system, which enables the stable growing environment for healthy and productive year-round production of crops.

Passive Climate Control (PCC)

PCC is an alternative to MCC, in which the natural phenomena acting upon a building are taken into prior design consideration or post retrofitting to achieve natural climate control and energy efficiency. PCC aims to appropriately use solar integration, shading, thermal mass, insulation, and natural ventilation in buildings design features to create a balanced indoor climate (Earthship Biotecture, 2020; Williams, 2020).

Mechanical Climate Control (MCC)

MCC is a mechanical and electricity dependent type of heating, ventilation, and air conditioning (HVAC) system. HVAC systems provide climate control for buildings (WebFinance Inc., 2020).

Hybrid Climate Control (HCC)

An HCC is the combination of MCC and PCC to create an effective and efficient climate control system by creating complementary support and redundancies.

4.3.2 Operational Control Systems

The other control domain systems refer to VTF systems that are important for supporting the VTF operations.

Automation

Automation is used to control and monitor the productivity of operations by the application of technology, such as through robotics, hardware, and software, that can improve productivity, decrease costs, and save time (Techopedia, 2020).

Internet of Things (IoT)

The IoT is an infrastructure of interconnected computer networks, known as the internet, which unifies things by enabling the control of these things while providing information concerning their status (Madakam & Lake, 2015).

Artificial Intelligence (AI)

AI is algorithm-based computer technology, which aims to imitate the complex biological thinking processes, for problem-solving applications (Makridakis, 2017).

Information Technology (IT)

IT is the application of technology that manages the transmission and storage of digital information (Grauer, 2001).

4.4 Energy Domain Systems

The energy domain systems refer to VTF systems that power operations. Energy use is directly related to operational costs. Sustainability goals and cutting costs are the primary energy goals of the VTF, which is the reason the literature expressly discusses the use of renewable energy as opposed to dependency on the grid and which come from potentially unsustainable energy sources that are expensive for VTF operations.

4.4.1 Renewable Energy

Renewable energy sources are sources of energy that can continually be replenished based on natural phenomenon, such as from sunlight, wind, gravity, or thermal properties of nature. These sources are in contrast to energy sources such as fossil fuels which are more finite in nature and can be depleted while at the same time causing environmental degradation. These energy sources aim at achieving sustainability goals and long term oriented cost savings (see figure 4).

Solar Energy

Solar energy takes advantage of the renewable energy source produced by the sun. One application of solar energy generation is from the thermal energy that can be produced by the heat of the sun, such as for heating of air or water, or the generation of power. Another is its more widely known application, called photovoltaic, known by its solar panels, which converts the suns energy into electricity (Sukhatme & Nayak, 2017.)

Wind Energy

Wind energy is generated by the power of the wind and transformed into electricity by a mechanism called a wind turbine (Manwell, McGowan & Rogers, 2010, 2).

Geothermal

Geothermal energy comes from the renewable reservoir of thermal energy contained beneath the earth's surface, which can be obtained through drilling and heat-mining technology (Tester et al., 2006).

Biogas

Biogas is a renewable energy source that is generated by a natural biochemical process, the anaerobic digestion of organic waste. Biogas can be used as a renewable alternative for gas power sources (Weiland, 2010.)

Hydroelectricity

Hydroelectricity is generated through the movement of water, and this kinetic energy is used to drive a turbine, converting this motion into electricity (Bakis, 2007).

Tidal Energy

Tidal energy comes from the gravitational force of the sun and moon acting upon the earth, which results in the movements of water, such as in the tides and waves. This kinetic energy can be used to drive turbines which converting it into electricity (Rourke, Boyle & Reynolds, 2010.)

Figure 4. Simple VTF design displaying renewable energy integration (Stewart Jr, 2020).

5 RESEARCH METHODOLOGY

This research used both quantitative and qualitative content analysis of the VTF literature. Quantitative content analysis is a research method that focuses on determining the occurrence frequency categories (Randolph, 2008). While qualitative content analysis is a systematic and repeatable research method which can be used to compress large volumes of data into manageable categories, through the use of coding rules. The reliability of these methods depends on the precise recording of coding instructions for its repeatability (Stemler, 2000.) The validity of research methods depends on precision consistency in the collection of cases being researched, which results in a generalisable outcome that is representative of the whole (Middleton, 2020). For both the quantitative and qualitative content analysis in this research, validity was intended to be enhanced by collecting a large enough sample size of publications, while ensuring the accuracy of the case topics collected, that the results would be generally applicable, and to ensure the reliability, the explicit approach to this research is recorded. Although a limitation to these methods is due to being based on a single researcher's perspective of what merits importance. To compensate for this, the researcher conducted multiple phases of preliminary manual analysis through reading each publication case and included a phase for becoming familiar with the text and note-taking to generate a preliminary list of relevant concepts, while the second phase took a deeper analysis, concentrating noticing new details, especially those which were to a lesser extent or rarely mentioned.

5.1 Data Collection

The first part of the content analysis was the collection of data. To do this, the Google Scholar database was chosen for its wide-reaching search results, estimated to reach 389 million records from scientific databases and other academic publishing sources (Gusenbauer, 2019). To collect relevant literature on VTFs the keywords selected were "Vertical Tower Farm*" and "Skyscraper Farm*", whereas the asterisk (*) was used as a wildcard input, for example, to include results that ended with an "s" or "ing" or no letter, for example, "farm*" would generate search results including farm, farms, farming. This was done to reach the maximum qualifying search return. This search was then repeated for both keyword, but the second time, instead of using the term "farm*", "agriculture" was used as a substitute. The case was admitted to the sample if it included any

phrase in the body of its text to indicate that farming within a tower was part of the main topic such as if the case mentioned: "vertical tower farming", "vertical tower agriculture", "skyscraper farming", "skyscraper agriculture", "multi-storey farming", "multi-storey agriculture", "greenhouse tower", "multi-storey plant factory", "high-rise farming", "high-rise agriculture", or any variation of those phrases, which were also used as search terms for collecting articles. The asterisk (*) was used as a wildcard input to include results that ended with an "s" or "ing" or no letter. This was first done through the automatic keyword search function for quick verification. If a close matching publication yielded no automatic keyword retrieval, a closer manual look at the text would be done to verify, if there was no mention of the VTF and its various terms throughout the text, then the publication would be disqualified.

The data collection resulted in 53 publications (see Appendix A, Case Analysis Publication, p. 97) between 2005 and 2015. They consisted essentially of theses and articles, and a few website publications. The total word count for the body of text consisted of 387,068 words, while the average publications word count was 7,303, averaging 1.89% of the text per publication, while 32% of publications were above this average, accounting for about 3.74% of the text per publication, with the highest publication word count accounting for 8.7% of the total publication word count, while almost 34% represented less than 1% of the total publication word count, with the average in this range accounting for 0.6%, with the smallest publication accounting for only 0.12% of the total word count. The data was then converted into a format usable by the analysis software QDA Miner Lite to assist in the content analysis.

5.2 System Frequency Content Analysis

The system frequency content analysis first began by reading through the literature to become familiar, while taking preliminary first round notes on relative content concerning potential VTF systems. This was done preliminary to developing the theoretical framework. The topic of systems was a reoccurring theme, which was then validated through testing the frequency of occurrence using the analysis software and the keyword "system*", whereas the asterisk represented a wild card to include results for the terms "systems", "systematic", systemise", etc. These results validated the importance of this term to the VTF field, accounting

for occurring more than one or more times in 94% of the case publications. The content concerning the term "system" and its variations was then examined for pattern analysis. It became apparent that there were a variety of proposed systems related to the VTF operations, their support function systems, control systems, and waste management systems. The literature cases were then manually reviewed to include any relevant system related to the VTF concepts potential operations that may not have explicitly been referred to in the text as a system, but qualified by the characteristics of a relevant set of interconnected elements that concern VTF operations, their support function systems, control systems, waste management systems, or any other value-added operation that would pertain to a VTF system. After developing a list of systems, they were grouped with any other term that would represent the same meaning. A thematic analysis of the categories was then conducted to create a higher-order for the organisation of these system categories into relevant themes. This resulted in the conception of the 4 domains of the VTF systems: Biological, Lighting, Energy, and Control. These categories and the variations of their keywords were separately entered into the analysis software for frequency retrieval. An analysis table was created for each domain, including the relevant system categories. Each system category had its primary term and its variation term. The primary term was named for the most prevailing, most accurate, and most encompassing term of the concepts the category represented. The categories terms and all the variations were then systematically analysed for the frequency of occurrence within the case publications. The categories were recorded for their frequency of occurrence, while the outcome of this data was the generation of the frequency of occurrences in a category for each publication. This was used to calculate the total amount of category frequency of the whole case sample size, and also verify the number of publications that mentioned a category at least once out of the whole sample size. Various generalisations could be inferred from this type of generated data, for example, due to the diversity of the cases and their total amount of text, this could indicate the depth of interest that VTF publications have in a category, which can indicate the potential level of importance of a category, or the level of awareness of researchers on a category, such as if a category may be emerging or fading in the field. This is useful to describe the uniformity of a category given by a publication vs the field. While verifying the number of publications that mentioned a category at least once out of the whole sample size could be useful to get a

broader perspective on the popular awareness regarding a category, its potential importance, or overemphasis. Another thing these results could represent is the evolution of categories within the VTF concept, while some have become outdated and replaced by newer more optimal categories.

After the results were compiled into their respective analysis tables, the results the categories were converted into graphs and charts for easy comparison and pattern analysis. The averaged percentage of occurrences of a category throughout the collected publications and their case occurrence were chosen to produce a result that could show an indication between where the most effort has been placed in the literature and the distribution of awareness throughout the whole of collected publications as a sample for the whole of the VTF field. To do this the percentages of each category by its total frequency of occurrence and by the number of cases a category had occurred within the whole of the publications were averaged. This approach will subsequently be referred to as a variable's averaged percentage occurrence and distribution within the collection of literature (See Appendix B, Formulas, p 100; and Appendix C, Domain Systems Analysis Tables, p. 101-109).

5.3 SWOT Analysis

The SWOT analysis stands for Strengths, Weakness, Opportunities, and Threats. This tool is useful for uncovering organisational elements that contribute to the sustainability and development of an organisation or hinder it. The strengths and weaknesses represent internal factors, while opportunities and threats represent external factors. The SWOT is a valuable analysis tool because it raises the situational awareness planners and decision-makers how to take advantage of an organisations strengths and opportunities and overcome its weaknesses and threats (Ansoff, 1965; Andrews, 1987; Porter, 1991; and Mintzberg et al., 1998.) To conduct the SWOT analysis, systems thinking and operations perspective was the lens, as had the previous content analysis of the systems had implied. The objective of the SWOT analysis was to uncover the possible challenges and opportunities to the wide-scale implementation of the VTF. To do this, the literature cases were re-examined for indications of challenges and opportunities, preliminary notes were taken. Next, categories of these notes were developed. Codes and categories resulted either explicitly, directly mentioned in the text, implicitly,

indirectly mentioned in the text, or through the researcher's synthesis of the bigger picture. Reflective practice is a research method that utilises reflective thinking throughout or subsequent to an action to generate novel perspectives on a matter (Coghlan & Brydon-Miller, 2014). This was done throughout the thesis process, pre, during, and post analysis, while it was based on the growing familiarity with the research, it was also synthesised with the researcher's background (e.g. long-held interest in sustainability, and as an international business B.A. degree student). Keywords and their variations associated with these categories were generated to follow up with using the analysis software. Additionally, terms associated strength, weakness, opportunity, and threat, and their variations were also searched. A refined list of SWOT categories was then developed, combining multiple where possible. After this, the SWOT outputs were compiled into an analysis table and references were gathered and categorised with associating SWOT variables based on their closeness of influence on developing the refined SWOT variable. Although it should be noted, due to the combination and refinement of multiple variables, some direct influencer shifted into more loosely associated influencers (see Appendix D, SWOT Analysis Table, p. 110).

5.4 Thematic Analysis of the SWOT Analysis

After generating the results from the SWOT analysis, it was further analysed using the qualitative content analysis method. For this, the SWOT analysis was examined for higher-order themes concerning the successful implementation of the VTF. Linking ideas were organised in a draft table. These ideas were rearranged in arrangements that seemed to have some logical order, this was done concurrently with reflective practices. As the order emerged, it was reflected on and refined, until it developed into a logical and useful higher order of knowledge. After this process, the thematic categories were then arranged into a draft version of a model to visually depict the concept. This was then subject to several iterations, revisions, and developments of the model until the final version was generated, thus transforming this content analysis process into a simultaneous constructive model generation. This idea of this analysis and construction was to create a useful tool to reflect upon for the next phase of the research, as a VTF framework for addressing the SWOT analysis weaknesses and threats, and the discussion, which was also a synthesis of the whole results section. The SWOT

analysis strengths and opportunities were also used to address the VTF weaknesses and threats.

6 RESULTS

In this section results of the content analysis, SWOT analysis, and the thematic of the SWOT analysis are presented. There were 53 publications sourced from the literature over the last 15 years. Figure 5 depicts the publication frequency over time. One publication from 2020 was removed from this graph since the year has not completed. Over 14 years, from 2005 to 2019, there was an average of 3.7 publications per year. 2018, marked a peak year with 9 publications. There is an upward trend in VTF publications. The Year 2005 contrasted 2019 by a 600% increase in VTF publications. The analysis of the publications was aimed at creating a more holistic and updated perspective on the VTF concept by answering the research questions, with each subsequent phase of the analysis building upon the previous through the lens of the theoretical framework of systems and operations thinking.

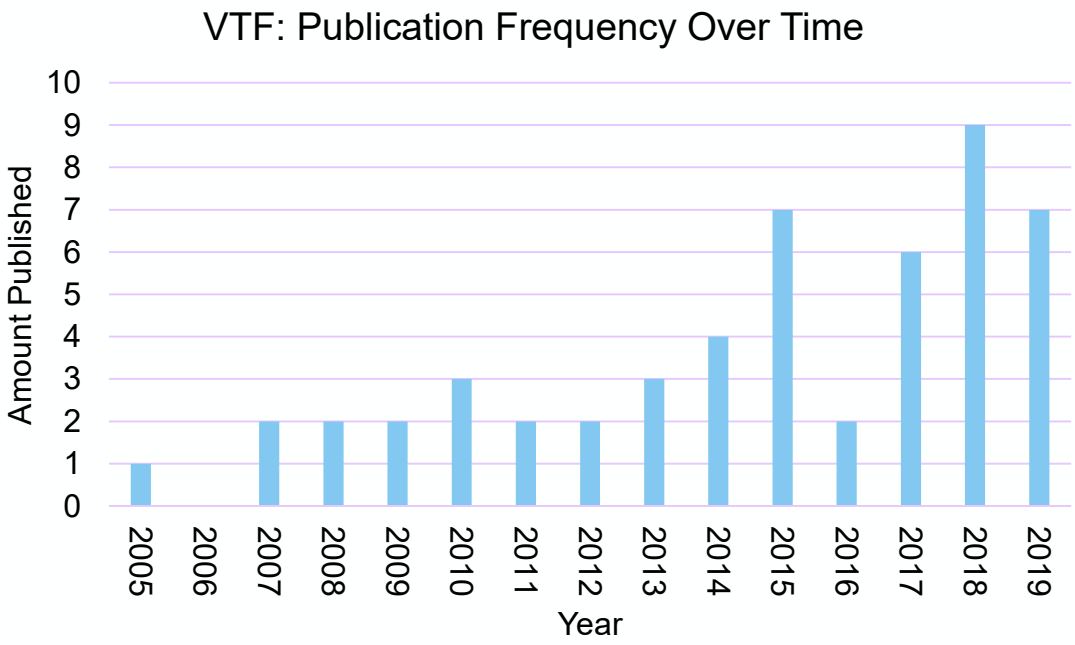

Figure 5. VTF publication frequency over time, from 2005 to 2019.

6.1 VTF System Domains in the Literature

After analysing the 53 literature cases, the VTF systems were identified, from these, numerous categories surfaced. These categories were defined into themes that resulted in the 4 domains of VTF systems:

1. Biological
2. Lighting
3. Energy
4. Control

Figure 6 presents the average percentage of each domain by its total frequency of occurrence and by the number of cases a domain has occurred within the whole of the publications. These results were the variables 'averaged percentage occurrence and distribution' within the sample collection of literature. The averaged percentage of these two results were chosen to produce a result that could show average between where effort has been placed in the literature and the distribution of awareness within the publications.

The average percentage occurrence and distribution within the collection of literature resulted in the Biological Domain Systems being the greatest domain in the literature at 45%, which had a 4.5% standard deviation (SD) between its occurrence and distribution, the Lighting Domain Systems were next at 23% with a 3.5% SD, followed by the Control Domain Systems at 17% with a 2.3% SD, and lastly, the Energy Domain Systems were at 15% with a 5.6% SD.

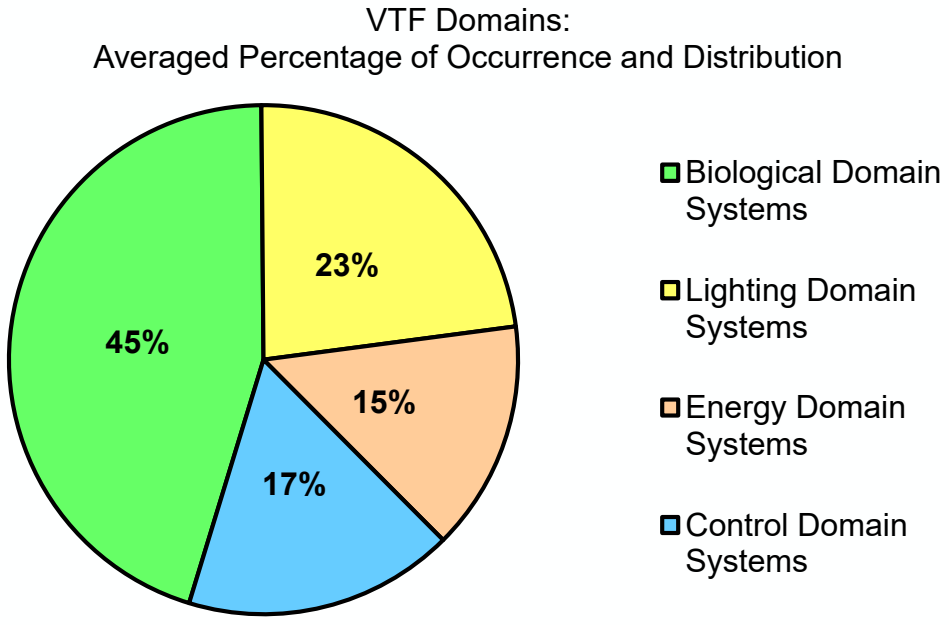

Figure 6. VTF Domains: Averaged Percentage of Occurrence and Distribution.

6.2 VTF System Categories in the Literature

In this section, each VTF system category is classified within its relevant domain and ordered by the number of cases that have mentioned the system. To present the results the averaged percentage occurrence and distribution and the SD of those two variables were chosen. The averaged percentage of these two results were chosen to produce a result that could show average between where effort has been placed in the literature and the distribution of awareness within the publications (See Appendix B, Formulas, p 100; and Appendix C, Domain Systems Analysis Tables, p. 101-109).

6.2.1 Biological Domain Systems

The Biological Domain Systems average percentage occurrence and distribution within the collection of literature was mentioned with the greatest frequency. There were 2 subdomains with 12 system categories:

1. Food Production
    a. Plant Production
        i. Hydroponics
        ii. Aeroponics
        iii. Rainwater
    b. Animal Production
        i. Aquaponics
        ii. Chicken Farming
        iii. Bee Farming
2. Bio-waste Management
    a. Wastewater
        i. Grey water
        ii. Black water
        iii. Living Machine
    b. Solid Waste
        i. Composting
        ii. Vermiculture
        iii. Mushroom Farming

Of all the biological systems, using the averaged percentage occurrence and distribution, plant production had the greatest percentage of occurrence at 39%, while wastewater was second at 27%, then solid waste at 24%, and lastly, animal production at 11%, all with a SD of 11% (See figure 7).

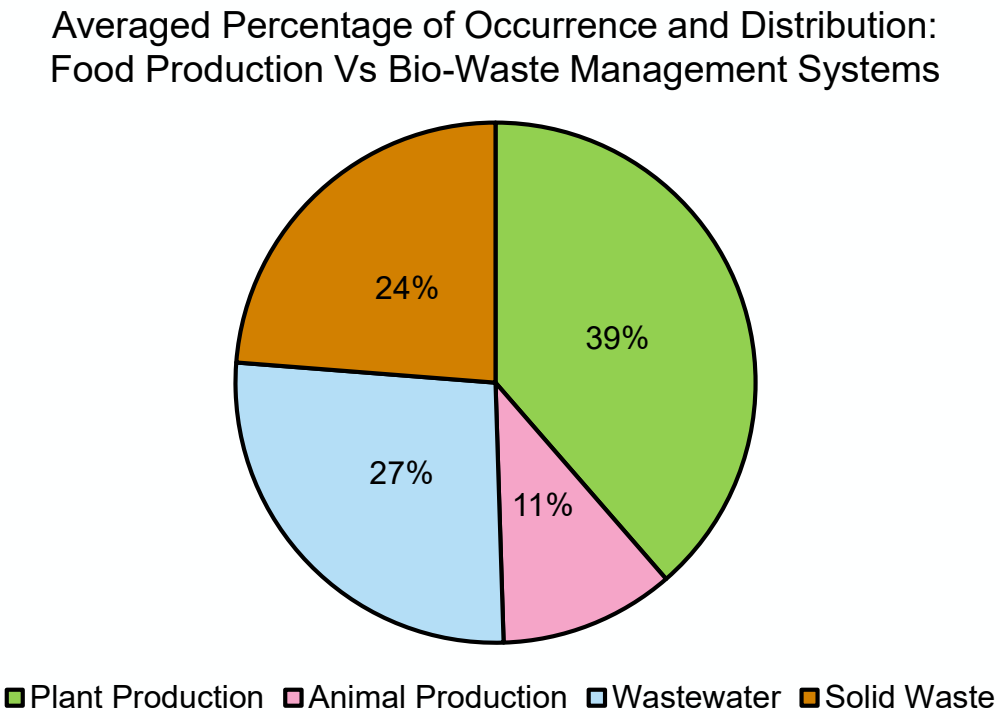

Figure 7. Averaged Percentage of Occurrence and Distribution: Food Production Vs Bio-Waste Management Systems.

Food Production Systems

This section presents the data results of the food production systems using the averaged percentage occurrence and distribution. The results are that plant production had the greatest percentage of occurrence and distribution of all plant production systems at 78%, while animal production was at 22%, both with a SD of 2.4% (see figure 8).

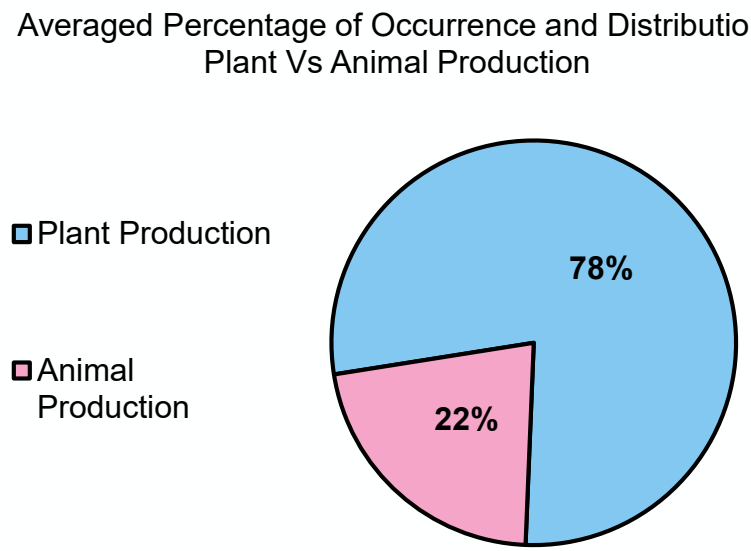

Figure 8. Averaged Percentage of Occurrence and Distribution: Plant Vs Animal Production.

Plant Production Systems

This section presents the data results of the plant production systems using the averaged percentage occurrence and distribution. The results are that hydroponics had the greatest percentage of occurrence and distribution of all plant production systems at 54% with a SD of 15%, followed by aeroponics at 31% with a SD of 3%, and lastly rainwater harvest at 16% with a SD of 12 (see figure 9).

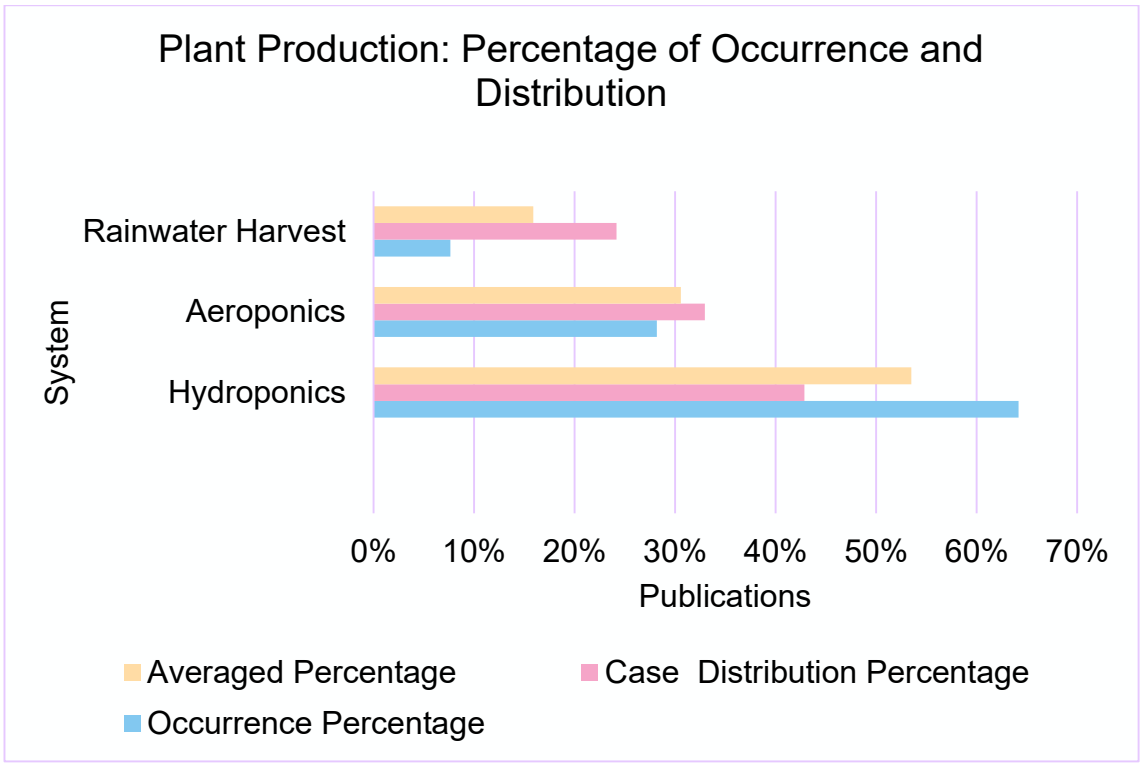

Figure 9. Plant Production: Percentage of Occurrence and Distribution.

Animal Production

This section presents the data results of the animal production systems using the averaged percentage occurrence and distribution. The results are that aquaponics had the greatest percentage of occurrence and distribution of all animal production systems at 64%, with a SD of 20%, followed by chicken farming at 27% with a SD of 12%, and lastly bee farming at 9% with a SD of 8% (see figure 10).

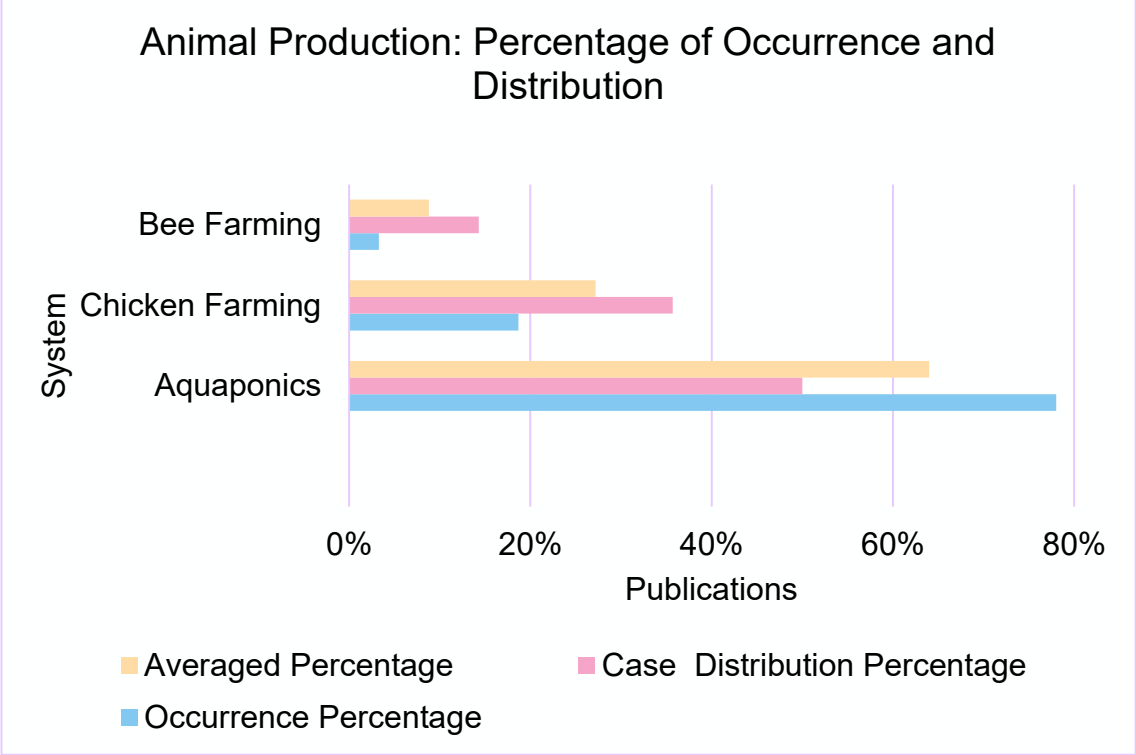

Figure 10. Animal Production: Percentage of Occurrence and Distribution.

Bio-waste Management

This section presents the data results of the bio-waste management systems using the averaged percentage occurrence and distribution. Bio-waste management has two subdomains: wastewater and solid waste. The results are that wastewater systems had the greatest percentage of occurrence and distribution of all bio-waste management systems at 54%, while solid waste had 46%, both with a SD of 2.3% (see figure 11).

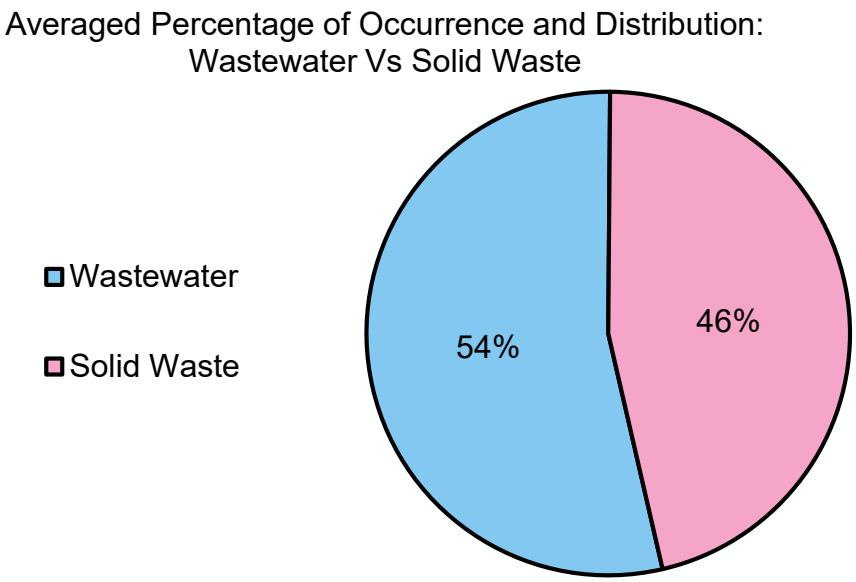

Figure 11. Averaged Percentage of Occurrence and Distribution: Wastewater Vs Solid Waste.

Wastewater

This section presents the data results of the wastewater systems using the averaged percentage occurrence and distribution. The results are that blackwater systems had the greatest percentage of occurrence and distribution of all wastewater systems at 46% with a SD at 2.5%, followed by greywater systems at 42% with a SD at 3.1%, and lastly living machine systems at 12% with a SD of 0.6% (see figure 12).

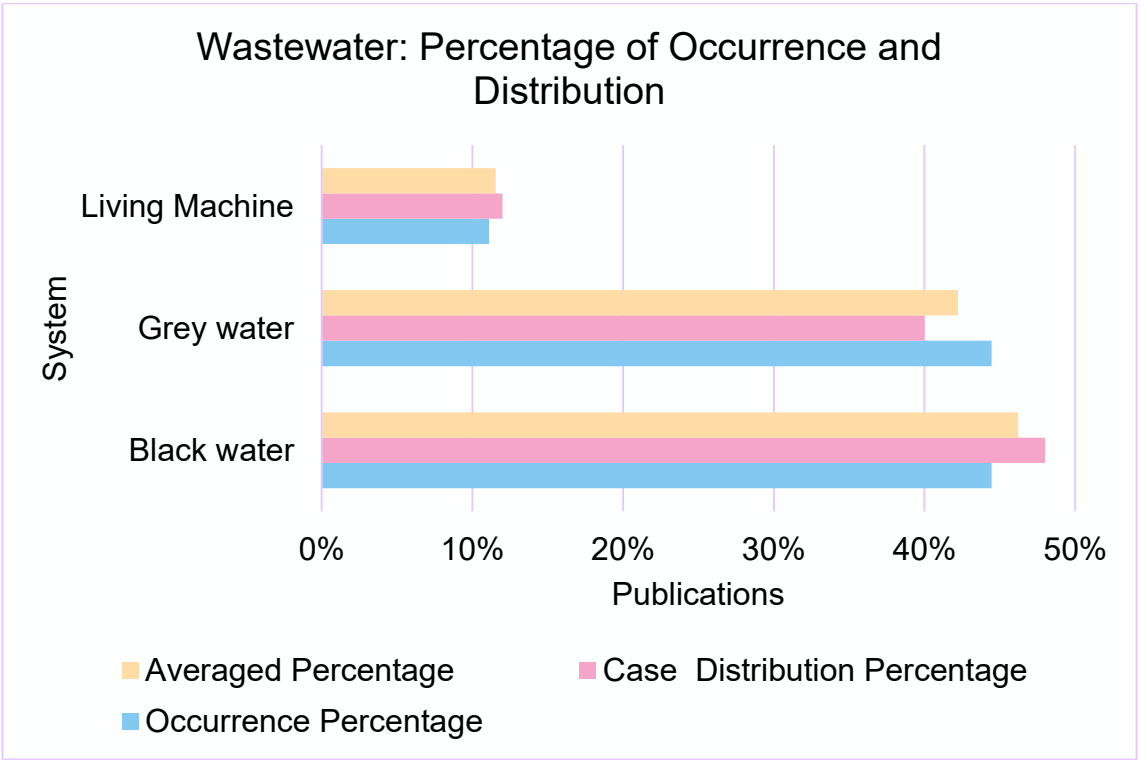

Figure 12. Wastewater: Percentage of Occurrence and Distribution.

Solid Waste

This section presents the data results of the solid waste systems using the averaged percentage occurrence and distribution. The results are that composting systems had the greatest percentage of occurrence and distribution of all solid waste systems at 57% with a SD of 7%, followed by mushroom farming at 35% with a SD of 6%, and lastly, vermiculture at 8% with a SD of 1% (see figure 13).

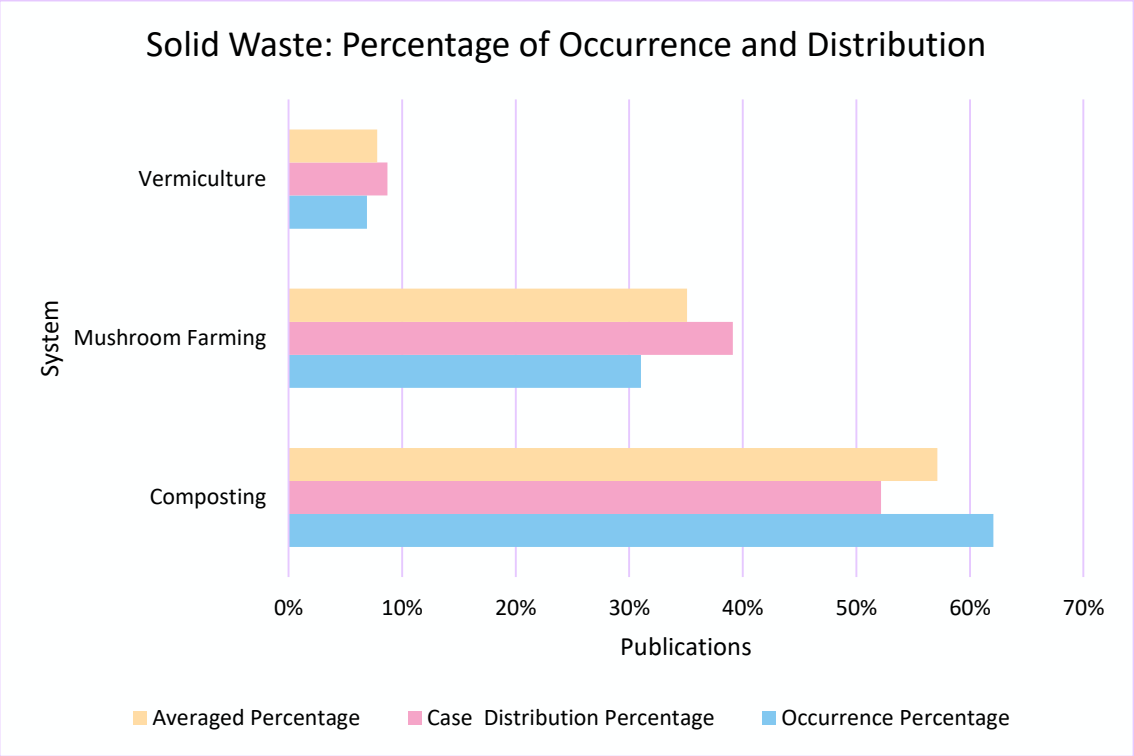

Figure 13. Solid Waste: Percentage of Occurrence and Distribution.

6.2.2 Lighting Domain Systems

This section presents the data results of the Lighting Domain Systems averaged percentage of occurrence and distribution within the collection of literature, and was mentioned with the second greatest frequency. This domain contains 2 sub-domains with 6 system categories:

1. **Natural Lighting**
    a. Sunlight
    b. Fibre Optics
    c. Mirrors
2. **Artificial Lighting**
    a. LEDs
    b. Fluorescent
    c. HID

Natural Lighting

The results are that sunlight systems had the greatest percentage of occurrence and distribution of all natural lighting systems at 85% with a SD of 6%, followed by mirrors at 11% with a SD of 4%, and lastly, fibre optics at 5% and a SD of 2% (see figure 14).

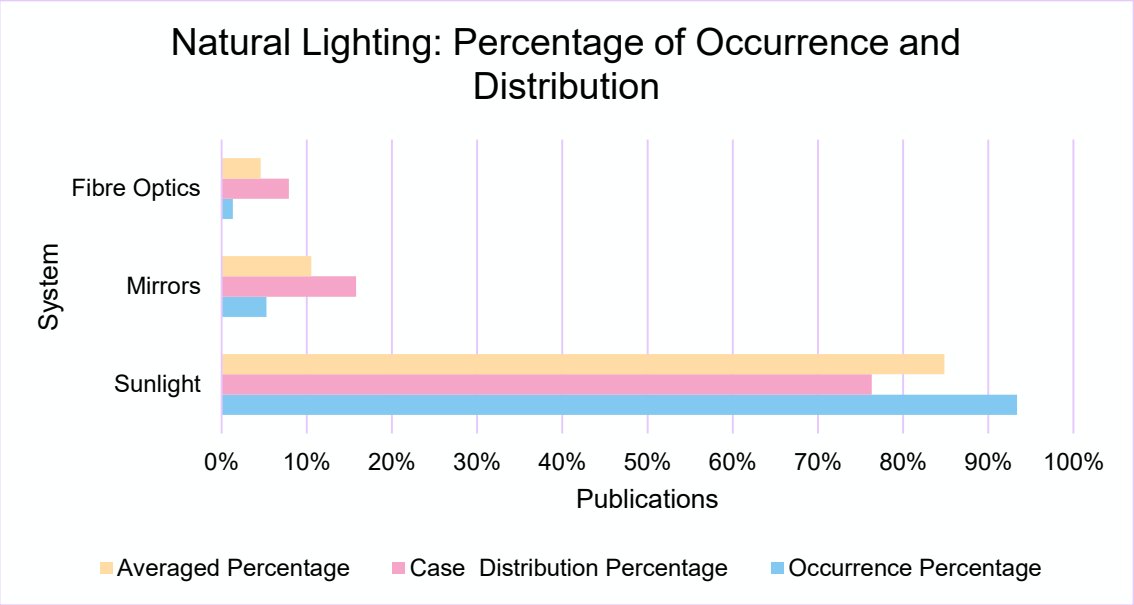

Figure 14. Natural Lighting: Percentage of Occurrence and Distribution.

Artificial Lighting

The results are that LED systems had the greatest percentage of occurrence and distribution of all artificial lighting systems at 75% with a SD of 1.9%, followed by fluorescents at 17% with a SD of 1.1%, and lastly, HID at 8% and a SD of 0.8% (see figure 15).

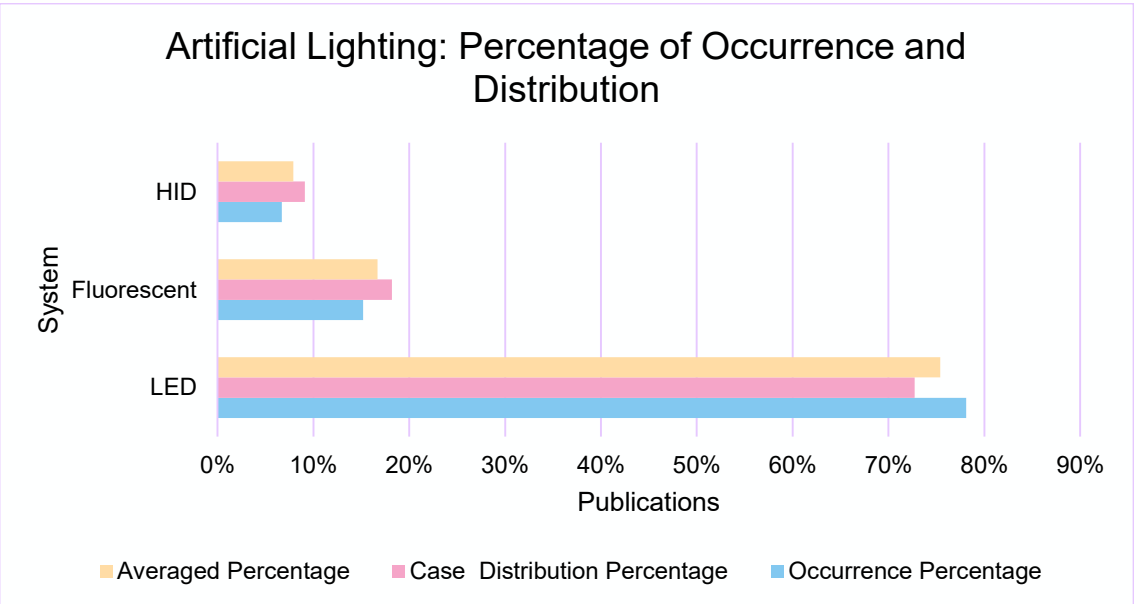

Figure 15. Artificial Lighting: Percentage of Occurrence and Distribution

6.2.3 Energy Domain Systems

This section presents the data results of the Energy Domain Systems average percentage occurrence and distribution within the collection of literature was mentioned with the third greatest frequency.

Renewable Energy

The results are that solar energy systems had the greatest percentage of occurrence and distribution of all renewable energy systems at 48% with a SD of 6%, followed by wind energy at 25% with a SD of 1%, next was geothermal at 13% with a SD 3%, then was biogas at 8% with a SD at 0.21%, after that was hydroelectricity at 4% with a SD of 1%, and lastly, tidal energy at 3% and a SD of 1% (see figure 16).

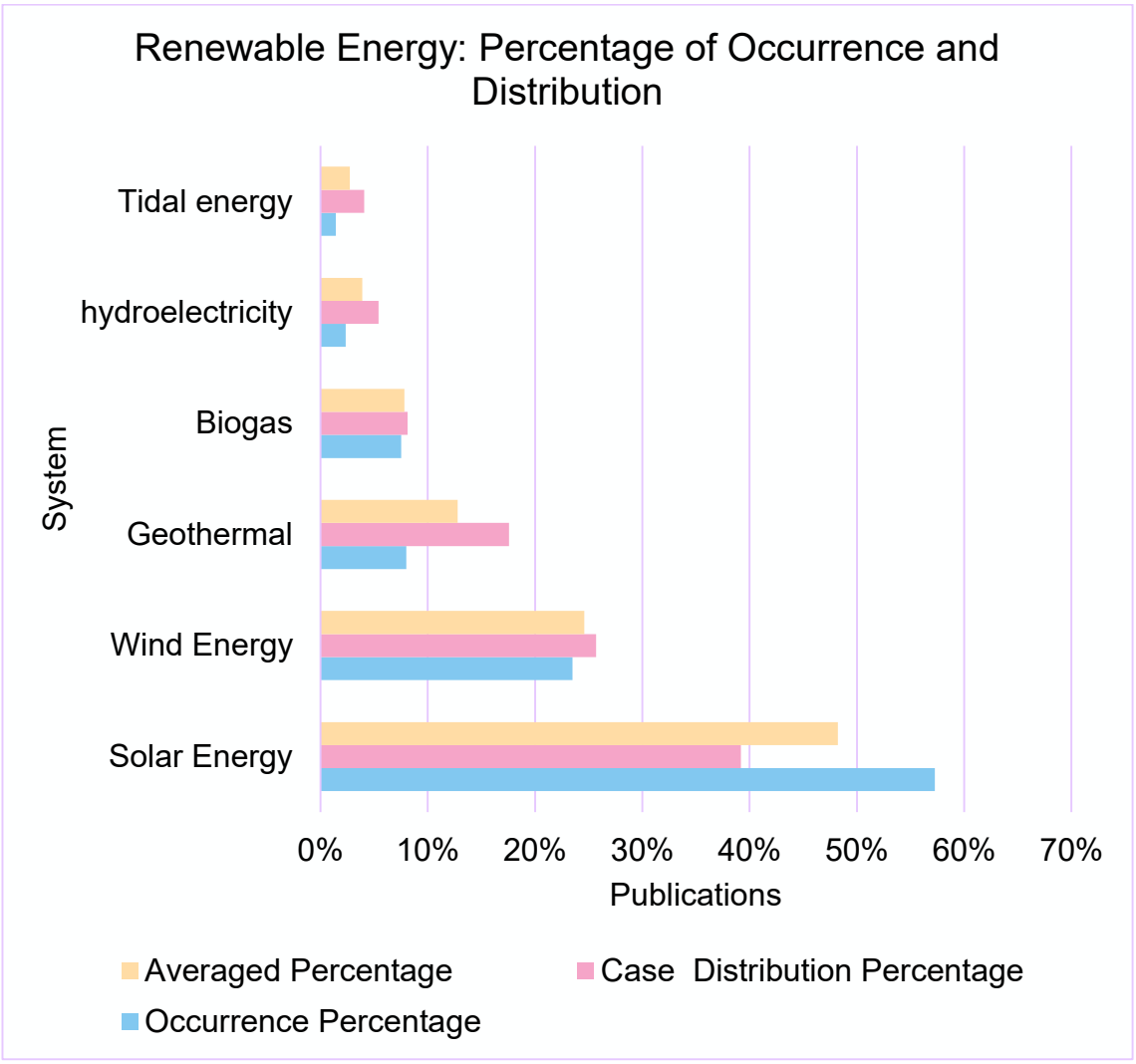

Figure 16. Renewable Energy: Percentage of Occurrence and Distribution.

6.2.4 Control Domain Systems

This section presents the data results of the Control Domain Systems average percentage occurrence and distribution within the collection of literature was mentioned with the fourth greatest frequency. There were 2 subdomains with 9 system categories:

1. Climate Control
    a. Passive Climate Control
    b. Mechanical Climate Control
    c. Hybrid Climate Control
2. Operational Control
    a. Automation
    b. Information Technology
    c. Internet of Things
    d. Artificial Intelligence

Of the control domain systems using the averaged percentage occurrence and distribution, operational control systems had the greatest percentage of occurrence and distribution of all at 56%, while the climate control systems had 44%, both with a SD of 2.5% (see figure 17).

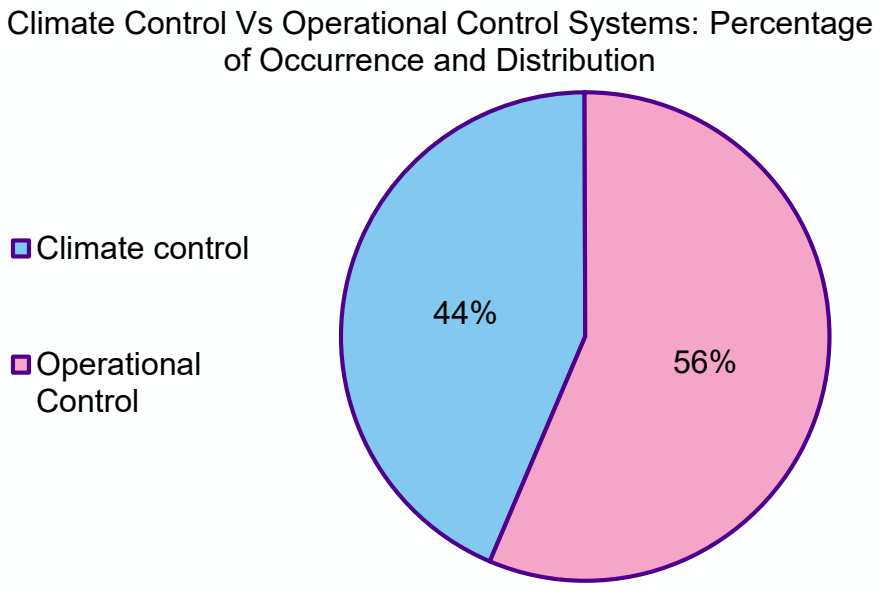

Figure 17. Averaged Percentage of Occurrence and Distribution: Climate Control Vs Operational Control Systems.

Climate Control

The results are that mechanical climate control had the greatest percentage of occurrence and distribution of all climate control systems at 48% with a SD of 2.8%, followed by passive climate control at 45% with a SD of 1.4%, and lastly, hybrid climate control at 7% and a SD of 1.5% (figure 18).

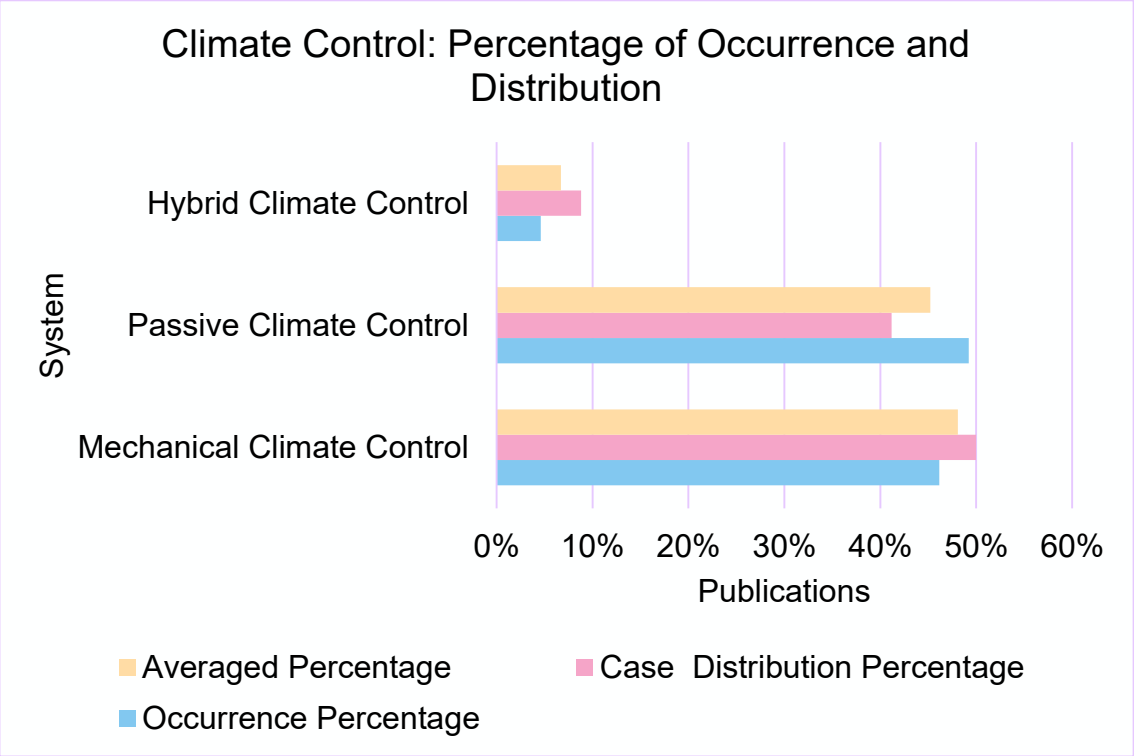

Figure 18. Climate Control: Percentage of Occurrence and Distribution.

Operational Control

The results are that automation had the greatest percentage of occurrence and distribution of all operational control systems at 48% with a SD of 2.8%, followed by the Internet of Things at 25% with a SD of 4.8%, then, artificial intelligence at 11% with a SD of 2.4%, and lastly, information technology at 3% and a SD of 2.7% (see figure 19).

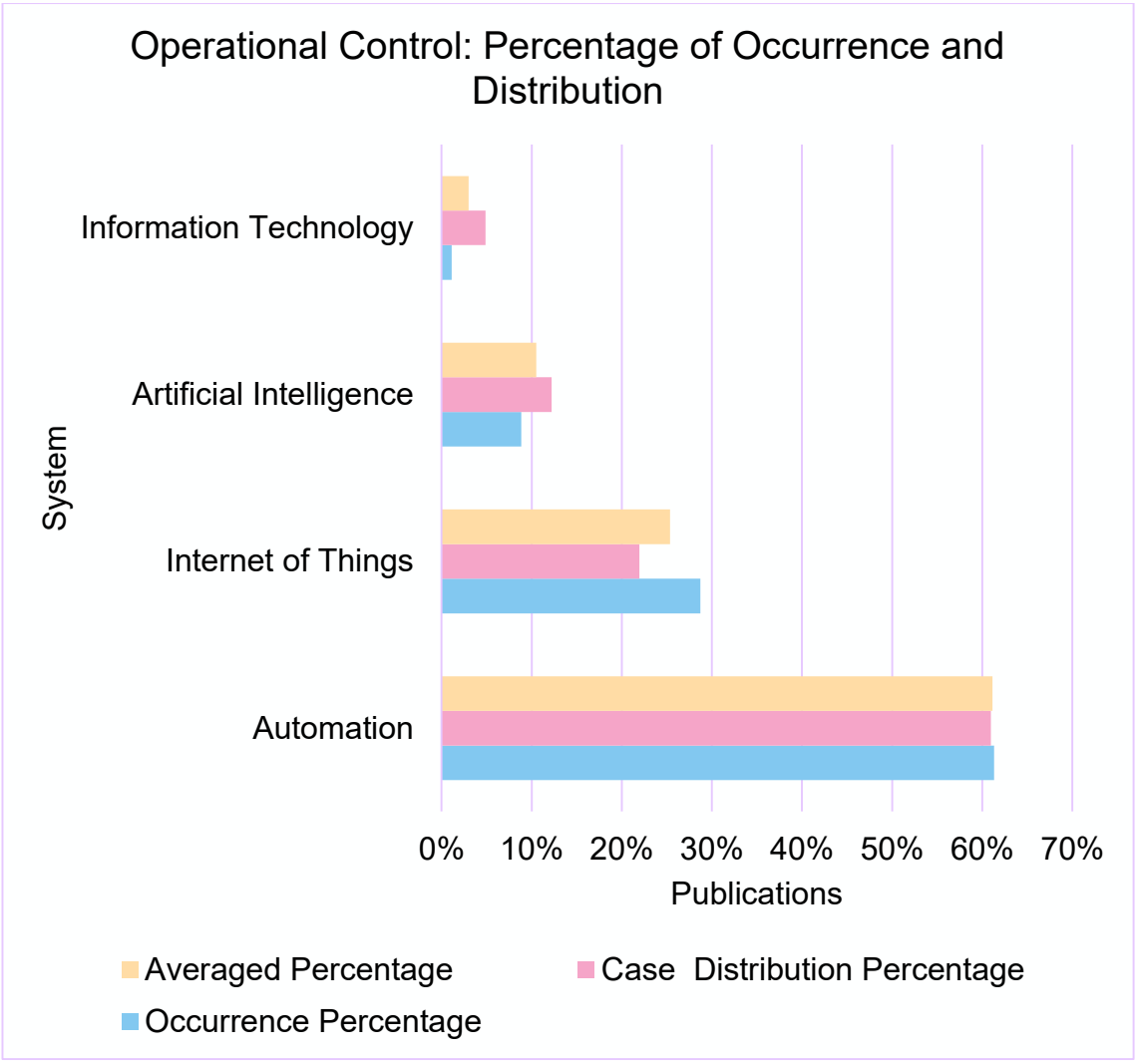

Figure 19. Operational Control: Percentage of Occurrence and Distribution.

7 SWOT ANALYSIS

In this section are the results of the SWOT analysis are presented. Here the strengths, weaknesses, opportunities, and threats of the potential VTF industry are arranged in order of more significant to less significant. The sources of this analysis were either directly or indirectly gathered from the cases. Related concepts from multiple cases were combined. Concepts were also developed from the researcher's general understanding of the collective cases. These concepts were then synthesised with the researchers understanding and developed into the SWOT analysis (See Appendix D, SWOT Analysis Table, p. 110 for a more detailed table of source cases).

7.1.1 Strengths

1. Vertical farms and their widespread adoption are currently validating underlying VTF concepts of mass productivity and profitability in limited space by using state-of-the-art food production practices and technologies while taking advantage of vertical space.
2. Renewable and energy-efficient technologies, plus passive design could significantly cut VTF operational costs in the long-term.
3. A passive designed VTF can take advantage of a location's natural phenomena while reducing energy dependencies and environmental impact.
4. The VTF could minimise the amount of land cleared for agriculture, supportive of conservation efforts.
5. The VTF controlled environment allows for all year production.
6. VTFs can protect crops from harsh weather conditions due to climate change, extreme weather, and seasonality.
7. The VTF could eliminate the environmental contaminations of agriculture by reducing, eliminating, containing, and treating their use onsite.
8. The VTF could reduce the distance food must travel before it reaches the consumer, thus reducing or eliminating fossil fuels used in the process.
9. The VTF takes advantage of numerous waste streams, transforming municipal and VTF bio-waste into a resource, for example, from liquid form with grey and blackwater, or solid form with organic matter.
10. A VTF's ability to capture and store rainwater reduces its dependency on the grid, and in turn, lessens the burden on natural resources for its extraction and transportation.
11. As similar to vertical farms, and their hydroponic and aeroponic practices, VTFs are also capable of significant water-use efficiency, in contrast, to open-field agriculture.

12. VTFs eliminate the issue of weeds from agriculture, thus eliminating costs and time associated with crop maintenance and the environmental damages related to herbicide use.

7.1.2 Weaknesses

1. The VTF has a high start-up cost, a long wait for a return on investment, high operational costs, expensive customised features, and it requires special expertise to design and implement, which all make it a risky and unattractive investment.
2. The VTF will receive limited sunlight to utilise, for example, due to its structural obstructions, and from other structures, such as surrounding towers, thus diminishing its use of this free and clean resource.
3. Developing the VTFs local food supply network could prove challenging and requires a specialised approach.
4. The VTF depends on a diversity of expertise and technical training on the customised systems of the VTF and its operations.
5. The VTF requires particular construction capabilities for its mass distribution, e.g. multidisciplinary expertise, supply chain and resource inputs, and transport efficiency and the accessibility of its outputs.
6. The VTF operations will occur under more compacted conditions than conventional agriculture, thus decreasing the area of space for working and movement.
7. The VTF must operate in specific environmental parameters to prevent plant disease.
8. The VTF will have a human resource management challenge, e.g. scouting, training, and developing of staff for its specialised operations.
9. The VTF operations have a dependency on waste streams for its operations and are subject to its variable availability.

7.1.3 Opportunities

1. VTFs could enhance a nation's food security by increasing domestic food production, decreasing dependency on food trade imports, reducing the food trade import deficit, and supporting the local and national economies.
2. The VTF significantly addresses the SDGs, thus aligning it with national and international interests, and making VTF initiatives a favourable candidate for sustainability-related grants.
3. Mass VTF production could reduce its cost.
4. The modularization of VTF components could reduce production and assembly costs, reduce construction time, increase ease of assembly, and

create a resilient and customisable product, which could enable its mass distribution.

5. The VTF could be complementary to urban planning strategies.
6. VTF complexity could be simplified by the modularization of its components.
7. First mover advantage.
8. VTF could deliver high-value crops closer to the market.
9. A VTF could integrate multiple enterprises into its structure, such as food shops, providing alternative cash flows, and local, fresh, and healthy foods as a competitive advantage.
10. Automation technology could enhance operational productivity and reduce labour costs.
11. Including the local community in the VTF operations could help break down social barriers.
12. Community advocates could be the key advocates of the VTF.
13. VTFs could use AI to manage controls systems with high precision and efficiency, as well for forecasting consumer demand.
14. VTFs have the possibility of retrofitting pre-existing unused buildings for urban food production.
15. Future emerging technological advancements will improve VTF efficiency.

7.1.4 Threats

1. The VTF must compete with established market competitors of conventional agriculture and its cheaper start-up costs and operational practices.
2. The complexity of the VTF is a challenge for its development, operations, management, and mass distribution.
3. The VTFs impact on the environment through its construction must align with its sustainability goals, which has yet to be considered.
4. Land in urban locations is typically more expensive.
5. The early VTFs models are cost-prohibitive to developing nations.
6. The VTF could be seen as a threat to current industries and way of life, which could result in campaigns of resistance and the promotion of its negative perceptions.
7. VTFs compete with other land uses.

8. The legalities of a VTF and its operations are not clearly understood and are based on local regulations, for example, the urban zoning constraints to agriculture.

7.2 Addressing the VTF Weaknesses and Threats

In this section, suggestions have been given to address the weaknesses and threats of the VTF using the strengths and opportunities, and through reflective practices of the researcher's familiarity with the literature, the research, and background knowledge in international business and sustainability.

7.2.1 Addressing the VTF's Weaknesses

This subsection will address the weaknesses from the SWOT analysis.

Start-up VTF Challenges

The top weakness of the VTF was:

1. The VTF has a high start-up cost, a long wait for a return on investment, high operational costs, expensive customised features, and it requires special expertise to design and implement, which all make it a risky and unattractive investment.

To address this, as mentioned by the top VTF strength:

1. Vertical farms and their widespread adoption are currently validating underlying VTF concepts of mass productivity and profitability in limited space by using state-of-the-art food production practices and technologies while taking advantage of vertical space.

High start-up costs have previously been addressed by vertical farms, for example, AeroFarms, a vertical farming company in the US, had secured over $130 million in funding, with $40 million from appealing to investors like IKEA Group and Momofuku Group in series D funding (Burwood-Taylor, 2017). As with vertical farms, VTFs can go through a series of funding rounds. Funding can begin with a pre-seed funding round. A preliminary VTF business model and structural design can be developed early on by seeking grant funding from universities and other aligned organisations, such as the United Nations programmes, governments, and crowdsource funding campaigns. Multidisciplinary expertise can be formed around the grant proposal projects. To address the high operational costs, viable technologies should be identified, such as with renewable and energy-ef-

ficient technologies to integrate, and the passive design capabilities of the structure. To address the expensive customised features, development of the modular design of the structure and its systems can reduce the number of diverse components of the structure and its systems, while enabling customisation of its arrangement within the structure, cutting costs, increasing system resilience and flexibility. After the pre-seed funding phase for the research and development of the VTF business model and structural design, the VTF can proceed to subsequent series of funding phases, as it progresses towards implementation and operation. Having the pre-seeding research and development phase decreases the uncertainty of a VTF project. This makes the VTF a less risky investment for investors. To speed up the VTF's return on investments, choosing high-value crops could give the VTF a competitive advantage with its closer food distance. Integrating direct to consumer food shops that specialise in the VTF produced food, such as a grocery store and restaurants could offer additional income sources. Other additional income sources could be from facility tours. Diversified income streams would provide the VTF with a quicker and more reliable return on investment and funding.

Natural Lighting Limitations

The second weakness was:

2. The VTF will receive limited sunlight to utilise, for example, due to its structural obstructions, and from other structures, such as surrounding towers, thus diminishing its use of this free and clean resource.

To address this, as mentioned by the second and third VTF strengths:

2. Renewable and energy-efficient technologies, plus passive design could significantly cut VTF operational costs in the long-term.
3. A passive designed VTF can take advantage of a location's natural phenomena while reducing energy dependencies and environmental impact.

As mentioned in strength number 2, energy-efficient technologies can be used to supplement natural sunlight, such as LED lighting because of its affordability, energy efficiency, long life, low temperature, and spectral precision for enhanced crop growth and quality (Kozai, 2016). Also, as mentioned in number 3, passive design techniques can take advantage of local conditions, such as through the use of mirrors and fibre optics to capture sunlight where it is available and redirect it to where it is needed. For example, a Norwegian village had redirected light

that had been obstructed by two mountains into their valley (Geddes, 2017). The VTF could use mirrors similarly, such as mounting mirrors on nearby towers, or tall objects, or other places natural light is accessible, to redirect light into angles that the sunlight is not hitting. Mirrors within the VTF could also be used to extend the reach of the natural light. Also, fibre optics is a technology to capture light where it is available and transfer it to areas it is needed (Parans Solar Lighting, 2020). Fibre optics capturing units can be placed in low utility places where sunlight is available, but not useful, fibre optics could be placed alongside the LEDs to supplement their lighting capabilities. Additionally, there may be stray light within the VTF that could be recycled back into the fibre optic light system, such as light that is hitting the walls and floors, it could be worth a research and development project to determine the utility of recycling such stray lighting.

Developing a Food Supply Network

The third weakness was:

3. Developing the VTFs local food supply network could prove challenging and requires a specialised approach.

To address this, as mentioned by the eleventh and twelfth VTF opportunities:

11. Including the local community in the VTF operations could help break down social barriers.
12. Community advocates could be the key advocates of the VTF.

Approaching the VTF as though it were an international business organisation, it is always key to have cultural insiders who have network links to expertise and resources. In the sense of discovering and negotiating contracts, having a community insider could be an asset. Including community members in the organisation can break down social barriers, and also, build community support from inside the community. Additionally, a community member may already have special knowledge of the local players, their needs, and cultural competency that would be useful.

Finding Multidisciplinary Expertise

The fourth, fifth, and eighth weaknesses were:

4. The VTF depends on a diversity of expertise and technical training on the customised systems of the VTF and its operations.
5. The VTF requires particular construction capabilities for its mass distribution, e.g. multidisciplinary expertise, supply chain and resource inputs, and transport efficiency and the accessibility of its outputs.

8. The VTF will have a human resource management challenge, e.g. scouting, training, and developing of staff for its specialised operations.

To address this, as mentioned by the second VTF opportunity:

2. The VTF significantly addresses the SDGs, thus aligning it with national and international interests, and making VTF initiatives a favourable candidate for sustainability-related grants.

The pre-seeding funding phase includes seeking grants for VTF research and development projects. During this time, advertisement of such projects can generate interest by relevant expertise. Team members can be scouted within the research organisation such as universities, where project team's future expertise can already begin to be trained and developed for later positions of importance while working on the research and development challenge areas. In the case of universities, multidisciplinary teams can be assembled to explore the VTF implementation challenges from a wide range of expertise.

Working Space

The sixth weakness was:

6. The VTF operations will occur under more compacted conditions than conventional agriculture, thus decreasing the area of space for working and movement.

To address this, as mentioned by the tenth VTF opportunity:

10. Automation technology could enhance operational productivity and reduce labour costs.

Although the VTF work space is more compact, automation could be used to overcome this, as robotics could function in a fraction of the space as humans could, with high precision and productivity, and reduce labour costs, which could over time make up for its high upfront investment.

Environmental Parameters

The seventh weakness was:

7. The VTF must operate in specific environmental parameters to prevent plant disease.

To address this, as mentioned by the thirteenth VTF opportunity:

13. VTFs could use AI to manage controls systems with high precision and efficiency, as well for forecasting consumer demand.

AI could manage the climate control system with precision reaching energy efficiency and optimum growing conditions for crops. This would also reduce the amount of labour and time spent on managing this complex system.

Waste Stream Dependency

The ninth weakness was:

9. The VTF operations have a dependency on waste streams for its operations and are subject to its variable availability.

To address this, as mentioned by ninth VTF strength:

9. The VTF takes advantage of numerous waste streams, transforming municipal and VTF bio-waste into a resource, for example, from liquid form with grey and blackwater, or solid form with organic matter.

and the fifth VTF opportunity:

5. The VTF could be complementary to urban planning strategies.

By taking advantage of multiple waste streams, redundancy of resource acquisition by multiple channels can compensate for variability in supply, as well as storing resources in times of excess to use in times of scarcity. Additionally, by working in partnership with regional urban planners, they can better understand the VTF's capabilities and needs, thus connecting people and resources in alignment with an urban planning strategy to manage waste.

7.2.2 Addressing the VTF's Threats

This subsection will address the threats from the SWOT analysis.

Established competitors

The top VTF threat was:

1. The VTF must compete with established market competitors of conventional agriculture and its cheaper start-up costs and operational practices.

To address this, as mentioned by the fourth, fifth, sixth, seventh, and eighth VTF strengths:

4. The VTF could minimise the amount of land cleared for agriculture, supportive of conservation efforts.
5. The VTF controlled environment allows for all year production.
6. VTFs can protect crops from harsh weather conditions due to climate change, extreme weather, and seasonality.

7. The VTF could eliminate the environmental contaminations of agriculture by reducing, eliminating, containing, and treating their use onsite.
8. The VTF could reduce the distance food must travel before it reaches the consumer, thus reducing or eliminating fossil fuels used in the process.

And opportunities eight, nine, and ten.

8. VTF could deliver high-value crops closer to the market.
9. A VTF could integrate multiple enterprises into its structure, such as food shops, providing alternative cash flows, and local, fresh, and healthy foods as a competitive advantage.
10. Automation technology could enhance operational productivity and reduce labour costs.

Conventional agriculture requires vast amounts of land and this land comes at a cost of the environment. Conventional agriculture also is known for its use of harmful environmental contaminants, such as fertilizers and pesticides. VTF's can minimise the amount of land cleared for agriculture to a fraction of the size, while also eliminating, containing, and managing onsite any potential environmental contaminants. As such, the VTF is supportive of land conservation efforts, which can be an advantage in developing the VTFs image as an eco-brand. Another contrast is that open field agriculture is constrained to the growing seasons and sensitive to climate change and extreme weather. Crop production of a VTF is environmentally protected from harsh weather conditions and climate variability, and the controlled climate of the VTF allows for optimum growing conditions and all-season production. Currently, the distance food must travel to reach the consumer has increased considerably with globalisation, this puts a strain on the global environment and the food security of nations. VTFs can be constructed near or within densely populated urban areas, thus cutting the food distance and its environmental concerns, while delivering healthy, fresh food, close to the consumer, and boasting a nations food security and economy. While many foods are travelling a long distance to consumers, and due to certain crops being climate constrained to certain regions, VTFs with climate-controlled environments can produce these high-value crops and closer to the market than the competitors. The VTF can also integrate multiple food shops on site, tapping into multiple revenue streams. While conventional agriculture is labour intensive, the VTF can reduce the amount of labour required through automation while increasing productivity.

VTF Complexity and Modularity

The second VTF threat was:

2. The complexity of the VTF is a challenge for its development, operations, management, and mass distribution.

To address this, as mentioned by the fourth and sixth VTF opportunities:

4. The modularization of VTF components could reduce production and assembly costs, reduce construction time, increase ease of assembly, and create a resilient and customisable product, which could enable its mass distribution.

6. VTF complexity could be simplified by the modularization of its components.

VTF complexity is due to a large number of its unique components and interdependent systems. Modularization is a way to break-down complexity into an organised order of interchangeable parts. By decreasing the number of unique parts in a system, it is easier and more affordable to produce and assemble the parts. Modularization allows the VTF systems to become more resilient, for example, if a system experienced a failure in one component, it would not cascade throughout all systems, and while the component is removed the system would continue to function normally. A standard modular design could be made for the basic VTF, its structure, and all its systems, thus reducing costs and opening opportunities for mass production. With VTF design more simple due to modularization, and more affordable due to the decrease in specialised parts, and easier to assemble, construction companies could be more competent to construct the VTF without a lot of specialised training. With a simpler design, the VTF operations would also become more simple for operating, requiring less specialised expertise of unique system parts.

VTF Construction Sustainability

The third VTF threat was:

3. The VTFs impact on the environment through its construction must align with its sustainability goals, which has yet to be considered.

To address this, as mentioned by the fifth and fourteenth VTF opportunities:

5. The VTF could be complementary to urban planning strategies.

14. VTFs have the possibility of retrofitting pre-existing unused buildings for urban food production.

Working with urban planners while planning a VTF could help align with sustainability goals. Locations with the least environmental impact can be chosen, and locally source materials can be identified. Materials can be sourced from sustainable suppliers where ever possible. Additionally, a VTF organisation can hold itself accountable by creating a sustainability loan to itself to pay off over time by setting aside earnings annually to donate to sustainability causes until this sustainability loan has been paid off. This can also help build the VTF's sustainability brand image by its commitment to sustainability. Other alternatives to VTF construction is the possibility to retrofit unused structures for food production.

Land Price

The fourth VTF threat was:

4. Land in urban locations is typically more expensive.

To address this, as mentioned by the first and fourth VTF strengths:

1. Vertical farms and their widespread adoption are currently validating underlying VTF concepts of mass productivity and profitability in limited space by using state-of-the-art food production practices and technologies while taking advantage of vertical space.
4. The VTF could minimise the amount of land cleared for agriculture, supportive of conservation efforts.

The vertical tower farm compresses land use to a fraction of the size than that of conventional agriculture, thus reducing the amount of land needed for purchase, and subsequently, the land cost. Although, the land on the exterior of urban areas tends to be much more affordable, and still within a local food distance. Buying local agricultural land on the exterior of cities could be the best option for the VTF.

Cost Prohibiting to Developing Countries

The fifth VTF threat was:

5. The early VTFs models are cost-prohibitive to developing nations.

To address this, as mentioned by the third, fourth, and sixth VTF opportunities:

3. Mass VTF production could reduce its cost.
4. The modularization of VTF components could reduce production and assembly costs, reduce construction time, increase ease of assembly, and create a resilient and customisable product, which could enable its mass distribution.
6. VTF complexity could be simplified by the modularization of its components.

While the early VTFs may be cost-prohibitive to developing nations, their lessons learned will help develop a more efficient and affordable VTF. Creating a standardised model with modular components would decrease the costs while increasing the ease of assembly and operations. Modularization of the VTF is the key to mass production, which will decrease cost and open VTF opportunities to developing nations. Additionally, sustainably oriented organisations, such as the United Nations, or governments, could support VTF opportunities by sponsoring grants, subsidising some of the start-up costs or early production periods, and providing long-term oriented loans designed for VTFs.

Threatening Way of Life

The sixth VTF threat was:

6. The VTF could be seen as a threat to current industries and way of life, which could result in campaigns of resistance and the promotion of its negative perceptions.

To address this, as mentioned by the eleventh and twelfth VTF opportunities:

11. Including the local community in the VTF operations could help break down social barriers.
12. Community advocates could be the key advocates of the VTF.

Including the community in the VTF could be a good way to develop goodwill for its brand image from community members. Community members are more likely to support a project that they feel a sense of ownership, community pride, and see as an investment in community development. Recruiting locals and supporting the community is a way the VTF could help break down social barriers. Developing key advocates within the community will help calm peoples fear of change. Also, taking time to listen to local's perceptions could go a long way in satisfying the communities needs and developing a strong public relations strategy. Promoting the positive influence that the VTF can have on sustainability challenges, supporting the public's wellbeing through local, fresh, healthy food, and the impact it could have on supporting the growth of the local economy and employment are areas the VTF public relations can aim to highlight.

Land Use Competition

The seventh VTF threat was:

7. VTFs compete with other land uses.

To address this, as mentioned by the fifth VTF opportunity:

5. The VTF could be complementary to urban planning strategies.

Conventionally, the VTF is a new concept that many are not yet familiar with its holistic value. Given the prevailing mind-set of short-sighted economic gain by society at large, the VTF could be seen as competing with other land uses, such as other types of buildings, for example, offices and apartments. Working with urban planners can help to inform important decision-makers of the long term value that a VTF could generate. The VTF can then be strategically located where it could bring the most benefit. Although agricultural land on the exterior of cities tends to be cheaper, and since the VTF takes up a fraction of space conventional agriculture does, a VTF plot could be better located in these less competitive locations.

VTF Legalities

The eighth VTF threat was:

8. The legalities of a VTF and its operations are not clearly understood and are based on local regulations, for example, the urban zoning constraints to agriculture.

The VTF, like all other businesses, must take care to identify the most relevant local regulations to avoid fines and disruption to the business. Also, there may be assets of the VTF, tangible and intangible, that require patent protection to maintain its competitive advantage. Intellectual property is another area of the VTF that will emerge as the VTF needs become more visible. Additionally, workplace safety is a consideration to have regarding VTF operations. The area of VTF legalities is circumstantial and requires special expertise to approach. Vertical farms could be looked to as a model for this.

8 THEMATIC ANALYSIS OF THE SWOT ANALYSIS

A thematic content analysis of the SWOT analysis resulted in categories and themes. The result after several iterations of analysis, category develop and refinement, is the VTF meta-model framework "A Sustainable Organisation: The Dimensions, Modes, and Drivers of Success" (Figure 20). The themes that resulted were the 5 dimensions of a VTF, the 2 modes of goal attainment, and the driving factor to achievement. For the successful planning and implementation of the VTF, these themes should be considered.

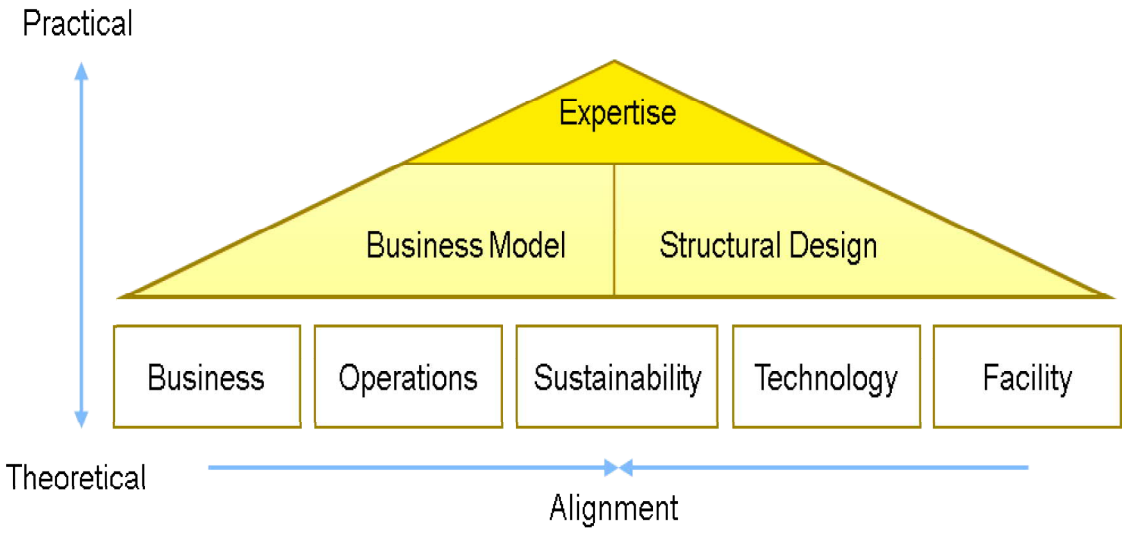

Figure 20. A Sustainable Organisation: The Dimensions, Modes, and Drivers of Success.

8.1 The 5 Dimensions of the VTF

The 5 dimensions of the VTF are business, operations, technology, facility, and sustainability. The business dimension concerns a VTF's business viability, the operations dimension concerns its operations management, the technology dimension concerns its technological integration, the facility dimension concerns its structure, and the sustainability dimension concerns its central alignment, the overarching objective of VTFs.

8.2 The 2 Modes of Goal Attainment

The 2 modes of goal attainment are the VTF's business model and its structural design, which must be aligned with the 5 dimensions of the VTF. These are necessary for a properly planned and implemented VTF.

8.3 The Driving Factor to Achievement

The driving factor to achievement is expertise. Expertise must be used to evaluate the 5 dimensions of the VTF to design and plan the 2 modes of goal attainment, synthesising their theoretical knowledge with their practical experience to actualise and sustain a VTF.

9 DISCUSSION

In response to the unsustainable practices of conventional agriculture, the food security vulnerabilities of globalisation, the growing global population, and the uncertainty brought about by the changing climate and extreme weather, this research explored a potential solution. The VTF concept can support reaching the SDGs while enhancing global and national food security. This research set out to generate a more comprehensive understanding of the VTF concept, exploring its development over the last 15 years. As vertical farming has seen a significant increase in search frequency since 2004, it has marked the growing awareness and interest in sustainably innovative agriculture, taking more advantage of compressed vertical space, and state-of-the-art technology. Vertical farming marks an important intermediate evolutionary stage between traditional indoor agriculture and the VTF. Similarly, the annual publications regarding the VTF concept have also increased significantly by 600% since 2005 and indicate a continuing upward trend. This suggests there is a growing consideration of the VTF concept by academia. However, translating this interest into a real-world successful VTF operation is currently the ongoing challenge.

Due to the large body of emerging VTF publications, a wide range of ideas and approaches to the VTF have emerged. Therefore, to further this developing field, it became necessary to gather relevant literature for analysis and to identify the commonalities, differences, and gaps in the literature, to guide the direction of future VTF research. This section reflects on the findings of this research by identifying areas of VTF thought to expand on, including the 4 VTF domains, the VTF opportunities and barriers to implementation, a meta-level view on VTF thought, and finally, recommendations on future actions in actualising the sustainable development goals with the VTF.

9.1 Updating the VTF Thinking: A Guide to Future Research, Development, and Innovation Projects

This research had identified 53 relevant VTF publications from 2005 to 2020. It was found that a significant number of cases had a blurred distinction between the vertical farm and the VTF, whereas these terms were often used interchangeably. This was due to the similarity in practices and technology. For this reason,

to narrow focus, this research defined the VTF as "agricultural operations in a tower, with its height greater than its width, and consisting of 10 or more levels.", whereas the use of a tower being was the primary difference. The importance of this distinction is that it improves the clarity and focus of this and future research and development on the subject.

One of the questions this research set out to answer is "What are the systems of a VTF?". This research had found that VTFs consist of many interdependent systems, although in the publications there had been a wide range of potential systems discussed. To encompass the last 15 years of the VTF concepts evolution into a modern holistic view, the publications were analysed. The use of averaged percentage occurrence and distribution was chosen to identify the level of depth devotion to the exploration of VTF systems and give some indication of its level of importance held by the publications, as well, the generally distributed awareness of topics among the collective publications.

Through the analysis of the literature, systems and patterns emerged. As there were so many categories mentioned, it became necessary to organise the diverse resulting systems into a higher order of thinking. This resulted in the 4 domains of VTF systems. These were then analysed and ranked into order by most to least, using averaged percentage occurrence and distribution, as follows:

1. Biological
2. Lighting
3. Control
4. Energy

The 4 domains of VTF systems are a useful development in the VTF literature because they represent important areas of focus to consider in designing and implementing the VTF business model and structural design.

9.1.1 Biological Domain Thoughts

The biological domain systems had numerous water related systems, which represented a significant topic discussed in the literature, water use, efficiency, harvest, treatment, and reuse. This is largely due to the relationship between water usage and food production systems. While hydroponics, aeroponics, and aquaponics were the top mentioned food production systems, the publications also

gave attention to the saving, reuse, and efficiency of water. The interdependency of these systems was also apparent. Hydroponic and aeroponic were noteworthy for their intensive production capabilities and resource efficiency in contrast to conventional agriculture. Additionally, the coupling of food production systems was widely recognised for the production of diversified yields. For example, the aquaponics system supports the production of fish, while its wastewater is an opportunity for reuse, containing a primary plant nutrient for fertilizing the plants, which the plants feed on and filter before it is returned once more to the aquaponic system. The research suggests that hydroponic and aeroponic, systems have the most potential as efficient and effective food production systems, while the aquaponics adds a useful byproduct and additional yield. These systems also remove the issue of weeds and the use of harmful herbicides. These water systems additionally protect the environment from contamination, by containing and managing their use on-site as contrasted to conventional agriculture.

The top mentioned water collecting system was the rainwater system, capitalising on free rainwater that hits the tower when it is abundant, to store and use at a later time, especially in times of scarcity While all these systems are water-efficient, rainwater harvest provides a safe secondary source of water and removes some dependency on the grid. Another mentioned reuse of water was with grey and blackwater systems, which hold potential for the reuse of water. The Grey and black water systems need special care for their safe usage, but also have worthy potential. Greywater systems add a tertiary source of water from the sink and bathwater. Greywater systems could prove important in areas of water scarcity. Blackwater's most promising use is from extracting macro and micronutrients from human urine, which have found to be an ideal fertilizer. Although this is promising, the public perception of using urine as a fertilizer could be risky. Additionally, the challenge of separating the urine from wastewater, which is best done through is separated collection. Although, this operation could be done onsite of the VTF operation, subsequently, cutting wasted water, and accumulating a valuable resource, which could cut costs. Living machines are biological grey and black water treatment systems modelled after wetland ecosystems. Living machines have the potential to treat these wastewaters while reaching sustainability goals. From these systems, waters can be cleaned for reuse, thus recycling a valuable resource, and especially significant in areas the water is scarce. The

organic matter that accumulates from this system could also be used to supplement the compost systems.

The VTF bio-waste management is a significant area of a VTF's structural design and its business model. These systems are the core of VTF operational productivity, resource efficiency, cost savings, and sustainability goals, and significantly contrast the water usage and environmental contamination of conventional agriculture. There are many other biological domain systems that deserve more highlight in the literature since they can add considerable value to the VTF's operations. For example, compost makes use of bio-waste, and as a byproduct produces a rich soil material. This could represent an additional revenue stream, sold raw to gardeners, or for potting house and garden plants, the VTF produces and sells. Another benefit of compost is that it produces heat from its process. This extra heat could cut some heating costs during the coldest seasons. Another lesser mentioned but valuable composting method is called vermiculture. This is composting with worms. Worms can rapidly break down bio-waste through eating it. Worms produce a rich compost byproduct, as well, leachate a high-quality organic fertilizer. Producing fertiliser from vermiculture is great, although, there could be a significantly greater benefit if a VTF could become certified 100% organic, as this would competitive advantage, while also aligning operations with public wellbeing. This would also be additional goodwill to the VTF brand image. Vermiculture has additional benefits since worm production could become an onsite produced food source for the aquaponic systems fish or potential VTF chicken systems.

What hasn't been mentioned to the researcher's knowledge yet in VTF publication is other insect systems. For example, soldier flies could complement and speed up compost operations, while also providing an additional food source for fish. Also, crickets are another source of potential fish food, while in certain markets, crickets may be a source of food for humans. With the growing global population and global hunger, insects could potentially replace the need for resource-intensive produce from cattle ranching. Although this may seem unlikely and taboo in many places, it is a matter of cultural perception of what food is considered acceptable and what is not. Yet, it may be worth the experimental investment, as

it would be relatively low cost, and since it also offers other benefits, such as to the aquaponic system. Another biological system that could add value and turn a common waste product into a resource is mushrooms. They can grow from papers, cardboard, and other organic waste products. Currently, there is far too much packaging in the world, mushrooms can both breakdown the waste product of cardboard packaging, create a valuable food product, and potentially other short term use products, such as packaging. Thus mushrooms could provide an additional low start-up cost alternative revenue stream with multiple useful outputs.

The idea of combining a chicken system into a VTF also has potential. Chickens are could provide multiple benefits to VTF operations, such as their meat, eggs, feathers, and their waste. Creating an artificial free-range environment could support ethical living conditions while providing local eggs to urban populations that may not have access to such local and fresh eggs, creating a quality product. Multiple levels on the floor housing the chicken systems could make better use of vertical space. Chicken feathers and waste could also supplement the composting operations. Concerning animals in the VTF, ethical consideration must be given to enhance their life while reducing potential suffering. It has not been discussed in the publications, but when it comes to farming animals for food, there are ethical concerns that should be considered. These concerns are important both regarding creatures wellbeing and the right to quality of living. An approach to this could be considering the creatures average lifespan when it comes to harvesting them for consumption. At this point, the researcher must note a personal preference towards vegetarianism, which they do not impose on others, having realised that humans have consumed animals for aeons and that this is a matter of culture and personal belief. However, it is important to note, that the sustainability and ethical concerns of animals should be better observed by agriculture. Presenting the VTF as an organisation with sustainable goals and ethical values regarding farmed animals is not only corporate responsibility but also, an investment in the goodwill of the VTF brand image.

Bees were another system that had been mentioned by very few publications. Bees provide valuable ecosystem services, while also producing valuable by-

product, honey. Bees are responsible for pollinating many crops that humans depend on for food. It may be necessary that some crops require pollination, while this is a delicate operation for the human hand, and labour intensive, bees do this process naturally. While bee systems could be very helpful in the VTF operation, consideration needs to be given to the care, and also those areas the people and bees will be coexisting. Some people have a fear of bees or are allergic to bees. If bees are to be used in a VTF system, care needs to be taken in protecting the bees and the people who enter the environment. Some places in the VTF could be specially designed to keep bees out, providing locations for the public to enjoy the VTF food and scenery, such as a restaurant within the facility.

9.1.2 Lighting Domain Thoughts

The lighting domain systems was the second most frequently discussed by the publications. Lighting provides a support function to the plant production systems. Therefore, lighting is an essential consideration of a VTF. Natural lighting is significant as it provides a free resource to the VTF, thus making good use of this resource is paramount. However, the availability of natural light is conditional, depending on the time of day, the weather, and it is also constrained by shade casting obstructions and the sunlight's angle of trajectory. Nearby buildings and the tower itself are the main obstructions. Although mirrors and fibre optics had been mentioned by the publications to a lesser extent, these could be major opportunities at a cost-friendly passive approach to maximising the utility of natural lighting by extending its reach, while also the decreasing the VTF's reliance on artificial lighting and its associated operational costs. Cutting costs through passive utilisation of natural resources is key to expanding the profit margin, and compensating the high start-up costs of the VTF.

Artificial lighting has been highly discussed in the publications as a supplement to the natural lighting and its limitations while coming at an additional operational cost. Reducing costs is key to profit, which is the reason LED lighting technology has been the most discussed lighting system. LEDs in contrast to HIDs are cost-effective, energy-efficient, has a long life, low temperature, less bulky, and a precision agricultural technology. The publications suggest this as the most effective supplementary lighting solution with its utility and affordability expected to sustain continued advancement. While HIDs are more expensive, have a shorter life, and

give off a higher temperature, they could still serve a less extensive role in the VTF, but not primarily for their lighting capability, but for their duel capability of provided lighting and heat. Temperature can stimulate crop growth, therefore, the benefits of maintaining a sparser system of HIDs integrated with the LEDs could outweigh their disadvantages. The cost of artificial lighting was most commonly predicted to be the highest operational cost, therefore maximising natural sunlight, utilising energy-efficient technology, and multiplying the number of uses from lighting are all part of a holistic and sustainability-oriented approach to lighting the VTF operations.

9.1.3 Energy Domain Thoughts

The energy domain systems were the third most frequently discussed by the publications. The expense of powering VTF operations was a typical challenge cited in the publications. While grid energy dependency was expected to come at high operational costs, given the current state of the world, it was also expected to promote unsustainable energy sources. For these reasons, cutting long term energy costs while pursuing sustainability goals was viewed as reason enough to justify higher upfront costs on renewable energy sources. Not surprisingly, solar and wind energy, as most popularly known, was discussed in most publications concerning energy. Since these sources depend on the variability of natural phenomena, such as sunlight and wind, they would most practically supplement grid power, while relying on the grid as little as possible, and as a backup source.

A resilient system would rely on a combination of energy sources with the capability of shifting to renewable sources when available and storing them after reaching system capacity to use during non-peak times. The challenges of utilising solar and wind are most prevalent in within dense urban locations on scarce and expensive land. These sources then compete for the space of the natural lighting and cast shadows. Instead, these deeply urban located VTFs should develop innovative uses of the technology to fit the limited space or develop another energy system. For example, a modular arrangement of smaller wind turbines could be made to fit vertically along with the corners of the tower, a location that will already be obstructed by the beams of the structure. Thus, unproductive space is efficiently used, plus, the exterior walls of the VTF are already redirecting any wind toward those locations. As for the solar panel, they could be fitted to the

least productive structural locations that receive sunlight, such as the area on the exterior wall obstructed by each storey.

Geothermal is another promising renewable energy, although certain locations may prove more favourable and affordable, its upfront cost should be considered on a case to case basis, as it could prove too costly for most VTF operations, but its potential for passive climate control could prove more practical. Biogas is also promising and makes use of bio-waste sources for gas production. A small biogas system could make more productive use of a waste stream, additionally, this could be a sustainable solution to some of the human blackwater waste produced on-site, regulations and safety precautions and system capacity should be strictly observed in its application. Hydroelectricity is location-oriented, although, on a larger scale it is not going to be an affordable option, and also comes with questionable environmental consequences, but on a small scale, these consequences may be avoidable and it could be an option worthy of consideration. Tidal power is also location-oriented, and most likely not an option at the moment until its affordability is significantly improved, but it may prove a worthy consideration as it advances.

Renewable energy is significant to the VTF because it is a long term oriented sustainable solution, although, it comes at higher upfront costs. Perhaps this could be met with a long term integration strategy, where renewable energy is phased in overtime as the dependency on the grid and unsustainable energy sources are also gradually phased out. While renewable energy can be a great alternative to unsustainable sources and less costly in the long term, finding ways to remove the need for energy use it the best way to cut energy-related costs and increase the profit margin.

9.1.4 Control Domain Thoughts

The control systems domain was the third frequently discussed by the publications. Automation stood out as compared to the other systems in this domain. Automation has the potential to create a lean operation by reducing time spent on repetitive tasks while increasing both productivity and accuracy. Automation concerns the daily operational demand of the VTF. The drawback of automation is the costly custom system design as a high upfront cost. This cost could be

reduced by the modularization of automation integrated systems, and their mass production, which could occur after successful operations have been demonstrated.

While this is a significant business model and structural design challenge, a partnership joint partnership on the VTF technology and its subsequent patents and intellectual property rights could prove a worthy long term investment depending on the widespread adoption of the VTF. Additionally, automation can cut long term operational costs by reducing the amount of labour needed, and open opportunities to economies of scale. However, automation is vulnerable to the public perception that it eliminates human jobs, although this is a valid argument, the VTF operations may have a great chance of success if it can compete with free market food prices. Additionally, the VTFs ability to provide affordable, healthy, and local food to the public may be seen as a worthy trade-off. Another drawback of automation is the operational costs of energy usage. While the trade-off for productivity could outweigh the cost, renewable energies, and passive design could balance it out.

Automation is not a standalone system and requires responsive information technologies (IT) such as enterprise resource management software, which is linked through the internet of things (IoT). IT and IoT are both support functions of automation, while another promising technology for operations is artificial intelligence (AI). AI is adaptive software that can learn and make decisions based on historical data and it can analyse complex data and make complex calculations quickly. This makes AI a powerful support function for operations which can adjust automation precisely to dynamic routines and fluctuations in consumer demand.

Besides operating the complex automation system, AI could also operate the other VTF systems, such as regulating the irrigation of the plant production systems, the feeding and environmental controls of the aquaponic systems, the operational lighting, the climate control, and any other system. Although, the cost of the AI should be considered. As well, there is a concern of public perception of it based on negative perceptions of the technology. Later on, technological ad-

vancements of AI could pose ethical implications if it were to become self-conscious. Additionally, there is a risk of completely automated operations if the system were to malfunction, which could cause potential crop damages. Therefore, having manual backups in a VTF makes the system more resilient to system failures.

An alternative to AI would be system-wide automated timing protocols based on forecasts and historically relevant data. While manual input could power operations, additional labour increases costs of operations, and at the same time, a fully automated system would have operational vulnerabilities creating a centralised operational dependency. Other control systems are significant to VTF operations yet less than half of the publications mentioned automation, and even less mentioned IoT, IT, and AI, which all had less than 10 publication mentions. Although, a significant effort in the publications have discussed the biological, lighting, and energy system domains, not enough attention has been given to this potentially essential VTF support functions, which would determine a great part of its structural design and business model.

The climate control systems had less averaged occurrence and distribution than operational control systems. Climate control was less discussed in the publications than the researcher had expected, and deserves significantly more focus, as climate control is a vital function for healthy food production. Proper climate can stimulate plant and fish growth, or promote their poor health, slow growth, and risk of loss. Conventionally, society has grown accustomed to energy-intensive climate control systems. However, pursuing sustainability goals and operational cost reduction with passive design practices could offer an enormous opportunity to cut operational costs, while naturally stabilising and regulating the VTF’s climate.

Solar integration provides the opportunity to use the sun's thermal radiation to heat the structure. Shading provides a low tech solution to cool the structure from the sun's thermal radiation. Thermal mass has been demonstrated in traditional buildings designs and is also a common feature in the alternative and sustainably oriented construction designs of Earthship Biotecture, in the form of an earth mound attached to the exterior wall of the structure. This works by collecting the

buildings excess heat, which is stored in the mound and is prevented from escaping through the use of insulation. This is known as a thermal battery. The thermal battery has a lot of potential for the VTF concept in regulating the structure's climate naturally, and overtime cutting cost by reducing the burden on other climate control systems.

Insulation provides another means to control the interior VTF climate, in addition to its use in thermal batteries, the windows are a key point of heat loss. Weatherised windows, minimise draft which could fluctuate the internal temperature and double-paned windows, i.e. two windows with a pocket of air in between, whereas the air acts as the temperature buffer between the building and the exterior temperature. Insulation can reduce energy costs for climate control while maintaining a more stable interior climate.

Natural ventilation is another opportunity to use natural phenomena rather than waste energy and money to produce a similar effect. As has been demonstrated by Earthship Biotecture, long ventilation tubes can go through the thermal battery, the exterior air creates natural ventilation, while the thermal mass works to acclimate the air as it is entering. This system works in conjunction with other ventilating windows to create airflow. These practices can be adapted to the VTF design.

Passive climate control is a holistic approach to climate control of a building, while also reaching sustainability goals and cost reductions. Mechanical climate control alone offers the costliest climate control system. While passive climate control systems alone can cut the most costs, they also leave the VTF vulnerable to the limits of their capacity. A hybrid climate control system may be the best of both worlds. While it cuts costs through passive design, it supplements this method with a less intensive mechanical climate control system while providing a more resilient system overall. The climate control system could be a significant source of operational costs or its long term oriented cost reductions. Although later retrofitting is an option, climate control systems should be considered early on in the structural design and business plans of the VTF.

9.1.5 Opportunities and Barriers to Wide-Scale VTF Implementation

The second research question addresses the opportunities and barriers of the VTFs wide-scale implementation, for this, a SWOT analysis was chosen. The SWOT analysis is typically used for real businesses, and a limitation of it on a theoretical concept may be that the results are less concrete and more theoretical. However, the researcher found it to be a useful tool in more deeply analysing the diversity of VTF publications, and that the results could serve more as a roadmap guiding future research in a generally helpful direction. The publications and researchers had a wide range of viewpoints on what were the advantages and disadvantages facing the VTF concepts. This research had gathered, revised, and synthesised an updated analysis of the VTF situation based on the previous 15 years of publications with the researcher's background knowledge concerning sustainability and international business.

The most prevalent strengths of the VTF were its high production potential on a fraction of the land contrasting conventional agriculture through its efficient use of vertical space, equally notable was its potential to solve urgent sustainability and food security challenges as an alternative to the unsustainable methods of conventional agriculture. The most prevalent weaknesses of the VTF concerned primarily the business viability, considering its high start-up costs, and operational costs. However, vertical farms are the to-be predecessor of the VTF and have already managed to secure the interest and support of high-level investors reaching the multimillion-dollar territory. Although, this does not automatically mean success, as investments extended into round D funding, which could either indicate the company could not make profits, or the company was not ready to go public yet.

Although it should also be noted, the VTF is an innovative solution to some of the toughest challenges facing humanity, while also producing a valuable service, this is because a VTF is a long term oriented solution, and such should be considered in its business model. Efforts must be made to plan for the generation of return on investment in three different time orientations, the short, medium, and long term. The short term is the early start-up period, from 1 to around 4 years, while the medium represents from year 5 to around year 9, and long term represents year 10 and beyond. Addressing the return on investment to investors on

these time scales could improve the funding capability of a VTF operation. While not all return on investment has to be money, at least in the short term but could be in some other form of value to the investor.

A top threat to a VTF was found to be from established competitors. Although this could prove a challenging competition to a VTF, the VTF has the possibility of high yield, local, and fresh food production all year round, while many competitors would be confined to their regional growing seasons. The VTF can also focus on producing high-value crops that it can produce outside of their common production seasons, or produce other crops that would be significantly more affordable and quality when grown locally.

While complexity was also found to be a top challenge to VTF development, operations, management, and mass distribution, this complexity could be simplified through modularization a top VTF opportunity. Modularization is a key feature of simplicity, cost efficiency, resilience, and customisation. Creating modular components decreases construction time and enhances the ease of assembly and operation. This is important for those who do not have the specialised knowledge of a VTF but understand how to follow basic directions and general construction principles. For mass production of the VTF concept to work, the VTF must become modular along with a standardised model. The modularization allows this standardised model to be reconfigured to meet the market demands and other special needs of its established location. The development of a modular VTF could open up opportunities in developing nations, which are in urgent need of food security and sustainability solutions.

9.1.6 VTF Meta-Level Thoughts

A thematic analysis of the SWOT analysis was conducted to determine the meta-levels of theoretically successful VTF implementation and wide scale distribution. The results generated the 5 dimensions of a VTF, the 2 modes of goal attainment, and the driving factor to achievement. This was a significant development for VTF literature because it gives research, development, and innovation projects another lens in which to focus on the viable actualisation of the VTF concept. The 5 dimensions of the VTF are business, operations, technology, facility, and sustain-

ability. These provided a foundation to develop a VTF project form, while sustainability is the overarching goal alignment of all dimensions. Although food security and sustainability tend to be the prevailing appeal for the VTF, practicality requires the VTF business and operations to also work sustainably within an economic model. Additionally, the VTF technology and facility are core to operational processes and business. Therefore, the structural design and the business model were the higher-order in which the 5 dimensions of the VTF must fit in. Expertise was considered the apex of the order, as the driving factor to achievement. This is due to the specialised knowledge and multidisciplinary nature of the VTF concept. While expertise must synthesise their practical knowledge and theoretical knowledge to actualise the VTF concept. These meta-levels provide direction and clarity of focus in developing multidisciplinary VTF project teams while identifying the most significant early stages of the VTF development, the synergy between a viable business model and a feasible structural design.

9.1.7 Actualising the SDGs with the VTF

This research suggests actualising the VTF requires significant planning, expertise, and funding. For this reason, smaller multidisciplinary teams should be formed in the early stage to address the VTF business model and structural design challenges. While grants or another source of funding would be ideal for these VTF project teams, universities provide an environment consisting of loosely connected communities of multiple fields of study. These are most likely minimal cost circumstances for gathering relevant expertise and enthusiasm in the concept, while the VTF sustainability challenge could flexibly fit into many curricula due to its multidisciplinary nature. Moving forward, the structural design research needs to focus on logically integrating systems, and the simplicity and modularization of the structure and its domain systems. Additionally, appropriate structural materials should be explored in great detail. Materials should keep in mind the principles of lean operations, which is to reduce waste, for example, structural steel beams are standard in construction, but the weight is heavy, and some of the steel is not necessary to the structural integrity, finding lighter weight modified steel beams could reduce weight and material, cutting cost, which could cascade throughout the chain of its embodied energy. Also, a VTF may be a structural tower, but it does not need to be designed so similarly to other standard towers, because its utility is different. Nor does its architecture require any fancy

complex aesthetic design, as complexity will increase costs and the difficulty of its construction. However, a VTF should be innovative in its uses of material and systems and their interrelation with natural phenomena.

Finally, for the structural design, while hydroponics, aeroponics, and aquaponics are the prevalent systems and quite significant to a VTF design, projects must not overlook the other value-added potential systems this research has mentioned. Adding value and cutting waste are what unify the structural design of the VTF with its business model, as this increases the VTF potential profit margin and ensuring its success. Therefore, the structural design and business model project teams must give this consideration, and work in partnership. As for the business model project team, more focus needs to go into the cost analysis of the VTF, its funding opportunities, and it's a business strategy, with more focus on specifics, such as potential partnerships, suppliers, waste resource recovery, construction agencies, development of operational competency hiring profiles, and location proposals. Following this preliminary conceptual development phase, projects should be presented to an audience for constructive feedback. Also, design thinking should be used to innovate VTF solutions. Projects then need a phase of simulating and testing of assumptions. After the revisions of the project proposals, a practical implementation playbook should be devised. At this point, additional funding should be investigated, while continuously building potential expertise and partnership networks to activate once proper funding is reached.

As for governments, universities, and organisations such as the United Nations, the Sustainable Development Goals (SDGs) were implemented with the deadline of 2030, while, reaching that goal on time is providing an incredible challenge. Investing in the research, development, and innovation of the VTF concept could set in motion sustainable actions that could later support reaching the SDGs. However, core project team members should have demonstrated a long term interest in sustainability, this way giving priority to those who are also invested in the values of sustainability, and not just as a passing trend. Additionally, universities can develop joint multidisciplinary curricula focusing on developing the VTF and generating research, development, and innovation deliverables. These pro-

jects could also be done internationally in a virtual context. Finally, the development of the VTF needs a context to share its refined developments such as an annually or biannually international conference, which could be held at the university, while benefiting the university by bringing it increased attention for its devotion to innovation and sustainability. Conferences are crucial for sharing developments and also building professional networks with the competencies to actualise the VTF.

10 CONCLUSION

The impacts of human activity on the planet is rapidly accumulating, humanity is now at a crossroads, either continuing business as usual, as though infinite economic growth is possible and has no consequences on the earth, or taking a strong reflection and deciding the future could be better for all. Sustainability is that path forward, and the Sustainable Development Goals of the United Nations is a powerful framework to pursue prosperity for all. The VTF symbolises the culmination of diverse sciences while approaching an achievable and a long term path towards reaching these sustainability goals. Through modelling nature, and utilising natural phenomena, the VTF puts humanity back in touch with its roots. Through novel design and innovative technology, the VTF also reaches towards the future. This research set out to clearly establish the current global condition regarding food security vulnerabilities and sustainability challenges. This research has established a clear call for change and urgent action. The global food system is at the source of it all, with unsustainable practices on a massive scale, particularly due to the majority of conventional agricultural practices.

The VTF offers an alternative to what is not going to work in the long term. Nations must shift the focus off of short term value creation that comes at the expense of environment and society. Long term oriented innovative concepts that significantly address the Sustainable Development Goals must be identified and fostered. Such projects offer an extraordinary opportunity to the prosperity of civilisation. Through more effectively utilising space, the mass implementation of VTFs could support the restoration of extensive amounts of land, thus shifting food production practices and supporting consumption habits to sustainable ones. This research has identified modularization and systems thinking is key to the VTFs mass implementation, while its ability to transform multiple wastes streams into valuable resources, along with its use of renewable energy, energy-efficient technology, passive design, lean operations, and high production capabilities are core to its sustainability and business viability. However, without proper support, the VTF concept remains just a vision, and out of reach by those nations most in need. For this reason, leaders and forward thinkers must champion the VTF concept forward into multidisciplinary research, development, and innovation projects.

11 REFERENCES

AeroFarms. 2020a. Our Story. Read on 30.5.2020. https://aerofarms.com/story/

AeroFarms. 2020b. Our Farms. Read on 30.5.2020. Read on 30.5.2020. https://aerofarms.com/farms/

AeroFarms. 2020c. Our Vertical Farming Technology. Read on 30.5.2020. https://aerofarms.com/technology/

AEssenseGrows. 2017. Aeroponics vs. Hydroponics vs. Soil Is Agricultural Plant Science. Read on 30.5.2020. https://www.aessensegrows.com/en/why-aeroponics

AGFO. 2019a. Plantagon talar ut efter konkursen. Read on 30.5.2020. https://agfo.se/2019/02/plantagon-talar-ut-efter-konkursen/

AGFO. 2019b. Vertikalodlingsföretag i konkurs. Read on 30.5.2020. https://agfo.se/2019/02/vertikalodlingsforetaget-plantagon-i-konkurs/

Al-Jayyousi, O. R. 2003. Greywater reuse: towards sustainable water management. Desalination, 156 1-3, p. 181-192.

Ansoff, H.I.1965.Corporate Strategy, McGraw-Hill, New York, NY.

AS SEB Pank. 2013. Estonia's agriculture is the most efficient among the Bal-tic States. Read on 30.5.2020. https://www.seb.ee/eng/news/2013-04-18/estonias-agriculture-most-efficient-among-baltic-states

Asner, G. P., Elmore, A. J., Olander, L. P., Martin, R. E. & Harris, A. T. 2004. Grazing systems, ecosystem responses, and global change. Annu. Rev. Environ. Resour., 29, 261-299.

Association for Vertical Farming. 2020. About Association for Vertical Farming. Read on 30.5.2020. https://www.linkedin.com/company/association-for-vertical-farming/about/

Bakis, R. 2007. The current status and future opportunities of hydroelectricity. Energy Sources, Part B, 2 3, p. 259-266.

Baulcombe, D., Crute, I., Davies, B., Dunwell, J., Gale, M., Jones, J., Pretty, J., Sutherland, W. & Toulmin, C. 2009. Reaping the benefits: science and the sustainable intensification of global agriculture. Report. The Royal Society. Read on 30.5.2020. https://royalsociety.org/topics-policy/publications/2009/reaping-benefits/

Bento de Souza Ferreira Filho, J., & Eduardo de Freitas Vian, C. 2016. The evolving role of large and medium farms on Brazilian agriculture. Read on 30.5.2020. https://www.researchgate.net/publication/311159054_The_evolving_role_of_large_and_medium_farms_on_Brazilian_agriculture

Blann, K. L., Anderson, J. L., Sands, G. R. & Vondracek, B. 2009. Effects of agricultural drainage on aquatic ecosystems: a review. Critical reviews in environmental science and technology, 39 11, p. 909-1001.

Boxall, A. B. A. 2012. New and emerging water pollutants arising from agriculture. Environment Department, University of York, United Kingdom. OECD. Read on 30.5.2020. eprints.whiterose.ac.uk/75319/1/oecdreport.pdf

Bradbear, N. 2009. Bees and their role in forest livelihoods: a guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Chapter 8. The Value of Bees for Crop pollination. Non-wood Forest Products.

Burwood-Taylor, L. 2017. UPDATE: AeroFarms Brings in IKEA and David Chang to Close $40m Series D. AgFunderNews. Read on 30.5.2020. https://agfundernews.com/breaking-aerofarms-raises-34m-40m-series-d-international-investors-overseas-expansion.html

Business Continuity Institute. 2013. Supply chain resilience 2013. 5th annual survey. Read on 30.5.2020. https://web.archive.org/web/20140628204427/ Read on 30.5.2020. www.bcifiles.com/131029SupplyChainSurveyReportfinallowres.pdf

Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. 2013. Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems. Nature Education Knowledge. Read on 30.5.2020. https://www.nature.com/scitable/knowledge/library/eutrophication-causes-consequences-and-controls-in-aquatic-102364466/

Christie, C. B. & Nichols, M. A. 2004. Aeroponics-a production system and research tool. In South Pacific Soilless Culture Conference-SPSCC, 648, p. 185-190

Cline, B. 2002. Envisioning Architecture: Drawings from The Museum of Modern Art. Matilda McQuaid, ed. New York: The Museum of Modern Art, p. 220.

Coghlan, D. & Brydon-Miller, M. 2014. The sage encyclopedia of action research, vol. 2, SAGE Publications Ltd, London, p. 675-678.

Columbia University. 2019. Dickson Despommier. Biography. Irving Medical Center. Read on 30.5.2020. https://www.mailman.columbia.edu/people/our-faculty/ddd1

Conway, G. R. & Pretty, J. N. 2013. Unwelcome harvest: agriculture and pollution. Routledge.

Corsolini, S., Romeo, T., Ademollo, N., Greco, S. & Focardi, S. 2002. POPs in key species of marine Antarctic ecosystem. Microchemical journal, p 73 1-2, 187-193.

Daniels, J. 2018. Giant indoor vertical farm backed by Chinese firm launching just east of Las Vegas Strip. CNBC. Read on 30.5.2020. https://www.cnbc.com/2018/07/17/las-vegas-indoor-vertical-farm-set-to-launch-deliveries-next-week.html

Darko, E., Heydarizadeh, P., Schoefs, B. & Sabzalian, M. R. 2014. Photosynthesis under artificial light: the shift in primary and secondary metabolism. Philosophical Transactions of the Royal Society B: Biological Sciences.

Dhingra, N., Singh, N. S., Sharma, R. & Parween, T. 2020. Rainwater Harvesting and Current Advancements. In Modern Age Waste Water Problems p. 293-307. Springer, Cham.

Dodds, W. K. et al. Eutrophication of U.S. freshwaters: analysis of potential economic damages. Environmental Science and Technology 43, p. 12-19 2009.

Downs, R.J. & Hellmers, H. 1978. Environment and the Experimental Control of Plant Growth. London: Academic Press, p. 31-82.

Earthship Biotecture. 2020. Top 6 benefits of a passive house. Read on 30.5.2020. https://earthshipbiotecture.com/top-6-benefits-of-a-passive-house/

EPA. 2017. Overview of Greenhouse Gases [Overviews and Fact-sheets].US EPA. Read on 30.5.2020. https://www.epa.gov/ghgemissions/overview-greenhouse-gases

eurostat. 2018. Archive: Agricultural census in Finland. Read on 30.5.2020. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_Finland&oldid=379542#Land_use

FAO, WFP & UNICEF. 2019. The state of food security and nutrition in the world 2019: safeguarding against economic slowdowns and downturns. Read on 30.5.2020. https://www.wfp.org/publications/2019-state-food-security-and-nutrition-world-sofi-safeguarding-against-economic

FAO. 1996. Rome Declaration on World Food Security & World Food Summit Plan of Action. World Food Summit. Read on 30.5.2020. www.fao.org/3/w3613e/w3613e00.htm

FAO. 2017. The future of food and agriculture – Trends and challenges. Rome. Read on 30.5.2020. www.fao.org/3/a-i6583e.pdf

FAO. 2020. Coronavirus Food Supply Chain Under Strain What to do?. Food Systems Transformation. Maximo Torero Cullen Chief Economist. Sustainable Development Goals. Read on 30.5.2020. www.fao.org/3/ca8308en/ca8308en.pdf

Faruqui, N. & Al-Jayyousi, O. 2002. Greywater reuse in urban agriculture for poverty alleviation: a case study in Jordan. Water international, p. 387-394.

Fearnside P. 2001. Soybean cultivation as a threat to the environment in Brazil. Environmental Conservation, p. 23–38. Read on 30.5.2020. https://doi.org/10.1017/S0376892901000030

Fondation Le Corbusier. 2020. Immeubles-villas, Sans lieu, 1922. Extrait de Le Corbusier et Pierre Jeanneret, Œuvre complète, volume 1, 1910-1929. Read on 30.5.2020. www.fondationlecorbusier.fr/

Forestry and Timber, UNECE. 2019. Carbon Sinks and Sequestration. UNECE, Food and Agriculture. Organization of the United Nations. Read on 30.5.2020. https://www.unece.org/forests/outlook/carbonsinks.html

Frediani, K. 2010. Vertical plant production as a public exhibit at Paignton Zoo. The 4th Global Botanic Gardens Congress. Paignton Zoo Environmental Park, United Kingdom. Read on 30.5.2020. https://www.bgci.org/files/Dublin2010/papers/Frediani-Kevin.pdf

Future Earth. 2020. Our Future on Earth 2020. www.futureearth.org/publications/our-future-on-earth

Geddes, L. 2017. The dark town that built a giant mirror to deflect the Sun. BBC. Read on 30.5.2020. https://www.bbc.com/future/article/20170314-the-town-that-built-a-mirror-to-catch-the-sun

Gell, K., De Ruijter, F. J., Kuntke, P., De Graaff, M., & Smit, A. L. 2011. Safety and effectiveness of struvite from black water and urine as a phosphorus fertilizer. Journal of Agricultural Science, p. 67.

GHI. 2019. 2019 Results. Global Hunger Index. Read on 30.5.2020. https://www.globalhungerindex.org/results.html

Google Trends. 2020. Term "Vertical Farming" Worldwide, 2004-2020. Read on 30.5.2020. https://trends.google.com/trends/explore?q=%2Fm%2F09l8pb&date=al l

Grauer, M. 2001. Information Technology. International Encyclopedia of the Social & Behavioral Sciences. Pergamon, p. 7473-7476. Read on 30.5.2020. https://doi.org/10.1016/B0-08-043076-7/04297-2

Gusenbauer, M. 2019. Google Scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. Scientometrics, p. 177-214.

Haren P. & Simchi-Levi D. 2020. How Coronavirus Could Impact the Global Supply Chain by Mid-March. Harvard Business School Publishing. Read on 30.5.2020. https://hbr.org/2020/02/how-coronavirus-could-impact-the-global-supply-chain-by-mid-march?ab=hero-subleft-1

Harris, C. 2006. Definitions: High-rise, High-rise Building 508; Tower, 1007. Dictionary of Architecture & Construction. Fourth Edition. McGraw-Hill.
Harris, N. L., Brown, S., Hagen, S. C., Saatchi, S. S., Petrova, S., Salas, W., … Lotsch, A. 2012. Baseline Map of Carbon Emissions from Deforestation in Tropical Regions. Science, p. 1573–1576.

Henry, M., Beguin, M., Requier, F., Rollin, O., Odoux, J. F., Aupinel, P., ... & Decourtye, A. 2012. A common pesticide decreases foraging success and survival in honey bees. Science, p. 348-350.

Hidden Architecture. 2016. Intersection Fields IV: Highrise of Homes. Read on 30.5.2020. hiddenarchitecture.net/highrise-of-homes/

Ives-Halperin, J. & Kangas, P. C. 2000. Design analysis of a recirculating living machine for domestic wastewater treatment. In 7th International Conference on Wetland Systems for Water Pollution Control. International Water Association, Orlando, FL, p. 547-555.

Jensen, M. H. 1999. Hydroponics worldwide. In International Symposium on Growing Media and Hydroponics, p. 719-730. Read on 30.5.2020. https://www.actahort.org/books/481/481_87.htm

Kissinger, M. 2012. International trade related food miles–The case of Canada. Food Policy, 171-178.

Kozai, T. 2016. Why LED Lighting for Urban Agriculture?. In LED lighting for urban agriculture p. 3-18. Springer, Singapore.

Lai, C.H. and Huili Lin, S. 2017. Systems theory. The international encyclopedia of organizational communication, pp.1-18.

Lambin, E. F., & Meyfroidt, P. 2011. Global land use change, economic globalization, and the looming land scarcity. Proceedings of the National Academy of Sciences, 3465-3472.

Langlois, R.N., 2002. Modularity in technology and organization. Journal of economic behavior & organization, p. 19-37.

Langlois, R.N., Burke, G. P., & Miller, R. C. 1998. Modularization speeds construction. Power engineering, p. 20-23.

Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K. & Hottle, R. 2014. Climate-smart agriculture for food security. Nature climate change, p.1068-1072. Read on 30.5.2020. https://www.nature.com/articles/nclimate2437

Litskas, V. D. Platis, D. P. Anagnostopoulos, C. D., Tsaboula, A. C., Menexes, G. C., Kalburtji, K. L., ... & Mamolos, A. P. 2020. Climate change and agriculture: Carbon footprint estimation for agricultural products and labeling for emissions mitigation. In Sustainability of the Food System. Academic Pres, p. 33-49.

Madakam, S. & Lake V. 2015. Internet of Things IoT: A literature review. Journal of Computer and Communications, p. 164.

Makridakis, S. 2017. The forthcoming Artificial Intelligence AI, revolution: Its impact on society and firms. Futures, p. 46-60.

Manwell, J. F., McGowan, J. G. & Rogers, A. L. 2010. Wind energy explained: theory, design and application. John Wiley & Sons, p. 2.

Mentzer J.T., DeWitt, W., Keebler J.S., Soonhoong, M., Nix, N.W., Smith C.D. & Zacharia, Z.G. 2001. Defining supply chain management. J Bus Logist, p. 1–25

Middleton, F. 2020. Reliability vs validity: what's the difference?. Scribbr. Read on 30.5.2020. https://www.scribbr.com/methodology/reliability-vs-validity/

Min, Q. W. & Jiao, Y. L. 2002. Effects of Agricultural Non-point Source Pollution on Eutrophication of Water Body and Its Control Measure [J]. Acta Ecologica Sinica.

Mintzberg, H., Ahlstrand, B. & Lampel, J.1998. Strategy Safari: A Guide through the Wilds of Strategic Management, Free Press, New York, NY.

Momagri. 2012. The average size of French farms is 135 acres. Read on 30.5.2020. https://web.archive.org/web/20121112085416/www.momagri.org/UK/agriculture-s-key-figures/The-average-size-of-French-farms-is-135-acres_1070.html

Moss, B. 2008. Water pollution by agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, p. 659-666.

Nagy, J. & Zseni, A. 2017. Human urine as an efficient fertilizer product in agriculture. Agronomy Research, 490-500.

NOAA. 2020a. U.S. Billion-Dollar Weather and Climate Disasters 2020. National Centers for Environmental Information NCEI. Time Series. Read on 30.5.2020. https://www.ncdc.noaa.gov/billions/

NOAA. 2020b. State of the Climate: Global Climate Report for Annual 2019. National Centers for Environmental Information. Read on 30.5.2020. https://www.ncdc.noaa.gov/sotc/global/201913

NOAA. 2020c. State of the Climate: Global Climate Report - January 2020. National Centers for Environmental Information. Read on 30.5.2020. https://www.ncdc.noaa.gov/sotc/global/202001

Oasis Biotech. 2020. LinkedIn. Read on 30.5.2020. https://www.linkedin.com/company/oasisbiotech/about/

Parans Solar Lighting. 2020. Parans Solar Lighting System - How It Works!; Parans Sunlight Applications. Read on 30.5.2020. https://www.parans.com/

Pirog, R. S., Van Pelt, T., Enshayan, K. & Cook, E. 2001. Food, fuel, and freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions.

Plantagon International. 2020. History. Read on 30.5.2020. www.plantagon.com/about/brand/history/

Pontell, H.N., Black, W.K. & Geis, G., 2014. Too big to fail, too powerful to jail? On the absence of criminal prosecutions after the 2008 financial meltdown. Crime, Law and Social Change, p.1-13.

Porter, M.E. 1991. “Towards a dynamic theory of strategy”, Strategic Management Journal, Vol. 12, pp. 95-117.

Rakocy, J., Bailey, D., Shultz, R. & Thoman, E. 2010. Update on tilapia and vegetable production in the UVI aquaponic system.

Ramankutty, N. & Foley, J. A. 1999. Estimating historical changes in global land cover: Croplands from 1700 to 1992. Global biogeochemical cycles, p. 997-1027.

Randolph J. 2008. Multidisciplinary Methods in Educational Technology Research and Development. Ed. In: HAMKin e-julkaisuja 1/2008, Hämeen ammattikorkeakoulu.

Rourke, F. O., Boyle, F. & Reynolds, A. 2010. Tidal energy update 2009. Applied energy, 87 2, p. 398-409.

Sasaki Associates Inc. 2020. A new model for urban farming for the world's largest agricultural producer and consumer: China. Sunqiao Urban Agricultural District. Read on 30.5.2020. https://www.sasaki.com/projects/sunqiao-urban-agricultural-district/

Scholten, K. & Fynes, B., 2017. Risk and uncertainty management for sustainable supply chains. In Sustainable supply chains. Springer, Cham, p. 413-436.

Sinha, R. K., Herat, S., Agarwal, S., Asadi, R. & Carretero, E. 2002. Vermiculture and waste management: study of action of earthworms Elsinia foetida, Eudrilus euginae and Perionyx excavatus on biodegradation of some community wastes in India and Australia. Environmentalist, p. 261-268.

Skipper, J.B. & Hanna, J.B. 2009. Minimizing supply chain disruption risk through enhanced flexibility. International Journal of Physical Distribution & Logistics Management, p. 404–427.

Sky Greens. 2014. About Sky Greens. Read on 30.5.2020. https://www.skygreens.com/about-skygreens/#

Slack N., Brandon-Jones A. & Johnston R. 2013. Operations Management 7th edition. Pearson Education Limited, p. 4-31, 644-490.
Stamets, P. 2011. Growing gourmet and medicinal mushrooms. Ten Speed Press.

Stehle, S., & Schulz, R. 2015. Agricultural insecticides threaten surface waters at the global scale. Proceedings of the National Academy of Sciences, 112 18, p. 5750-5755.

Stemler, S. 2000. An overview of content analysis. Practical Assessment, Research, and Evaluation, 7 1, p. 17.

Stewart Jr., R. G. 2020. Amazon Deforestation, A Situation Overview and Proposed Solution: Vertical Tower Farming with Hemp. Sustainability Challenges. Sustainability and Impact Club. YKampus. Read on 30.5.2020. https://club.sustainabletampere.fi/amazon-deforestation-a-situation

Sukhatme, S. P. & Nayak, J. K. 2017. Solar energy, Fourth Edition. McGraw-Hill Education.

Techopedia. 2020. Automation. Dictionary, IT Business, IT Management. Read on 30.5.2020. https://www.techopedia.com/definition/32099/automation

Tester, J. W., Anderson, B. J., Batchelor, A. S., Blackwell, D. D., DiPippo, R., Drake, E. M., ... & Petty, S. 2006. The future of geothermal energy. Massachusetts Institute of Technology, p. 358.

The Bee Farmers' Association. 2020. What Is Bee Farming?. Read on 30.5.2020. https://beefarmers.co.uk/about-bee-farming/what-is-bee-farming

Torraco, R. J. 2005. Writing integrative literature reviews: Guidelines and examples. Human resource development review, p. 356-367.

Cotter, T. 2020. Mushroom Adventures: Mushroom Composting and Recycling. Chelsea Green Publishing. Read on 30.5.2020. https://www.chelseagreen.com/2018/mushroom-composting-and-recycling/

Tuladhar, R. & Yin, S. 2019. Sustainability of using recycled plastic fiber in concrete. In Use of Recycled Plastics in Eco-efficient Concrete. Woodhead Publishing, p. 441-460.

UMASS. 2020. Hydroponic Systems. Center for Agriculture, Food and the Environment. College of Natural Sciences. University of Massachusetts Amherst. Read on 30.5.2020. https://ag.umass.edu/greenhouse-floriculture/fact-sheets/hydroponic-systems

UN News. 2008. UN agency launches scheme to protect bees, birds and other pollinators. United Nations. Read on 30.5.2020. https://news.un.org/en/story/2008/08/268992-un-agency-launches-scheme-protect-bees-birds-and-other-pollinators

UN News. 2015. UN projects world population to reach 8.5 billion by 2030, driven by growth in developing countries. Global Perspective Human stories. Read on 30.5.2020. https://news.un.org/en/story/2015/07/505352-un-projects-world-population-reach-85-billion-2030-driven-growth-developing

United Nations Population Division. 2019. Urban population % of total population. World Urbanization Prospects: 2018 Revision. Read on 30.5.2020. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2018&start=1960&view=chart

United Nations. 2019a. Sustainable Development Goal 2. Progress of Goal 2 In 2019. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg2

United Nations. 2019b. Sustainable Development Goal 6. Progress of Goal 6 In 2019. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg6

United Nations. 2019c. Sustainable Development Goal 7. Progress of Goal 7 In 2019; Targets & Indicators. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg7

United Nations. 2019d. Sustainable Development Goal 8. Progress of Goal 8 In 2019. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg8

United Nations. 2019e. Sustainable Development Goal 9. Progress of Goal 9 In 2019; Targets & Indicators. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg9

United Nations. 2019f. Sustainable Development Goal 11. Progress of Goal 11 In 2019; Targets & Indicators. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg11

United Nations. 2019g. Sustainable Development Goal 12. Progress of Goal 12 In 2019. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg12

United Nations. 2019h. Sustainable Development Goal 13. Progress of Goal 13 In 2019. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg13

United Nations. 2019i. Sustainable Development Goal 14. Progress of Goal 14 In 2019. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg14

United Nations. 2019j. Sustainable Development Goal 15. Progress of Goal 15 In 2019. Knowledge Platforms. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdg15

United Nations. 2020. Sustainable Development Goals. Knowledge Platforms. Read on 30.5.2020. https://sustainabledevelopment.un.org/sdgs

US Department of Energy. 2020. Fluorescent Lighting. Lighting. Electricity & Fuel. Read on 30.5.2020. https://www.energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money/fluorescent-lighting

USDA. 2019. Farms and Land in Farms 2018 Summary. National Agricultural Statistics Service. Read on 30.5.2020. https://www.nass.usda.gov/Publications/Todays_Reports/reports/fnlo0419.pdf

USDA. 2020. Composting. Natural Resource Conservation Service. Read on 30.5.2020. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/features/?cid=nrcs143_023537

Van der Sluijs, J. P. & Vaage, N. S. 2016. Pollinators and global food security: the need for holistic global stewardship. Food ethics, 1 1., p. 75-91.

Van der Vegt, G.S., Essens, P., Wahlström, M. & George, G. 2015. From the editors: managing risk and resilience. Acad Manage J 58 4, p. 971–980.

Vidyasagar, A. 2018. What Is Photosynthesis?. Livescience.com. Read on 30.5.2020. https://www.livescience.com/51720-photosynthesis.html

Voulvoulis, N., Arpon, K. D. & Giakoumis, T. 2017. The EU Water Framework Directive: From great expectations to problems with implementation. Science of the Total Environment, 575, p. 358-366.

Wearn, O. R., Reuman, D. C. & Ewers, R. M. 2012. Extinction Debt and Windows of Conservation Opportunity in the Brazilian Amazon. Science, p. 228–232. Read on 30.5.2020. https://doi.org/10.1126/science.1219013

WebFinance Inc. 2020. HVAC. BusinessDictionary.com. Read on 30.5.2020. www.businessdictionary.com/definition/HVAC.html

Weiland, P. 2010. Biogas production: current state and perspectives. Applied microbiology and biotechnology, 85 4, p. 849-860.

WHO. 2020. Nutrition for older persons. World Health Organization. Read on 30.5.2020. https://www.who.int/nutrition/topics/ageing/en/index1.html

Williams. 2020. Passive Solar Design. Green Building Basics. Sustainability. Read on 30.5.2020. https://sustainability.williams.edu/green-building-basics/passive-solar-design

Worldometers. 2020. World Population Clock: 7.7 Billion People2020. Current World Population. Read on 30.5.2020. https://www.worldometers.info/world-population/

12 APPENDICES

12.1 Appendix A, Case Analysis Publications

A1, 1 (3)

Case #	Case References
1	Al-Chalabi, M., 2015. Vertical farming: Skyscraper sustainability? *Sustainable Cities and Society*, *18*, pp.74-77.
2	Aleksandrov, Y., 2018. New solution–cultivation and storage of soft fruits and vegetables in chambers of the “containers” type with positive temperatures (Container Skyscraper, Mumbai, India). *Bulgarian Journal of Agricultural Science*, *24*(2), pp.326-334.
3	Aleksandrov, Y., 2019. New solution–a skyscraper with integrated floor gardens, multi-storey panoramic elevators and aquariums filled with fluorescent algae. *Bulgarian Journal of Agricultural Science*, *25*(3), pp.595-604.
4	Al-Kodmany, K., 2018. The vertical farm: A review of developments and implications for the vertical city. Buildings, 8(2), p.24.
5	Badami, M.G. and Ramankutty, N., 2015. Urban agriculture and food security: A critique based on an assessment of urban land constraints. *Global Food Security*, *4*, pp.8-15.
6	Banerjee, C. and Adenaeuer, L., 2014. Up, up and away! The economics of vertical farming. *Journal of Agricultural Studies*, *2*(1), pp.40-60.
7	Benis, K., Reinhart, C. and Ferrão, P., 2017. Development of a simulation-based decision support workflow for the implementation of Building-Integrated Agriculture (BIA) in urban contexts. *Journal of cleaner production*, *147*, pp.589-602.
8	Business, W.D., 2020. Dragonfly City Farm–We Dream Business.
9	Canal, A., 2019. The Rise of Vertical Farming.
10	Cox, S. and Van Tassel, D., 2010. Vertical farming’doesn’t stack up. Synthesis/Regeneration, 52(4).
11	De Anda, J. and Shear, H., 2017. Potential of vertical hydroponic agriculture in Mexico. *Sustainability*, *9*(1), p.140.
12	Despommier, D., 2009. The rise of vertical farms. *Scientific American*, *301*(5), pp.80-87.
13	Despommier, D., 2013. Farming up the city: the rise of urban vertical farms. *Trends in biotechnology*, *31*(7), pp.388-389.
14	Despommier, D., 2014. Vertical farms in horticulture. *Encyclopedia of Food and Agricultural Ethics, Springer, Netherlands*, pp.1791-1799.
15	Dewidar, K., Nabil, M. and AEH, A.E.A., THE MARRIAGE BETWEEN ARCHITECTURE AND SUSTAINABILITY. ALGAE BASED TOWERS.
16	Doron, G., 2005. Urban agriculture: Small, medium, large. *Architectural Design*, *75*(3), pp.52-59.
17	Drożdż-Szczybura, M., 2014. Vertical farms in the cities of the future. *Czasopismo Techniczne*.
18	Ehrenberg, R., 2008. Let's get vertical: City buildings offer opportunities for farms to grow up instead of out. *Science News*, *174*(8), pp.16-20.

19	Ellingsen, E. and Despommier, D., 2008. The Vertical Farm-The origin of a 21st century Architectural Typology. *CTBUH Journal*, *3*, pp.26-34.
20	Franchini, L., 2015. Vertical Farm: perspective of development.
21	Goldstein, H., 2018. The green promise of vertical farms [Blueprints for a Miracle]. *IEEE Spectrum*, *55*(6), pp.50-55.
22	Graamans, L.J.A., 2015. VERTICAL-The re-development of vacant urban structures into viable food production centres utilising agricultural production techniques.
23	Graff, G.J., 2007. THE VERTICAL FARM THEORY.
24	Grewal, S.S. and Grewal, P.S., 2012. Can cities become self-reliant in food? *Cities*, *29*(1), pp.1-11.
25	Gumble, J.J., 2015. Green towers: production and financial analyses of urban agricultural systems.
26	Haris, I., Fasching, A., Punzenberger, L. and Grosu, R., 2019, June. CPS/IoT Ecosystem: Indoor Vertical Farming System. In *2019 IEEE 23rd International Symposium on Consumer Technologies (ISCT)* (pp. 47-52). IEEE.
27	Imam, M. and Kolarevic, B., 2016. Towards resource generative skyscrapers. *Council on Tall Buildings and Urban Habitat research paper*.
28	Januszkiewicz, K. and Jarmusz, M., 2017, October. Envisioning urban farming for food security during the climate change era. Vertical farm within highly urbanized areas. In *IOP Conference Series: Materials Science and Engineering* (Vol. 245, No. 5, p. 052094). IOP Publishing.
29	Jenkins, D., 2017. *Rise to the challenge: vertical farming within the urban environment* (Master's thesis).
30	Kalantari, F., Mohd Tahir, O., Mahmoudi Lahijani, A. and Kalantari, S., 2017. A review of vertical farming technology: A guide for implementation of building integrated agriculture in cities. In *Advanced Engineering Forum* (Vol. 24, pp. 76-91). Trans Tech Publications Ltd.
31	Kalantari, F., Tahir, O.M., Joni, R.A. and Fatemi, E., 2018. Opportunities and challenges in sustainability of vertical farming: A review. *Journal of Landscape Ecology*, *11*(1), pp.35-60.
32	Kretschmer, F. and Kollenberg, M.E., 2011. Can Urban Agriculture Feed a Hungry World. *Spiegel Online International*, *1*.
33	Krzemińska, A.E., Zaręba, A.D., Dzikowska, A. and Jarosz, K.R., 2019. Cities of the future—bionic systems of new urban environment. *Environmental Science and Pollution Research*, *26*(9), pp.8362-8370.
34	Kumar, V., Kumar, M., Dwivedi, A., Kumar, S. and Naresh, R.K..2018. Chapter-1 Food and Nutritional Security through Technological Intervention of Vertical Farming of Vegetables in India. Agricultural-based Interventions for Sustainable Food Security & Climate Change.
35	Marcynuk, A., 2011. *Urban growth: a synthesis of agriculture and architecture* (Doctoral dissertation, Carleton University).

36	Orazi, D.C., Dare, R. and Gruner, R.L., 2013. Vertical Farms: Building Leverage into Production Processes in Food Consumption Choices. In *Australia and New Zealand Marketing Academy Conference 2013* (p. 7pp). University of Auckland.
37	Platt, P., 2007. Vertical farming: an interview with Dickson Despommier. *Gastronomica*, *7*(3), pp.80-87.
38	Prades Villanova, M., 2013. Vertical farm façade: first approach to the energetic savings applied to the Seagram Building in New York.
39	Putri, N.Y., Sharfina, N.P. and Prakarti, T., 2015. Sky farming: The alternative concept of green building using vertical landscape model in urban area as an effort to achieve sustainable development. *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*, *9*(7), pp.938-941.
40	Quinn, H., 2017. Urbanizing Agriculture; Vertical Farming as a Potential Solution to Food Security Issues.
41	Shamshiri, R., Kalantari, F., Ting, K.C., Thorp, K.R., Hameed, I.A., Weltzien, C., Ahmad, D. and Shad, Z.M., 2018. Advances in greenhouse automation and controlled environment agriculture: A transition to plant factories and urban agriculture.
42	Sarkar, A. and Majumder, M., 2015. Opportunities and challenges in sustainability of vertical eco-farming: A review. *Journal of Advanced Agricultural Technologies Vol*, *2*(2).
43	Shao, Y., Heath, T. and Zhu, Y., 2016. Developing an economic estimation system for vertical farms. *International Journal of Agricultural and Environmental Information Systems (IJAEIS)*, *7*(2), pp.26-51.
44	Sheng, J., 2018. Vertical Farming Feasibility.
45	The Green Giants. 2019. Tall Farm. 2nd Annual UCI Engineering Conference.
46	Torreggiani, D., Dall'Ara, E. and Tassinari, P., 2012. The urban nature of agriculture: Bidirectional trends between city and countryside. *Cities*, *29*(6), pp.412-416.
47	Vergne, E., 2010. Dystopian Farming. Architectural Design, 80(6), pp.94-101.
48	Wagner, C.G., 2010. Vertical farming: An idea whose time has come back. *The Futurist*, *44*(2), p.68.
49	WALDRON, D., 2018. EVOLUTION OF VERTICAL FARMS AND THE DEVELOPMENT OF A SIMULATION METHODOLOGY. *WIT Transactions on Ecology and the Environment*, *217*, pp.975-986.
50	Warkhade, M.N., Bagle, M.M. and BHMCT, F.Y., TO STUDY "THE CONCEPT OF VERTICAL FARMING IN INDIA".
51	Wilson, M., 2009. Condenser Typology: open envelope vertical farming, the extremes of tower urbanism. *CTBUH Journal*, (2), pp.26-34.
52	Wood, A., 2014. Rethinking the skyscraper in the ecological age: Design principles for a new high-rise vernacular. *Proceedings of the Council on Tall Buildings and Urban Habitat (CTBUH), Shanghai, China*, pp.16-19.
53	Zhang, H., Asutosh, A. and Hu, W., 2018. Implementing vertical farming at university scale to promote sustainable communities: a feasibility analysis. *Sustainability*, *10*(12), p.4429.

12.2 Appendix B, Formulas

N_x = Number of Cases a Category Occurred / Total Publications

$$\text{Case Distribution Percentage} = \left[\frac{N_x}{(N_1 + N_2 \ldots N_x)} \right] 100$$

Figure 21. Case Distribution Percentage Formula.

N_x = Category Occurrence Frequency Per Case

$$\text{Category Occurrence Percentage} = \left[\frac{N_x}{(N_1 + N_2 \ldots N_x)} \right] 100$$

Figure 22. Category Occurrence Percentage Formula.

12.3 Appendix C, Domain Systems Analysis Tables

C1, 1 (2)

12.3.1 C1, Biological Domain Systems

Case #	Biological Domain Systems												
	Food Production						Bio-waste Management						Number of Biological Systems
	Plant Production			Animal Production			Wastewater			Solid Waste			
	Hydroponics	Aeroponics	Rainwater Harvest	Aquaponics	Chicken Farming	Bee Farming	Greywater	Blackwater	Living Machine	Composting	Vermiculture	Mushroom Farming	
1	7												1
2			2										1
3			1										1
4	50	25	6	23	1		1	2		4		1	9
5	1	1											2
6	1	4	1	2			1			1		1	7
7	19		1										2
8			1							1			2
9													0
10	3	1											2
11	40	9											2
12	10	4						1					3
13	4	3											2
14	14	2			1								3
15	1	1		1		1					1		5
16	1									1			2
17	4		1		2								3
18	3		1		1	1				2			5
19	5	5			1			2	2	2			6
20													0
21	1	1		2									3
22													0
23	14									1			2
24	11		2		21	3				1		1	6
25	46	5	2	92				1					5
26	6	2		1									3
27			2				2						2
28	6	3	2	2								1	5
29	18	8	6	4			2			1			6
30	12	4	2	3				1					5
31	13	6		3				1		1	1	1	7
32													0
33	4	1										1	3

C1, 2 (2)

34	3	2					1						3
35	40	89		2	3		3	1		2			7
36	1	1			2								3
37	1	1								1			3
38	17	2	4			1	2	2					6
39	10		7				2	1					4
40	8		1						1				3
41	7	1	2	3	1		1	1	1			1	9
42	37	4		1				2					4
43	16												1
44	3		1										2
45	1	2	4										3
46													0
47		2											1
48					1							1	2
49													0
50	6	2	1									1	4
51		6											1
52			5										1
53	18	6		3			1	1					5
Total Occurrence	**462**	**203**	**55**	**142**	**34**	**6**	**16**	**16**	**4**	**18**	**2**	**9**	**Average**
Total Cases	**39**	**30**	**22**	**14**	**10**	**4**	**10**	**12**	**3**	**12**	**2**	**9**	**3.15**

12.3.2 C2, Lighting Domain Systems

C2, 1 (2)

	Lighting Domain Systems						
Case #	Natural Lighting			Artificial Lighting			Number Of Lighting Systems
	Natural light, Sunlight	Fibre Optics/Fiber Optics	Mirrors	LED (ight-emitting diode)	Fluorescent	HID	
1	2			3			**2**
2					1		**1**
3					18		**1**
4	14			14	2		**3**
5							**0**
6			1	8			**2**
7	9						**1**
8							**0**
9	1						**1**
10	9					1	**2**
11	2			6			**2**
12	1						**1**
13	3			2			**2**
14				8	1		**2**
15	3						**1**
16							**0**
17							**0**
18							**0**
19				1			**1**
20							**0**
21				7			**1**
22							**0**
23	2	1		2			**3**
24				1			**1**
25	21	1		50	15	14	**5**
26				5			**1**
27							**0**
28	4			3	2		**3**
29	12			12			**2**
30	12		1	17			**3**
31	11			12			**2**
32	2			2			**2**
33	2		4	2			**3**
34	3	1		1			**3**
35	29		4	1			**3**
36							**0**
37				1			**1**
38	23		1	6			**3**
39	3			2			**2**
40	3			3			**2**

41	11			10	2	1	**4**
42	9			1		3	**3**
43	2			4			**2**
44				10			**1**
45	1			8	2		**3**
46							**0**
47							**0**
48							**0**
49							**0**
50	9		1	15			**3**
51	4			1			**2**
52							**0**
53	5			3			**2**
Total Men-tions	**212**	**3**	**12**	**221**	**43**	**19**	**Average**
Total Cases	**29**	**3**	**6**	**32**	**8**	**4**	**1.55**

12.3.3 C3, Energy Domain Systems

C3, 1 (2)

	Energy Domain Systems						
Case #	**Solar Energy / Power**	**Wind Energy / Power**	**Bio-gas**	**hydro energy / power /hydroelectricity**	**Tidal energy / power**	**Geo-thermal**	**Number Of Energy Systems**
1	8						1
2	6	2					2
3	1	1					2
4	6	4	8			1	4
5							0
6	2	5		2		1	4
7	8						1
8	3	3					2
9							0
10	3					1	2
11	7			1			2
12							0
13							0
14	1					1	2
15							0
16							0
17	3	1					2
18	1						1
19			2		1	1	3
20							0
21				1			1
22							0
23	3	6					2
24							0
25	3	1				2	3
26							0
27		7				2	2
28		1					1
29	1						1
30	10	1				2	3
31	2		1			2	3
32	1						1
33	8	2			1		3
34							0
35							0
36							0
37							0
38	3	3	2				3
39	4	1					2
40			1			1	2
41	17	4			1	1	4

C3, 2 (2)

42							0
43	1		2			1	3
44	4						1
45	6						1
46							0
47							0
48	1	1		1			3
49							0
50	5	1				1	3
51							0
52	3	5					2
53	1	1					2
Total Men-tions	**122**	**50**	**16**	**5**	**3**	**17**	**Average**
Total Cases	**29**	**19**	**6**	**4**	**3**	**13**	1.4

12.3.4 C4, Control Domain Systems

C4, 1 (2)

Case #	Control Domain Systems									
	Operational Control				Climate Control					Number Of Climate Systems
					Passive Climate Control		Mechanical Climate Control			
	automation	Information Technology	Internet of Things	A.I.	Natural Ventilation	Passive Thermal, Passive Cooling, Passive Climate	HVAC	Mechanical Ventilation	Hybrid Climate Control	
1										0
2	2									1
3	1									1
4	7	1	2		2		1	1		6
5										0
6										0
7	2				6		1	1	2	5
8					1					1
9	1			1						2
10										0
11	3		1							2
12										0
13	1									1
14	3						1			2
15	1									1
16										0
17										0
18										0
19										0
20										0
21	1			2			2			3
22										0
23										0
24			1							1
25	2									1
26	9		24			1				3
27					3					1
28	3						3			2
29					4		2			2
30	3		1		1		3			4
31	4		1							2
32										0
33						1				1
34										0

C4, 2 (2)

35	1									1
36										0
37										0
38	4		1		10	2	20	6	3	7
39										0
40	1						1			2
41	39	1	18	5	21	2		7		7
42	1									1
43				3			6			2
44	2									1
45	9			5		4				3
46										0
47										0
48										0
49	2									1
50	1						2			2
51							2			1
52					6			1	1	3
53	8		3							2
Total Men-tions	**111**	**2**	**52**	**16**	**54**	**10**	**44**	**16**	**6**	**Aver-age**
Total Cases	**25**	**2**	**9**	**5**	**9**	**5**	**12**	**5**	**3**	**1.42**

12.3.5 C5, VTF Domain Systems Occurrence

Domains	Total Domain Term category Occurrence	Total Occurrence Percentage	Total Cases Occurrence	Total Cases occurrence Percentage	Averaged Percentage Totals: Mentions Frequency and Number of Cases	Standard Deviation
Biological Domain Systems	967	48.33%	167	41.96%	45%	4.5%
Lighting Domain Systems	510	25.49%	82	20.60%	23%	3.5%
Energy Domain Systems	213	10.64%	74	18.59%	15%	5.6%
Control Domain Systems	311	15.54%	75	18.84%	17%	2.3%
Total	2001	100.00%	398	100.00%	100.00%	0.00%

12.4 Appendix D, SWOT Analysis Table

Output Code	SWOT	Case # (As Directly or indirectly related to resulting SWOT code)			Keywords
Vertical farms and their widespread adoption are currently validating underlying VTF concepts of mass productivity and profitability in limited space by using state-of-the-art food production practices and technologies while taking advantage of vertical space.	Strength	53			Vertical farming success;
Renewable and energy efficient technologies, plus passive design could significantly cut VTF operational costs in the long-term.	Strength	34	30	41	Renewable energy, costs; Passive design, reduction, energy consumption; affordable, energy efficient
A passive designed VTF can take advantage of a locations natural phenomena, while reducing energy dependencies and environmental impact.	Strength				
The VTF could minimize the amount of land cleared for agriculture, supportive of conservation efforts.	Strength	39	38		Reducing, land cleared, farming; Less, deforestation
The VTF controlled environment allows for all year production.	Strength	43	28	40	Vertical farms, all year production;
VTFs can protect crops from harsh weather conditions due to climate change, extreme weather, and seasonality.	Strength	46	6	34	Crop protection, weather; climate change

The VTF could eliminate the environmental contaminations of agriculture by reducing, eliminating, containing, and treating their use onsite.	Strength	4			Eliminate, herbicides, pesticides
The VTF could reduce the distance food must travel before it reaches the consumer, thus reducing or eliminating fossil fuels used in the process.	Strength	34			Food distance
The VTF takes advantage of numerous waste streams, transforming municipal and VTF bio-waste into a resource, for example, from liquid form with grey and blackwater, or solid form with organic matter.	Strength	4	8		Waste, becomes, nutrients; Reuse, biowaste, nutrient
A VTF's ability to capture and store rainwater reduces its dependency on the grid, and in turn, lessens the burden on natural resources for its extraction and transportation.	Strength	41	39		rainwater, harvest, irrigation
As similar to vertical farms, and their hydroponic and aeroponic practices, VTFs are also capable of significant water-use efficiency, in contrast to open field agriculture.	Strength	4	11		Efficiency, less water; Water use efficiency
VTFs eliminate the issue of weeds from agriculture, thus eliminating costs and time associated with crop maintenance and the environmental damages related to herbicide use.	Strength	23			Weeds, agriculture, removed;
The VTF represents a monumental business challenge, requiring significant up-front investment, specialized and multidisciplinary expertise, and a viable business model.	Weakness	41	49	4	Higher, economic, investment; High, expertise, knowledge; Robust, resilient, business models

D1, 2 (6)

The long-term orientation of VTFs requires sufficient cash-flow in the start-up phase of operations, requiring advanced funding, and a longer period before any return on investment, which also makes this an unattractive investment to many investors.	Weakness	25	9	40	Funding urban agriculture; Upfront costs
Powering VTF operations could require significant energy costs, for example, with climate control, lighting, and automation.	Weakness	41	31	7	High, energy consumption; Very high, energy use; Operating cost, energy bill
The VTF could provide a risky investment.	Weakness	43			Vertical farm, risky investment
The VTF represents a huge design challenge to reach cost efficiency with productivity, while an inefficient VTF could lead to its business failure.	Weakness				
The customized features of the VTF could require significant cost.	Weakness	25			Sophisticated features, cost
The VTF will receive limited sunlight to utilise, for example due to its own structural obstructions, and from other structures, such as surrounding towers, thus diminishing its use of this free and clean resource.	Weakness	7	35	38	Penetration, natural daylight; Addressing natural lighting; Shade, less sunlight
Developing the VTFs local food supply network could prove challenging and requires a specialized approach.	Weakness				

The VTF depends on a diversity of expertise and technical training to the customised systems of the VTF and its operations.	Weakness	4	23		Technical expertise, implement; Vertical farms, technicians
The VTF requires particular construction capabilities for its mass distribution, e.g. multidisciplinary expertise, supply chain and resource inputs, and transport efficient and the accessibility of its outputs.	Weakness	43			Construction, expert knowledge, system
The VTF operations will occur under more compacted conditions than conventional agriculture, thus decreasing area of space for working and movement.	Weakness	29			Stacked system, less floor area
The VTF must operate in specific environmental parameters to prevent plant disease.	Weakness	41			Environmental control, disease reduction
The VTF will have a human resource management challenge, scouting, training, and developing of staff.	Weakness				
The VTF operations has a dependency on waste streams for its operations and is subjected to its variable availability.	Weakness				
VTFs could enhance a nation's food security by increasing domestic food production, decreasing dependency on food trade imports, reducing the food trade import deficit, and supporting the local and national economies.	Opportunity	38	34	4	Increase in food production; Food security; Support local economy
The VTF significantly addresses the SDGs, thus aligning it with national and international interests, and making VTF initiatives a favourable candidate for sustainability-related grants.	Opportunity	53			sustainable development goals;
Mass VTF production could reduce their cost.	Opportunity	6	8		Mass production

					D1, 4 (6)
The modularization of VTF components could reduce production and assembly costs, reduce construction time, increase ease of assembly, and create a resilient and customisable product, which could enable its mass distribution.	Opportunity	26	25	50	Modular;
The VTF could be complementary to urban planning strategies.	Opportunity	41	24		Urban agriculture, vertical farming, growing population, food security; Agriculture, urban planners, vertical farms
VTF complexity could be simplified by the modularization of its components.	Opportunity				
First mover advantage.	Opportunity				
VTF could deliver high-value crops closer to market.	Opportunity	50	6		High value crops
A VTF could integrate multiple enterprises into its structure, such as food shops, providing alternative cash flows, and local, fresh, and healthy foods as a competitive advantage.	Opportunity	42	4		Food shops; Local food
Automation technology could enhance operational productivity and reduce labour costs.	Opportunity	21	41	28	Automation productivity/production; Automation labour
Including the local community in the VTF operations could help break down social barriers.	Opportunity	24			local community
Community advocates could be the key advocates of the VTF.	Opportunity	24			Community leaders collaborate

VTFs could use AI to manage controls systems with high precision and efficiency, as well for forecasting consumer demand.	Opportunity	21	9		Indoor farms, AI, efficient; AI, controlled environment, exact
VTFs have the possibility of retrofitting pre-existing unused buildings for urban food production.	Opportunity	23			Renovation
Future emerging technological advancements will improve VTF efficiency.	Opportunity	23	4	44	Technological advancements
The VTF must compete with established market competitors of conventional agriculture and its cheaper start-up costs and operational practices.	Threat	44	35		Compete, global market; Unaffordable, compete, current, food, market
The complexity of the VTF is a challenge for its development, operations, management, and mass distribution.	Threat	27	22		Complexity, integrated, systems; Complexity, facility
The VTFs impact on the environment through its construction must align with its sustainability goals, which has yet to be clearly considered.	Threat	38			Construction, technologies, environmental, impact;
Land in urban locations, are typically more expensive.	Threat	4	9		Urban agriculture, high costs; Cost, vertical farms, urban areas

The early VTFs models will be cost prohibitive to developing nations.	Threat	42	4		Food security, developing countries, priority; Vertical farm, obstacle, developing countries
The VTF could be seen as a threat to current industries and way of life, which could result in campaigns of resistance and the promotion of its negative perceptions.	Threat	10			Agriculture, displaced;
VTFs compete with other land uses.	Threat	16			Agriculture, compete, other, usage
The legalities of a VTF and its operations are not clearly understood, and are based on local regulations, for example, the urban zoning constraints to agriculture.	Threat	53			National policy, legal system

Tampere University of Applied Sciences

Community Coordinator Theory

Robert Garey Stewart Jr

Learning Lab
May, 2020
BACHELOR'S DEGREE
International Business Degree Programme

ABSTRACT

Tampereen ammattikorkeakoulu
Tampere University of Applied Sciences
International Business Degree Programme

Robert Garey Stewart Jr.
Community Coordinator Theory

Bachelor's Research 45 pages, appendices 16 pages
May 2020

Communities contain valuable expertise and resources, that when used properly can support community development. However, communities risk losing valuable opportunities due to collaborative barriers. One of the reasons is due to weak links between dispersed expertise and resources within a community. Another is that community members do not have sufficient time, energy, or reward to foster multidisciplinary projects, and already have substantial workloads to consider. Further, the additional workloads would come at the reduction of personal time, and failure, at the risk to their professional standing.

Too much burden has been placed on community members alone to act on interdisciplinary opportunities, resulting in unactualized opportunities, and unaccountable losses to community development. The position of community coordinator (CC) aims to address these barriers to opportunities for community development. The CC relieves the burden of the community members by specializing in the process of joining dispersed expertise and resources of communities, through identifying and supporting the development and actualization of projects by multiple parties to reach both their party's individual goals and concurrently, an overarching mutually beneficial goal held by all parties.

This research aimed to support the development of the CC theory. To do this, the CC position has been explored through action research and reflective practices and resulted in the development of meta-models to describe the CC position, and thoughts on CC competencies, tasks, tactics, and strategies. The meta-models that were developed are as follows: The Core Principles of a CC, The Realms and Dimensions of a CC, The Relationship and Alliance Hierarchy, Bridging the Community Gap, The CC Visibility Field, The CC Journey, Seeking a Contact,

The CC and the Collaboration Life Cycle, and A Path Towards Strategic Alignment. The top competencies of a CC were found to be human-relationship, organizational, research, analysis, problem-solving, and creative thinking skills.

This research contributes to the emerging body of CC literature, the advancement of the CC position, and by supporting the development of the CC theory. Due to the subjective nature of the research approach, it is suggested that further qualitative and quantitative research be conducted to validate these research findings, identify gaps, improve the current CC models, and develop new CC models. Additionally, multidisciplinary teams of experienced CC's should work together to identify and improve the CC's working methods and develop a practical training guide.

Key words: Community, Coordinator, Facilitation, Collaboration, Competencies, Community Coordinator Theory

CONTENTS

1 Introduction

A community consists of people that are unified in a particular area, either physically and/or virtually, and with their purpose in some form of commonality (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). Communities depend on certain resources and the value that it can provide to its stakeholders to sustain itself and develop. In the article *Community resilience: An indicator of social sustainability*, Magis (2010) describes the importance of resilience as an aspect of social sustainability in communities, concluding that resilience is important in the ability of communities to manage and influence change. Communities also have capacities in their ability to activate human competencies and social resources (e.g. relationships and social networks), as well as other physical and nonphysical resources of a community. A community's capacity is the extent to which they can access and collaborate these elements toward problem-solving, development, and the sustainability of the community (Chaskin et al., 2001, p. 7.) While resilience is dependent on the capacity for adaptation to change, both the concept of community resilience and community capacity consider resources inherent to a community and the use of its resources as essential in satisfying the needs of a community (Magis, 2010).

Communities can risk missing out on valuable opportunities to activate their capacity with the inability to use their expertise potential and utilize their resources efficiently and effectively. A challenge in actualizing these potentials could occur when a community’s actors lack the specialized knowledge and/or experience for activating these opportunities. Because of the dynamic internal and external forces that act upon complex systems such as communities, complex challenges can emerge. As well, a community’s opportunities may remain hidden or unrealized due to no clear path or a limited focus to address the innovation process. When resources are limited and expertise dispersed, the ability of a community to address these challenges and opportunities is diminished and relies on the knowledge and experience of fewer people. Although this could be overcome by connecting dispersed people and resources who have similar goals.

It could be beneficial for a community to intentionally develop individuals and/or groups with the capabilities to address their challenges and opportunities. A community needs an approach to effectively and efficiently activate their dispersed

assets, such as their expertise and limited resources. This requires the development of initiatives and the coordination of people and resources. The position of Community Coordinator (CC) could be used to reach such goals. Coordination is the development of organization between groups and people towards operational alignment and productivity to reach common and mutually beneficial goals (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). Therefore, it would be reasonable to define a community coordinator as an intermediary that builds relationships, organization, and through coordination of people and resources facilitates actions to develop and actualize mutually beneficial value creation between entities. The CC has the purpose to identify challenges or opportunities that exist within a community or communities that could be better addressed through a combination of expertise, resources, and mutually beneficial objectives between collaborative parties.

The knowledge and skills of a CC should be developed to support the training and development of the CC position. With the position of CC, communities can better tap into their expertise and resources to address challenges and opportunities. Having individuals and groups trained in the position of CC could help facilitate the development of projects that require the coordination of multiple parties. This also relieves the collaborative parties of the time-intensive process and responsibility of intermediary tasks such as planning, coordinating, facilitating dialogues and workshops; and also supporting the development of a common vision, objectives, roles, and responsibilities. In short, allowing collaborative parties to focus more on the position of their expertise than as a coordinator. This research aims to develop a knowledge base for the position of CC by exploring:

1. What are the meta-models of the CC position?
2. What competencies would human resources need to focus on, to train and develop an employee for the position of CC?

2 Literature review

In the field of computer science, according to the article *Virtual Communities and Community Coordinator* by Akram, Allan, & Rana (2005), resource discovery could be made efficient for communities through the organizing of people and resources. Such communities depend on the active position of a CC to be effective. Communities contain unique people and services, who share and control community resources. To increase resource efficiency, they make cooperation agreements. This cooperation requires a coordination process, the development of negotiation policies, observation, and leadership for conflict resolution. It is unlikely that dispersed resources and people develop spontaneous collaboration agreements to create a community without a coordinating person or someone to manage the community and additionally provide a unique service. It is the CC's responsibility to coordinate people and resources within the community. To manage dynamic networks, the position of CC could be made. A key to an effective community is its ability to coordinate various people to reach a precise goal. When it comes to organizing coordination certain challenges need to be considered. How will the goals be divided into tasks, and how will the responsibilities be decided? How will resources be shared between collaborating parties? How will information be shared between individuals? How to overcome the conflicting preferences of collaborating parties to reach a common goal? The CC helps facilitate the development of strategic partnerships, the organization of network activity, and discover collaboration possibilities that could improve a community and its member’s effectiveness.

Similarly, a coordinator position exists as a project coordinator, in the article *What attributes should a project coordinator possess?* by Jha & Iyer (2006), they surveyed the construction field, as they state the increasingly multidisciplinary nature of the field is requiring a coordination role as a critical factor for success. Through literature review and survey of top construction professionals in India, they identified attributes of the project coordinator that made a difference between the success or failure of a project. These qualities included the project coordinators relationship with clients, timeliness, expertise, team player mind-set, and coordination. They found the results were the same whether they worked for the contractor or owner's organization. There were also three major skill categories from the 24 qualities that were generated: team building, contract implementation, and project

organization. They concluded, that due to the nature of a project coordinator's need to interact with a vast amount of people, human relationship skill was the most important skill to seek in developing the position.

Another similar position to the CC position could be the Cooperative Engagement Professional CEP. In the article *Cooperative Extension Competencies for the Community Engagement Professional* by Atiles (2019), Atiles explains that the CEP represents a university in its extended infrastructure and that they are responsible in engaging communities of students, staff, and teachers. Additionally, stating that knowledge in systems theory and thinking is important to the CEP because it allows the CEP to see the bigger picture more clearly and take an interdisciplinary approach to complex systems and the challenges and behaviours observed within them. Seeing how the parts of the system have interdependencies and relations important when planning. System theory and thinking can be an important foundation for planning and problem solving because it allows for developing consideration of how one action on a system part could affect another part. Additionally, stating that the need for teamwork, learning collaboratively, and development of community engagement that leads to changes in practice. The primary goal of these competencies is to develop mutually beneficial goals between parties through the use of democratic strategies.

In the article *Confessions of a Learning Community Coordinator*, Mendelson (2006) describes a four-year experience as the English department community coordinator in a larger learning community program in the US. Stating that interdisciplinary collaboration created new opportunities and possibilities for teachers and students. A challenge of coordinating learning communities seemed to be from the time it took to organize and coordinate the curriculum and activities. Stating that many teachers may go beyond the call of duty if they see it as an investment in their career. But the incentives remain as personal satisfaction while the risk being to their professional standing. After surveying department chairs, it was found that when asked if they would support a learning community by full or associate professors, the response was 84% in agreeance. The same question was then asked, but in terms of untenured assistant professors, with the result of 58% disagreeing, with reasons such as taking time away from research, and that these efforts are not recognized by the higher administration. Mendelson

follows this up with the comment saying that the collaboration of learning communities offers the possibility to widen the scope of thinking and realize novel concepts, although the faculty are at a loss how to follow up and publish beyond their discipline. Summarizing that teachers do not pursue interdisciplinary connections because they require extra time on their half and the uncertainty of reward. Through linking interdisciplinary teaching, research, and program trends together, partnerships for grant proposals could be developed that go beyond the boundaries of disciplines.

Between the above examples, a coordinator has been related to serving an important functional position within communities as linking people and resources. A common theme of a coordinator is the ability to develop human relationships, which requires intentional effort by the coordinator. The coordinator has been explained as a position that is a facilitator of interaction and organization between parties to reach mutually beneficial goals. All the above-mentioned cases included the need for a coordinator for interdisciplinary and/or interdepartmental collaboration, even going as far as to say the success of a project was dependent on the role of the coordinator. Although, it is unlikely that these goals will be achieved without the intentional position of a community coordinator, otherwise as state earlier it requires one member of the community to both manage an additional workload while continuing to produce their regular service at the same time. Also, the time that initiative require could be too-taxing on many professionals and lacks a validated reward. This is a barrier to accessing potential opportunities to enhance the community and its member's productivity and development. Similar positions already exist such as project coordinator or the cooperative engagement professional (CEP). In the field of computer science as mentioned above, there was a need and effort to develop the specific position of community coordination for virtual communities with the position as a service focus and not an additional workload. Whereas, in Mendelson’s account of the situation of a learning community coordinator was viewed as an additional workload with little professional reward as the top barriers to pursue interdisciplinary opportunities that could enhance the community efficiency and the value it delivered to its members. Additionally, efforts need to be validated by an authority within the community and incentivize collaborative participation, which the position of CC could help legitimize. Finally, since a community has unique elements, processes, and

forces within, a community coordinator needs to understand and develop approaches interact with these factors to reach successful results. As was also recommended for the CEP position, to generate the knowledge of the CC competency a theoretical perspective of system thinking will be used as a viewpoint to develop an understanding of interdependencies and relations of the community as a foundation for interaction.

2.1 Systems, Social Networks, and Stakeholders

Systems are made of elements. Multiple coupled systems form a meta-system. Systems have specific laws and special processes. Laws and functions reveal a system's mechanics and the relationship among elements. The composition of a system is determined by the links between elements within the system. These coupled elements compose processes and shape operations. With a systems perspective, a system can be examined and applied to theoretical models.

- System theory is a viewpoint for discerning the interconnections and associations of organizational elements within a system and by its environment (Lai & Huili Lin, 2017).
- The standard qualities of a system, include its structure, interconnections, its emergent properties, how parts relate to the whole, its ability to reach results by various possible approaches, and tendency towards equilibrium (Lai & Huili Lin, 2017).

The developed models can represent a system, its coupled elements, processes and operations. Understanding a system provides the ability to identify patterns and plan for interventions and improvements. Many systems can coexist in a complex environment. The links between systems can vary in intensity. While individuals and groups form a community, multiple overlapping communities shape societies. Systems connected to the meta-system environment support dynamic interactions.

A community is a complex system. Membership is regulated by a set of unifying conditions, whether explicit or implicit. For example, membership could be satisfied by an individual holding one or several of the following attributes: location, common interest, expertise, and/or purpose. Membership depends on an individual maintaining the minimal qualifying conditions of a community. Abstractly, a

community operation can be divided into elements to model its processes. Elements include members and environmental factors.

Within the environment, resources are diversely dispersed. Resources occur in different locations and at various levels. Resources in particular forms may be scarce while others are abundant, while its distribution may be concentrated with certain groups or members. Collaboration can compensate for the uneven distribution of resources. Such exchanges could be symbiotic and mutually beneficial. Parties within a community must satisfy their departmental objectives. Although, in collaboration, they must also achieve a common goal held between multiple parties.

Opportunities may sometimes occur as an emergent property of the community to satisfy a common goal, while other opportunities are too complex to emerge without intervention. A CC is a dynamic system element and member. A CC must develop a meta-perspective on particular functions within a community by linking members and resources towards a common goal. As a dynamic system member, the CC must identify resources and expertise, recruit participants, develop networks, and facilitate communication to build participant relationships.

The CC also must facilitate project development and the coordinated actions of participating parties. Community decision-makers are stakeholders with authority and particular needs. They influence the possibility and extent of collaboration. It is the responsibility of the CC to align stakeholders needs towards common goals between parties. Social Network Theory may have overlaps in the systems perspective on the CC position and their relation and interactions within the community social system. For example,

- Social network theory, is the social structure that defines the essence of social patterns, such as members within a group and their interactions and associations (Hinde 1976; Whitehead 1997).

These social networks may be observed as communal interaction points between members within the system environment. Additionally, interacting with community

members and developing social network relationships for collaboration and coordination towards mutually beneficial goals will require the consideration of relevant stakeholders. For example, stakeholder theory describes:

- An organization as having numerous stakeholder relationships (Freeman, 1984).
- Regards processes and results of an organization's stakeholder relationships.
- States that all stakeholder interest holds merit, but none should be viewed as more significant than another (Clarkson, 1995; Donaldson & Preston, 1995.)
- And the decision-making of management is a particular focus (Donaldson & Preston, 1995).

A CC is responsible for decision-making and underlying processes that affect participating parties and human-relationships. The CC must consider stakeholder interest and work towards developing an alignment between multiple participating parties.

3 Methodology

Reflective practices are a type of research that involves reflective thinking during and/or after an action. It includes the practitioner of processes as a means to observe their performance and develop subjective awareness, as a means for constructive development, or to discover unique perspectives and approaches for such processes. Reflective practice is thought to be in alignment with the concept of continuous learning. A subject of concern is how to make reflective practice occur intentionally, as it may happen on an unconscious level. While recognizing effective processes of reflective practice is an area of interest in the literature. A lack of structured methodology or framework is some of the criticisms of reflective practices. To this, reflective practice can be complemented with the structured framework of action research, thus connecting reflecting with acting and theorizing. Action research is known for using the following methods: creating autobiographies, memos, journaling, recording, and storytelling. These methods can be used as a tool for reflection. The opportunity for collaborative action also increases the chances to generate critical reflection (Coghlan & Brydon-Miller, 2014.)

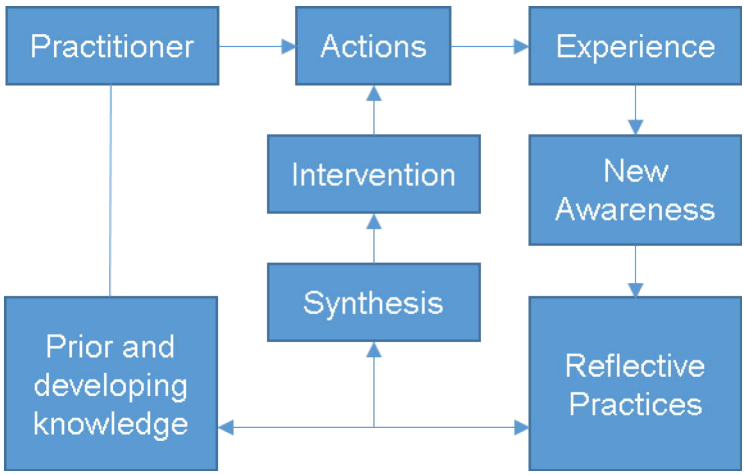

Figure 1. The action research & reflective practices feedback loop.

3.1 Reflective Practices

The following are key reflection practices used in the study.

3.1.1 Journaling

Journaling is a tool that is used as reflection papers to encourage learning through facilitating greater awareness of one's beliefs, values, and work, and also their other relations (Billings, 2006).

3.1.2 Visualizations

Mind mapping

According to the article *Social Work Students' Thoughts on Self-Reflection: A Qualitative Study Based on Reflective Journaling* by Toros & Medar (2015), out of 39 Estonian undergraduate social work students participated in a study on reflective learning. The findings were that journaling and mind mapping were the top practices for self-reflection. The students attributed the visual nature of the mind map and the ability to structure knowledge.

Creating models

Similar to the visual strengths of mind mapping for self-reflection, creating models in another way to visualize and structure knowledge for self-reflection of the researcher's thoughts, ideas, and of my experiences. This will be used to describe the researchers experience as a CC with the intention of developing meta-level knowledge of the CC position as a universal theory.

3.1.3 Reflective discussion and dialogs

In the article *An Approach to Analyzing the Role and Structure of Reflective Dialogue* by Katz, O'Donnell, & Kay (2000), they developed an approach to analyse educational dialogue. They found that problem solving combined with post-practice reflective discussions were likely to resolve misconceptions than from problem solving alone. There results were that including reflective activities supported teaching conceptual knowledge that strategic tasks were founded upon. This study will use reflective dialogues and discussion with the researchers and their supervisor pre and post CC activity, planning, and theoretical knowledge development to enhance reflective learning and also create an action research feedback loop.

3.1.4 Developmental iterations of created content

Created content such as the mind maps and models will go through stages of progression in knowledge from draft to revised forms based on reflective practices such as discussion and dialog with the researcher and supervisor.

3.1.5 Cognitive priming

In the study done by Sparking Creativity: Improving Electronic Brainstorming with Individual Cognitive Priming by Dennis, Minas & Bhagwatwar (2013), they explore the phenomena of cognitive priming. They explained that human behaviour is influenced on a subconscious level and can be influenced through priming with the use of content aimed to be implanted on a subconscious level an idea that in the working memory could alter behaviour. In their study, when participants played a game that was used to prime their minds to improve their generation of ideas and creativity for brainstorming. The results found that those primed with the showed a significant enhancement in idea generation and creativity compared to neutral primed participants. In a similar way, and as a supplement to the researcher's reflective practices, the researcher had also used a wide variety of relevant literature as a means for cognitive priming to enhance the outcome of the action research and reflective practices.

3.1.6 Meditational practices

Through the use of a brain measuring instrument called the electroencephalographic (EEG), studies on Zen meditation have found to influence many brain regions, and are able to increase certain brain waves such as alpha and theta, these are associated with relaxation (Chiesa, 2009). In the article *Applied Research Using Alpha/Theta Training for Enhancing Creativity and Well-Being* by Boynton (2001), a study was used to investigate EEG biofeedback of intentional hypnagogia to enhance creativity and wellbeing. Hypnagogia is a state of primarily alpha and theta brain wave activity. In this study's results it was found that participant's flexibility in thinking had a significant increase ($p<.001$) and in addition to wellbeing ($p = .002$). For this study meditation practices such as focused breathing, were used with the aim to produce alpha and theta brainwaves in an attempt to create a brain state that might enhance self-reflection.

4 CC Meta-Level Thinking

This section describes the results of the action research and reflective practices approach to exploring the CC position by the development of the researcher's meta-level understanding presented through the use of constructed models.

4.1 The Core Principles of a CC

A result of this action research process using reflective practices was the development of the CC theory and explanatory models. To explain what CC theory is, it is important to understand the core principles of a CC. Figure 2 depicts the CC core principles. The CC can use the three main principles of "Relate, Organize, & Coordinate" and their linking principles "Collaborate, Develop, & Facilitate" to bring the primary alignment of "People, Resources, & Goals" together.

Figure 2. The Core Principles of a CC.

The CC needs to identify challenges or opportunity's that hold a common theme aligning with the needs of their community, or even multiple communities. Next, the CC needs to use this theme to find what connections could exist between people, resources, and goals. To develop a solution or innovation, people's competencies and social resources, as well as tangible and non-tangible resources, are also required. To access people and resources towards goals, the benefits of the collaboration should be in alignment with the needs of the parties involved. It is up to the CC to relate people, resources, and goals of involved parties and

develop interlinking relationships. The CC must develop relationships between involved parties to organize people and resources. This requires the CC to coordinate interested parties and facilitate their collaboration toward developing plans and objectives to reach an overarching theme and mutually beneficial goals toward solutions or innovations. This is created through the enabling of access to the resources between parties and the use of people's competencies and social networks to achieve such goals.

4.1.1 Primary Alignment: People, Resources, & Goals

People, resources, and goals are the primary alignment outcome of the CC. In a successful community coordination effort, the CC has developed the relationships between these three elements. People and resources may be dispersed within or between communities. It is the CC's responsibility to align the efforts and expertise of people, along with their access to diverse resources, into a collaborative effort toward achieving a common goal. A goal which meets the needs of the various involved parties, that supports the sustainability and development of the community and enhances value to its members.

4.1.2 Relate, Organize, & Coordinate

Relate has two similar meanings, to develop a relationship, and the discovery or display of the links between multiple things (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). The CC needs to find and develop the relationships between people, resources, and community goals.

Organize has two similar meanings, it is the planning of things to occur, and the formation into a holistic harmony (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). The CC is in charge of developing a master plan and to form the various involved parties' actions into a well-functioning holistic effort. The CC is developing a new entity by joining multiple parties into a harmonizing initiative.

Coordinate means to create holistic developments and actions of multiple different things (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). The CC has the objective to combine the relationships of people and resources into coordinated developments and actions harmoniously between multiple involved parties.

4.1.3 Collaborate, Develop, & Facilitate

To active the three main principles, the CC must use the three linking principles facilitate, develop, and collaborate to reach alignment of people, resources, and goals.

Collaborate means to cooperate towards a common purpose by working jointly with a single person or multiple peoples and/or groups (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). It is the objective of the CC to use relations between people, resources, and goals, to coordinate collaboration.

Develop means to promote somethings evolution, or to increase somethings clarity with details (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). It is the CC's objective to develop the relations and organization between people, resources, and goals.

Facilitate means to support the ease of making a thing possible (Cambridge Dictionary, 2020; Merriam-Webster Dictionary, 2020). The CC needs to make the organization and coordination efforts of involved parties as easy to increase the chances of actualizing the alignment of people, resources, and goals.

4.2 The Realms and Dimensions of a Community Coordinator

The Community Coordinator (CC) is a dynamic element. A CC works at the convergence between the community and its members (see figure 3). A CC acts on relationships, within environments, and through operations, to support functions that align community members toward achieving a mutual goal. These realms contain dimensions the CC must act within. These dimensions are social, networks, systems, processes, communication, and interaction. A community lives in an environment, which is the foundation that enables members to assemble. Community members survive by growing complex networks through social behaviours to produce beneficial relationships. Interactions can support and work through social networks which enables the cycling of resources essential to the development and sustainability of the community. Interactions occur through actions which become more highly ordered when coordinated by members and pro-

cesses with communication. The communications occur organically for social interaction purposes to build and maintain relationships. Communication also occurs to develop and maintain operations through structured system processes. The function of communication is to interact within the environment that satisfies relationships and operations. The purpose of a CC is to achieve a higher order of coordination between community members to assist in the development and sustainability of a community.

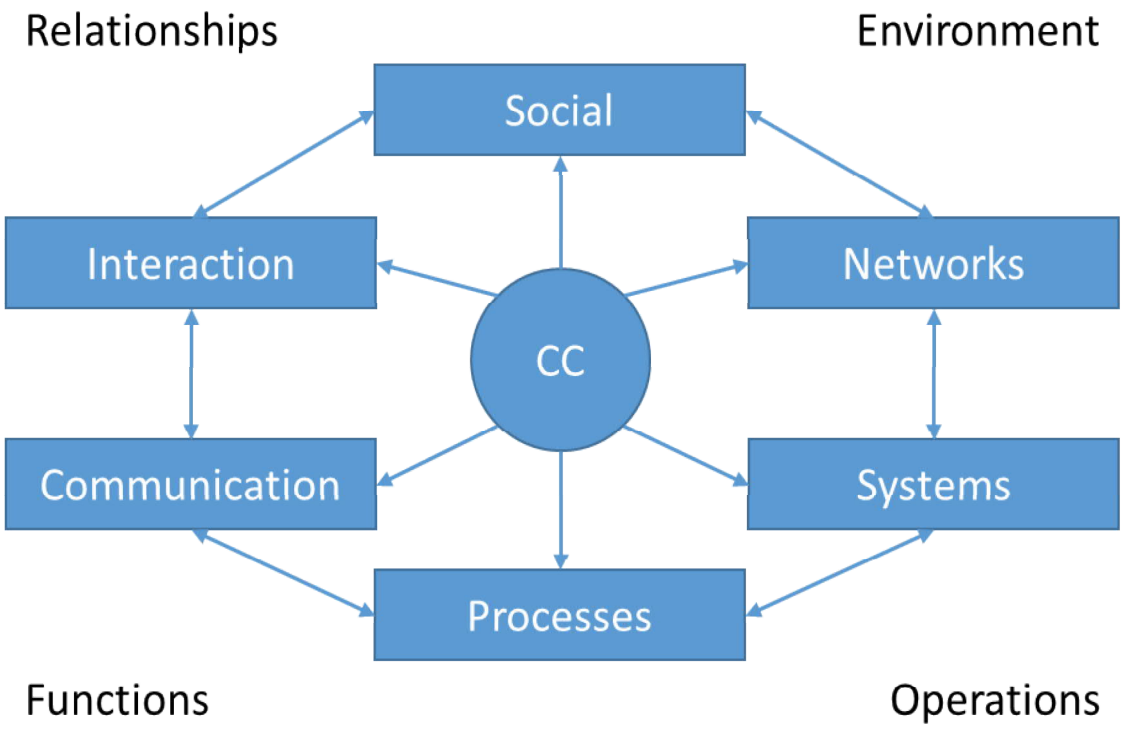

Figure 3. The Realms and Dimensions of a Community Coordinator.

4.3 The Relationship and Alliance Hierarchy

A core function of the CC is to develop human relationships (see figure 4). The relationship and alliance hierarchy represents the stages of relationship development. Relationships are needed for healthy partnerships. At the foundation of a relationship are trust and respect. In psychology, trust is a basis for relationships among adults. Trust is related to the confidence and dependability that people have between each other. A person's predictability also supports the trust they receive. Respect is also said to play an important role in relationships by supporting communication. Respect is the display of honourable interactions regarding another (APA. 2020.)

As a CC, building trust and respect is the first level of relationship development. Trust and respect are minimal requirements for developing a healthy relationship and alliance with people. Through these elements, the CC is more easily able to move up the relationship development pyramid into cooperation. Cooperation is more available at this stage. Cooperation will develop over time through interactions. During this relationship process, the outcome is to develop an ally to reach a goal. Each level of the relationship and alliance hierarchy must be maintained to reach the next level of relationship development. This means, to reach the next level of responsibility, trust and respect must be sustained, at the same time cooperation must be fostered. When trust, respect, and cooperation are satisfied, a potential ally will become more available to take up responsibility. As a CC, trust and respect will continuously be challenged throughout the relationship development. For example, actions the CC must take to align the relationship toward a mutual goal, such as preparation and consideration for a meeting will act to demonstrates the CC's competencies to organize and handle the challenges of a project. This will either support or diminish trust, respect, and a person's willingness to cooperate and take on responsibility.

Building a professional relationship to reach a goal requires a significant effort on the CC's part. When a CC can demonstrate that they are worthy of continuous trust, respect, and cooperation, the person will be ready to move up the relationship and alliance hierarchy to take on the responsibility themselves toward a common goal. At the stage that responsibility is held within the relationship, collaboration can begin. Collaboration happens when those within the relationship are ready to work together towards a common goal. This leads to alignment when those within the relationship are collaborating towards a common goal, sharing responsibility, cooperating, with an underlying sense of respect and trust for the best interests of each other. While there are key people in projects that the CC will need to achieve alignment with, there will be people that require only gaining cooperation. Reaching cooperation in the relationship and alliance hierarchy may only require a short-term relationship while reaching alignment is a long-term relationship investment that requires attention to foster and sustain. Developing allies is key to a project's success and requires human relationship competencies. Developing human relationship competencies is key to the CC position.

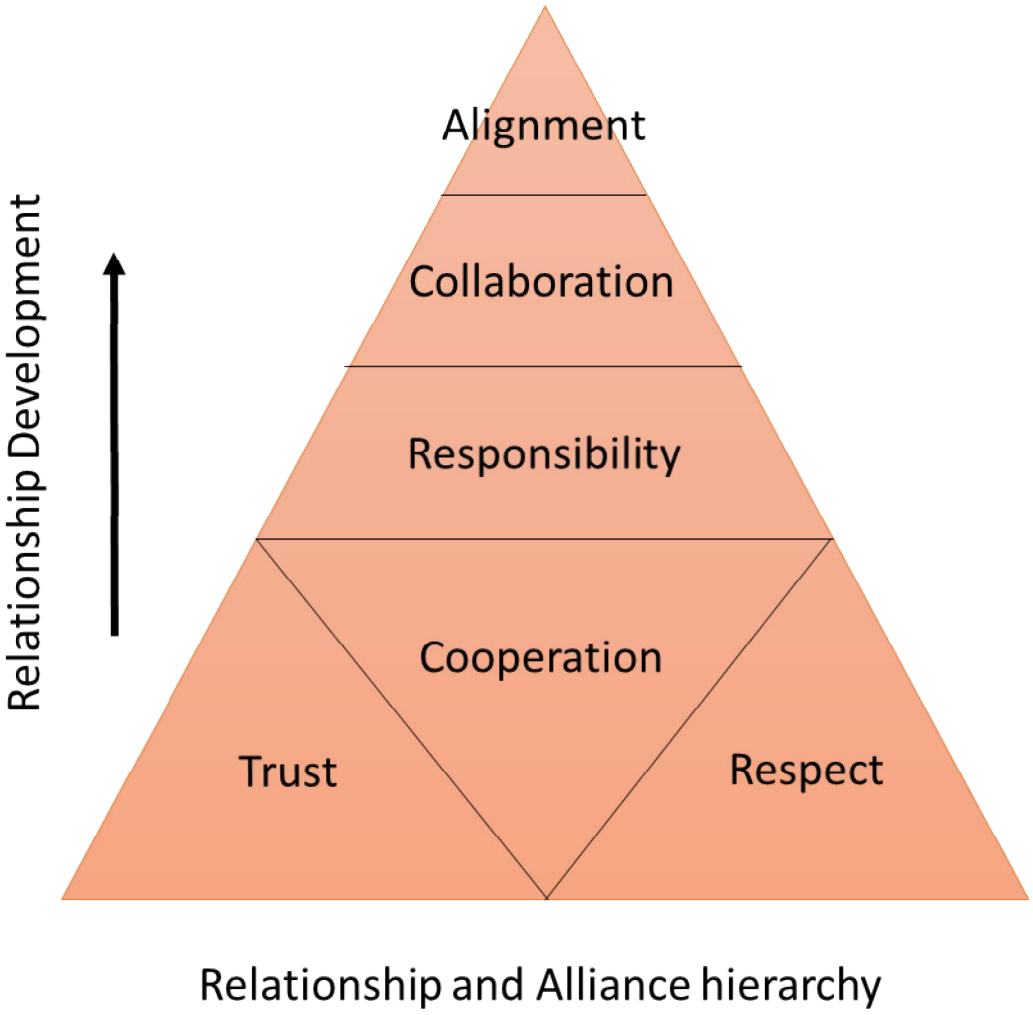

Figure 4. The Relationship and Alliance Hierarchy.

4.4 Bridging the Community Gap

A community can be viewed as both a system and a social network. From the systems perspective, a community can contain numerous sub-communities. For example, if a university is considered the primary community, then the various departments, would be considered its sub-communities. They together make up a whole, but individually, each sub-community has its purpose. For example, in figure 5, let's say that community A and B represent two distant departments. In systems terminology, they are loosely coupled, due to the community gap, although, they have a weak connection through being a part of the whole, that is the university. To connect these two distant sub-communities, A & B, they require an interface, this is where the CC comes in to bridge the gap between these two loosely coupled communities, making node C a point of tighter coupling. Addi-

tionally, a community functions to develop and sustain itself. Linking these communities through the CC requires a greater purpose to satisfy the inter-community collaboration. This greater purpose is a mutually beneficial goal, that to reach requires the actions and resources of each other.

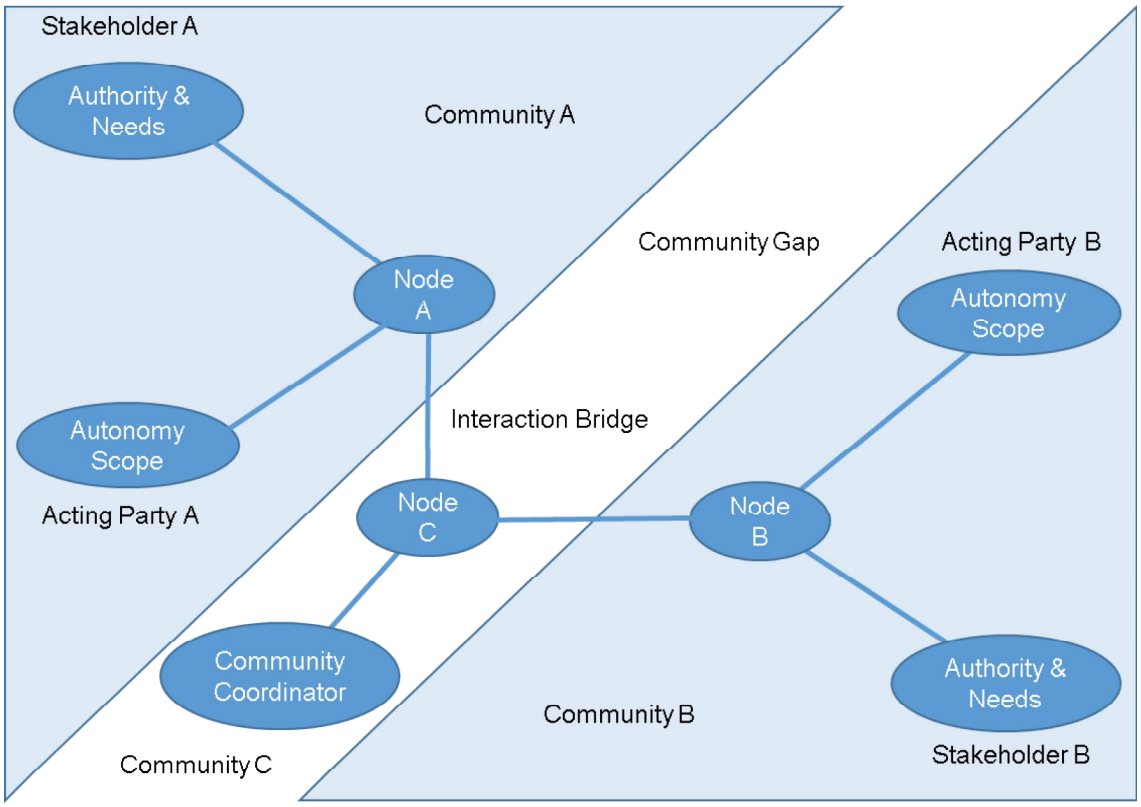

Figure 5. Bridging the Community Gap.

From a social network perspective, each community is built on its social networks between members. In figure 5, interaction points are depicted as nodes, A, B, & C. Intra-community nodes are A and B. While inter-community nodes may occur emergently, they may be a weaker link than is with the intra-community nodes due to the community gap. The community gap represents any barriers to interaction between communities A and B. For this reason, the CC acts as an inter-community bridge for interaction by creating node C.

When a systems perspective is over-laid with a social network perspective, these communities come to life as complex and dynamic organisms, with the core purpose to develop and sustain themselves. In nature, symbiotic relationships are

known to occur between lifeforms that depend on one another to accomplish mutual survival-related goals. Between communities, these relationships can also occur, or be developed. A CC's job is to facilitate this symbiosis.

If a community were to be viewed as an organism, it would have numerous functional parts to perform its object of growth or its development, and survival or its sustainability. For example, a community's stakeholders serve as the executive function, as the brain of an organism, and are responsible for decision-making and setting the community's objective. The CC's function is to find connections to these stakeholders and develop goals that are mutually beneficial to the community's objectives. The community stakeholders have their community interests as a priority, as well, they have the authority to make decisions that affect community activities. It is wise for a CC to seek an understanding of these needs. In this way, the CC can build a better alignment with project goals and stakeholder needs.

Also, a community has its acting parties, these are not completely exclusive from stakeholders, but their decision powers fall under the framework of the top decision-maker’s policies. An acting party is like the legs and arms of an organism and gives the organism the ability to perform actions. Acting parties are the people in a community that will be taking actions within a community to perform their functions. As a CC, identifying and building relationships with acting parties is necessary for implementing projects actions. Acting parties are limited to the scope of their organization's mission and policies. Additionally, they need to be empowered within their scope to achieve their objectives. The autonomy of an acting party is important to respect, as it gives them a sense of ownership over their actions. As CC, making connections and building relationships in a community with their stakeholders and actors is necessary towards reaching dispersed expertise and resources needed to actualise an objective. Also as a CC, such as in Figure 5, will be bridging the gap between communities so that that may take collective and coordinated actions that are in alignment with achieving a greater mutually beneficial goal.

4.5 The CC Visibility Field

In figure 6, the CC is the central figure, surrounding is the visibility field and its content: A, B, C, & D which represent contact persons from each group. The CC

must discover a contact person within each group to uncover each group's available resources. Resources are represented as puzzle pieces because each group's resources could become connected to another groups resources. Resources are both assets and expenses. For this reason, each group has focused on some development of specific resources and excluded others due to their focus scope and/or the constraint of costs.

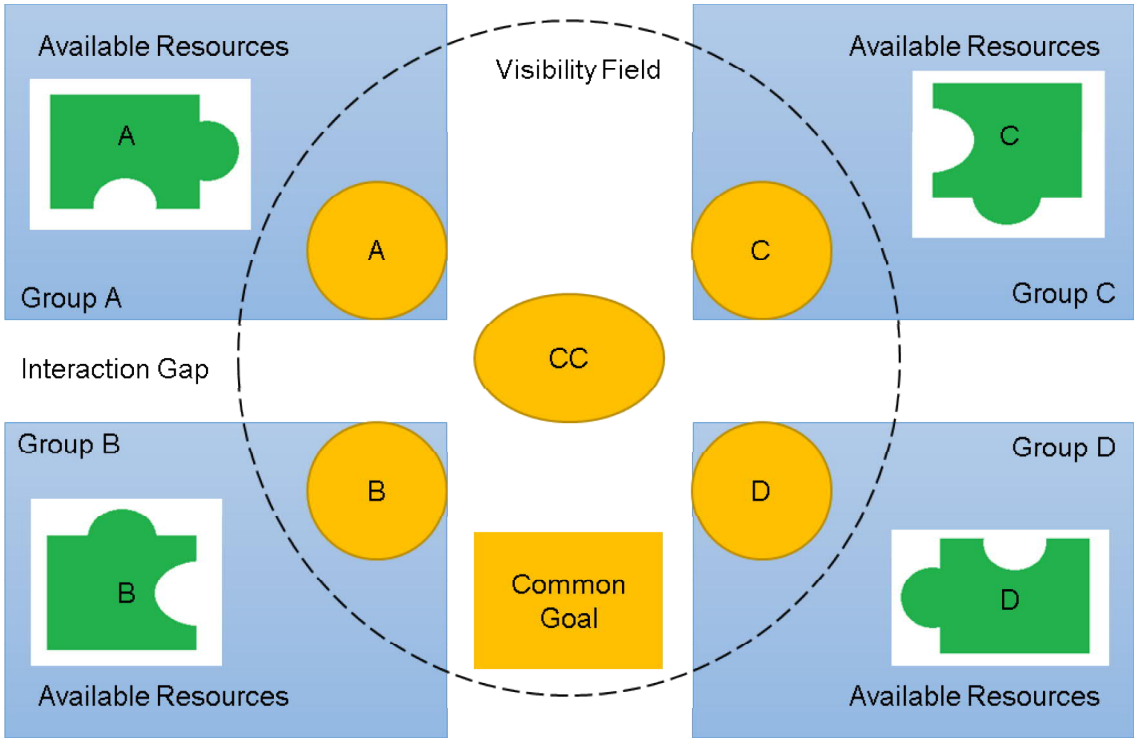

Figure 6. The CC Visibility field.

When a common goal is discovered between the groups, to bridge the interaction gap and the constraints of resources, the CC can facilitate awareness of the opportunity to each group. This requires the discovery of a contact person from each group while using this contact to link back to available resources and additional contacts such as a decision making stakeholder being one of them, although they may not be the first contacted, only those within the visible field can be contacted directly, and through their links back into their own groups resources the CC's field of vision is supplemented. A process will then take place in identifying and unifying compatible goals between the groups.

4.6 The CC Journey, Seeking a Contact.

Figure 7 depicts the systems view of the CC's journey for seeking a contact person. A contact person is important because they are a community systems access point. Through the contact person, important collaboration opportunities exist, such as an access point to the community network and resources. Through the CC journey, the CC will first need to enter the system environment where the CC will encounter gates. Gates restrict further entry until their requirements have been satisfied. This could be, for example, needed information, such as the qualifying contact credentials and directions. Once the gate requirements have been satisfied, the CC will continue the journey towards finding a suitable contact. The CC must find the right place for contact, this could be physical or digital. Finding the right place is not enough, the timing also has to be right, otherwise, another gate requirement in time will have to be satisfied. When these two qualities are in alignment, the system environment's emergent opportunities will become accessible. For example, this may come in the form of a potential ally along the way, such as a helpful person. The helpful person may deliver you right to the qualified contact person or through a series of gates requirements, which they may assist you through. Otherwise, the emergent opportunities could lead the CC directly to the contact person, or directly through the potential ally. In these system environments actively seeking information and the contact person by the CC is a necessary function of the CC throughout their journey.

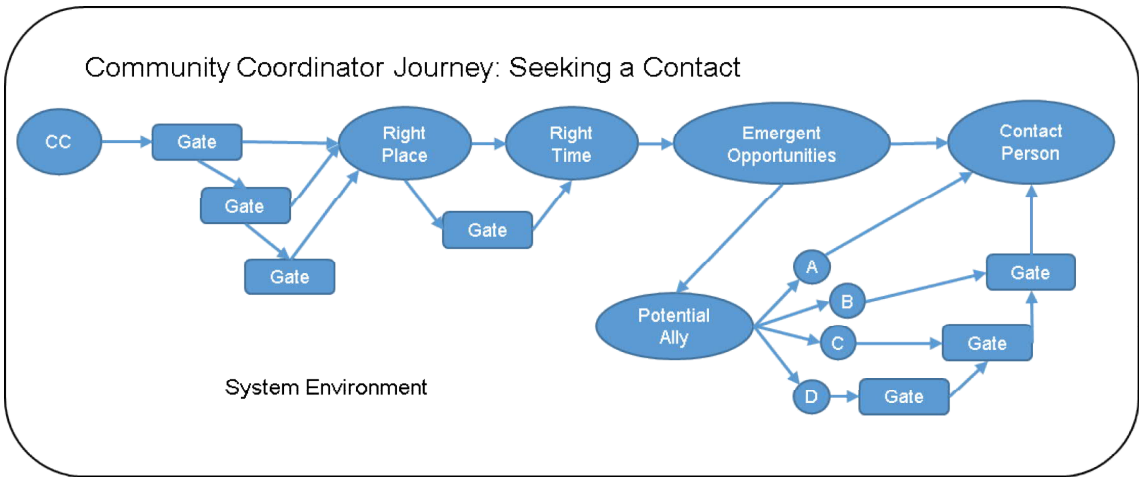

Figure 7. The CC Journey, Seeking a Contact.

4.7 The CC and the Collaboration Life Cycle

The collaboration of people towards a common goal has a life of its own in the collaboration life cycle (see figure 8). Similar to lifeforms, collaboration has its life phases: incubation, birth, growth periods, and life transitions. The CC plays a special role in fostering the collaboration life cycle by facilitating situations and actions that promote its evolution. In the incubation phase, a common goal and initial project proposal that could be mutually beneficial to multiple parties are conceived. The CC enters the collaboration life cycle, whether emergent or assigned by a higher order, with this background information. The next step comes from the CC intentionally seeking to develop a coordination effort. This includes actions such as research, organizing a logical order of the information to present to potential partner parties, and seeking out these parties with a project proposal and collaboration invitation. This occurs by discovering a contact person and making contact.

The developmental phase begins when a collaboration invitation is accepted by interested parties. This phase is about building enough trust and respect with interested parties that they are willing to continue and increase their scope of cooperation from not only the CC but to other interested parties. In the birth phase, the initial group is formed, and there is a general acceptance of the project, as well, there is a continued interest in continued cooperation to the next phase of the collaboration life cycle. The growth phase of the project begins with a minimal amount of responsibility and collaboration among the project group. Through the coordination effort of the CC, a meeting time and place are arranged among participating parties. Coordination occurs when this group of participating parties and the CC move to a common interaction location. At this meeting place, increased collaboration occurs through the collaboration process facilitated by the CC between the participating parties. This collaborative process consists of a set of key topic areas to explore, and an ideation process that develops the project definition and common understanding of all parties. From each topic area that is explored, awareness and ideas will emerge. It is the CC's responsibility to note and organize this information. As each input should be aimed at creating a more refined and developed output, which should also be used through further developmental feedback loops. These meetings are important to build further

clarity of the project scope and objectives, which supports the alignment of participating parties towards a common goal. As well as to support increased trust and respect within the group to lead to the participating parties taking on more responsibility for the project, which enables further collaboration.

The coordinated meeting of the project group leads to a new awareness as an outcome of the collaboration process. This output of group meetings results in a project package, clarifying participating parties' roles, responsibilities, and objectives. As well, a project plan must be defined to reach these objectives and the overall goal. This project package will lead to the implementation of the project plan in the form of actions by the CC and participating parties towards reaching their objectives and reaching the overall goal. Implemented actions will lead to project outcomes. This is a form of feedback that will indicate future actions to take to align the collaborating parties towards the overall goal. With these feedbacks, the project will reach a developmental cycle. This is a feedback loop of the in the collaboration life cycle, of reflecting, planning, implementing, and revaluating the results. This is a process the CC will guide and facilitate.

When the project group have reached their primary objective, the collaboration life cycle will reach a life transition phase. In this phase, the project may be closed. Although, the project can be rebirthed and go through a transition phase. In this phase, a new project proposal will be created, and group members or the CC

may change. From there, the project is rebirthed and the collaboration life cycle continues once more.

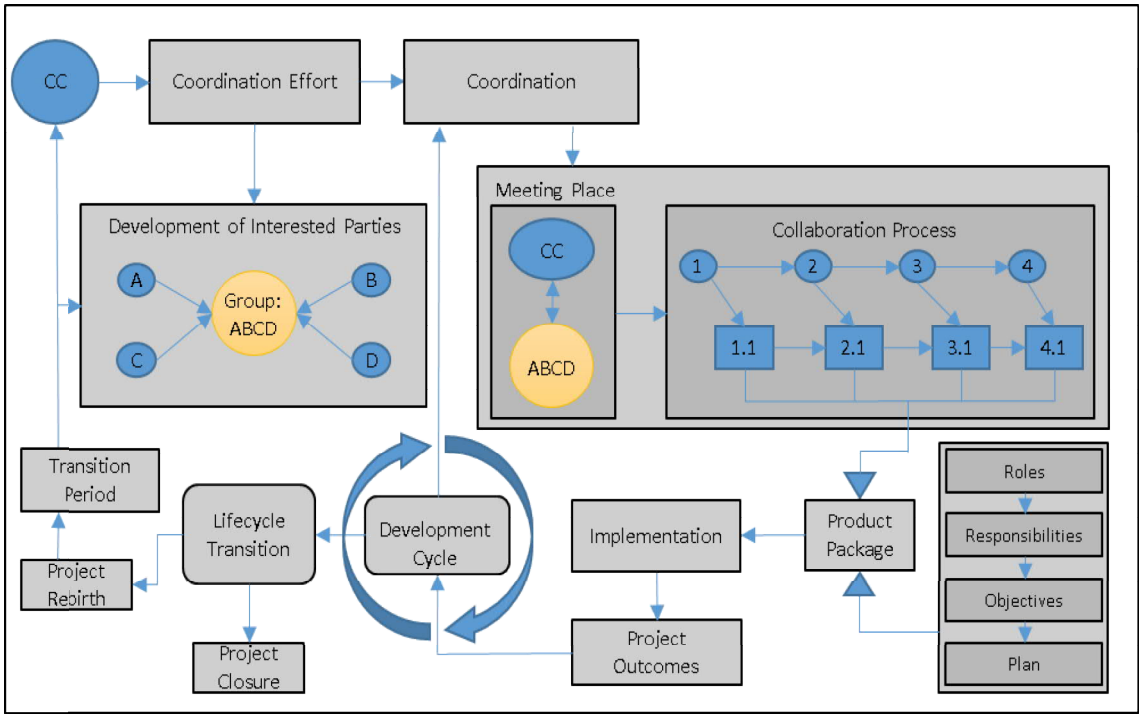

Figure 8. The CC and the collaboration life cycle.

4.8 A Path Towards Strategic Alignment

An essential aspect of the CC position is activating interested parties towards strategic alignment, as depicted in Figure 9. On the Y-axis, the higher up, the more orderly the operation must be implemented, while the lower down, the more emergent that characteristics will arise from an operation. On the X-axis, the further left, the more cooperative an effort is, while the further right, the more collaborative the effort becomes. The path to activating interested parties begins on the far left. After qualifying interested parties, the CC must organize them towards a purposeful collaborative effort. Through gaining interested parties cooperation a meeting must take place, this will occur when all parties' schedules align. Planning requires both order and emergent properties, as the CC cannot organize the interested parties' entire schedules around an orderly one favouring the project. Therefore, organizing people for meetings is semi-orderly, and semi-emergent from their availabilities. A CC must be open to opportunity and agile to act upon them to gather interested parties together. Also, a meeting must be open to emergent properties that arise from the process that could benefit the project, while the information for the project must be clear and orderly, from which participants

can build a common understanding. Planning the project will arise from both of these properties. It is the CC's role to organize the structure of gatherings while being open to the direction participants can contribute.

Moving to the right of this diagram is dialogue and workshop. Dialogue is useful in gaining participants expertise and creativity while focusing on a specific progression of topics. The topics are key areas, that will engage participants in discussions that will define the details and scope of the project. Workshops are activities that engage the participant in some kind of discussion and activities. The CC's job is to facilitate meetings to plan and organize future actions, dialogue and workshops are methods to tap into the participants' expertise and creative resources. While dialogue leads to a focused series of discussions, brainstorming is a workshop activity that can lead to creative and emergent solutions. From these meetings, the CC must organize the resulting information into a coherent plan, that both guides toward the primary goal, and is flexible to adjustments along the way. This process has the potential to lead the interested parties into becoming longer-term collaborative parties aligned towards achieving a common goal. Through the ordering of information, people, and processes, while also facilitating cooperation, the CC can guide interested parties toward taking goal-related actions.

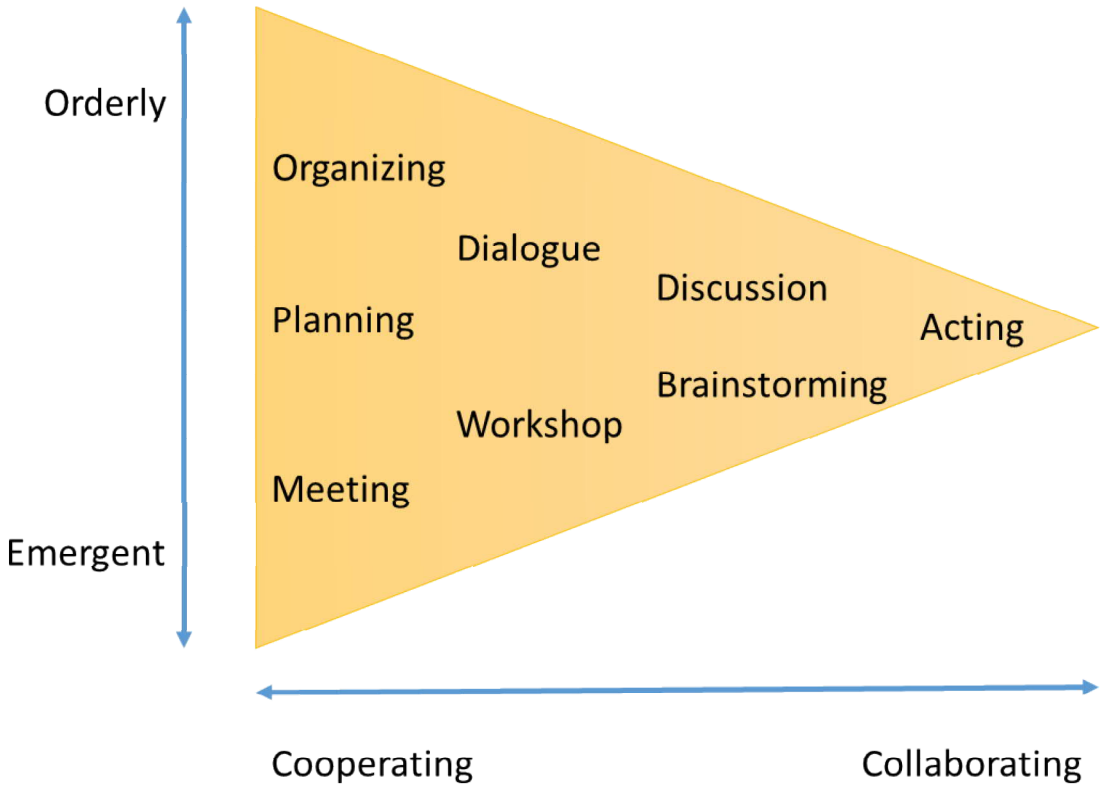

Figure 9. A path towards strategic alignment.

5 CC Practicalities

This section presents the synthesis of the researcher's experience through familiarity with the body of relevant literature on the subject and through the action research and reflective practices. The resulting subsections regard the researcher's thoughts on the competencies of the CC, and also gives suggestions on some tasks, tactics, strategies that a CC may encounter.

5.1 Competencies of a CC

Through this action research experience, and upon the researcher's reflections, the following are recommended competencies for human resources to consider when selecting a job candidate, or training and developing employees for the CC position. As mentioned previously by Jha & Iyer (2006), human relationship skill was the most important skill to seek in developing the project coordinator position. The researcher also affirms those findings through experience as a CC, human relationship skills are a core competency of the CC position. The article *Social Skills: Definition and Examples* listed the following six professional social skills: effective communication, respect, empathy, active listening, conflict resolution, and relationship management. Stating, these skills support to develop and sustain professional interpersonal relationships (Indeed, 2020.)

Organizational skills are another competency the researcher's experience has shown important to the CC position. In the article *Organizational Skills for Your Resume* three types of organizational skills are mentioned, time management, mental and physical organizational skills. Time management supports adaptation challenges while reaching task deadlines, such as scheduling and coordinating people, planning, and strategic thinking. Mental organization skills concern attention to details, information processing, and it's clearly expressing one's thoughts. The physical organization skills regard documentation and the organization of information, and also the coordination of people and resources to perform activities (MacIntosh, 2020.)

The CC position also requires research, analysis, problem-solving, and creative thinking skills. Additionally, facilitation is a skill needed to guide people through the project development process to reach a common goal, such as by hosting, guiding, and leading meetings, and taking care of related considerations to make

the process as easy as possible for the participants. Also, multicultural competency is a useful skill for the CC. Since people are diverse in backgrounds, this ability will assist the CC in navigating a variety of situations with people, giving them a better chance in achieving a positive outcome. Finally, the ability to acquire multiple stakeholder perspectives and understand their needs, while also aligning them towards a common goal. This essential competency requires the ability to explore multiple domains of expertise to gain enough general understanding. This allows the CC to competently interact and support a party's specialized development within the project.

5.2 Tasks, Tactics, and Strategies of a CC

A CC is responsible to align and coordinating multiple parties to achieve a common goal. This process is not a standard formula for all situations but may consist of common tasks, tactics, and strategies. First, the CC must work with their associates if they have any, that is involved in the community coordination project, such as a supervisor or project member. The CC must develop the preliminary project proposal and identify what diverse groups could collaborate their expertise and resources towards reaching this goal. The CC should catalogue a list of potentially interested parties and gather necessary contact information. If there are no known contacts within a group, finding the intermediary options is necessary, to reach an appropriate contact. An intermediary can be any person of an organisation that could point you in the right direction to locating a contact. The project outcome should be considered, and a timeline should be created. This must include major milestones to reach the end goal. At this phase, it does not need to explicitly detail, but give a guide in a general direction. The project timeline should have hard deadlines and soft deadlines. The hard deadlines should be aimed to reach on time as a top priority, while soft deadlines are more flexible to adjust. A weekly agenda needs to be made to schedule daily tasks. This will keep the CC organized and timely. When a task is completed it can be check-off as completed. Through doing tasks, the CC will increase their directional awareness of the project and should continuously update the weekly tasks.

A project folder should be created and include general subfolders that will keep documentation organized as they emerge. It is recommended that there be active and archive folders, for example, a main file for the "preliminary project proposal".

Documents should be catalogued with sensible names for easy retrieval, while draft documents should be labelled by its version number in the document title, such as V1, V2, V3, etc. Each day the CC works on a draft it should be saved as the updated version, such as V1 at its creation, and the following times it is opened to work on it, it should be first saved as V2, and so on. In this way, important information is not lost if one needs to refer to a previous version. Older versions of a document can be filed away in its main folder when it becomes outdated, this way folders stay organized and documents are easy to retrieve. For example, a folder titled "archive" or "old" can be used for this purpose. Title all folders according to their theme and category, while documents by their relevant topic, plus version number, and date. Non-essential files can go into a subfolder within its relevant category folder, for example in a folder for miscellaneous named "misc". In the long-term, files concerning the project will accumulate, and without proper organization, the CC won't be as effective.

The first primary task of the CC is to take the preliminary project proposal, find good-fit collaborators, and begin contacting them. It is good practice for the CC to introduce themselves, and if a relevant person had put the CC in touch with the contact, which the contact is familiar with, that should be mentioned to begin building trust. An email is one way to contact a potential collaborative party, although it is less personal than meeting in person. It is important to begin relations with respect, so the CC should address the candidate by their full name and professional title. If the candidate later responds addressing the CC by the first name, then relation has built enough for the CC to do the same.

If the CC cannot find contact information, or a contact the CC can go to the location of a good-fit organization and explore the environment to find information and people who can help the CC contact an appropriate person. The CC must introduce themselves, explain who they are, whom they are working for, and why they want to contact someone from their organization. At this point, the CC should explain the preliminary proposal and get their feedback. It is helpful for the CC to create and practice a sort of "sales pitch" of the project, in this way advertising the most valuable points to the candidate which will help promote their curiosity. Although this sales pitch does not have to be formally pitched. By practising a sales pitch prior, it will assist the CC in remembering key points to cover so that

they can emerge naturally in the conversation. This type of practice may enhance the CC's communication ability since meeting new people can be stressful for many. Following the meeting in person, the CC should acquire the candidate's contact information, while giving their own.

There needs to be a delicate balance between formal and informal when emailing or meeting with candidates for the first time. For example, regarding the persons with respect and seriousness about the project is important, while adding a few personal touches throughout the interaction can support building human relationships. For example, taking some time to ask how the person is doing on that day can open interaction with a personalized feeling that most people will appreciate. The content of the first contact should consist of communicating a clear enough understanding of the project that they see a logical connection to their organization while leaving enough room that they can help define the details of the project. If the first contact was done through an email, the follow up should be to schedule the first meeting to discuss in person the project. Although this first meeting may simply go back over everything already written in the email, people appreciate a more personal meeting to get to know a person. A physical or virtual meeting will give a face to the person behind the email, and help build trust.

To build awareness of the project needs the CC must ask for the candidate’s initial feedback, for example, the ideas and concerns. This information should be used to develop a clearer understanding of the project, this is a continuous process of the CC, as there will be much domain-specific awareness that will arise through the process. After the first contact, the CC should evaluate the response of the candidate. Did they explicitly or implicitly show interest in further cooperation? Did they show confusion or implicit or explicit disinterest? Reflecting on interactions is the job of the CC, as they are working to build human relationships, they must be introspective and agile to the development of the relationship. The CC should follow up all meetings thanking the person for their time and consideration. For the first contact, this should be within a day or two after the meeting. This helps busy people remember the CC and their project invitation. It is also a chance to build the relationship further, and at the same time, follow up on any important considerations regarding the first contact.

If a candidate has shown as unwilling of further cooperation, an alternative candidate should be discovered, contacted, and met. In the meantime, other interested people should be given a weekly to bi-weekly update on the project status. This will promote the continued interest of the other potential collaborative parties. The first major milestone of the CC's job is after they have met with all candidates for the project who show an interest in further cooperation. At this point, it is important that all interested parties met together and further explore developing the project. With multiple parties, scheduling can be difficult. From the researcher's experience, a democratically chosen meeting date did not work and delayed the project. The CC may want to take the initiative to set a likely date in advance. In the researcher's experience, this strategy had repeated success. However, meeting in person may be inconvenient or not possible for all parties. In this case, virtually meeting can be a reasonable alternative, as compared to further delaying the progress of the project. Even if not all parties can make it to this meeting, this is a good touchpoint to make with the interested parties. Anyone who cannot attend can be assured that it is no problem, and they will be updated with the meeting highlights. The CC can also allow them to suggest the time for the next meeting. The CC should use common sense situational awareness in scheduling meetings, considering holidays, or any other significant indication that a particular day would be an unreasonable date.

For all meetings the CC must plan an agenda. The agenda should cover key topics of the project, while at the same time this should not necessarily be an extended presentation. The CC should consider creating dialogue points and questions to cover. A dialogue will assist in raising awareness in areas about the topic that will help the CC develop a common understanding of the overall project among participants, and also bring to the CCs attention, areas of the project that have not yet been considered. The highlights of the discussions should be noted before they are forgotten. If it is a virtual meeting, and it is accepted by the participants, recording the meeting can be a helpful tool in reflecting on everything that had been covered.

The first meeting should aim towards gaining enough information to make a clearer project proposal. The main project goals should be discussed and the

major milestones between interested parties should be explored. Asking questions to the participants helps them engage and feel empowered about the project creation. If the project requires a more creative solution, brainstorming or design thinking type processes could be used to develop solutions. The CC may find that this type of activity would be useful in the following meeting. The goal of the meeting is to build human relationships between the interested parties and the CC, aiming for their long-term interest in collaborating, and reaching alignment and direction towards the primary mutual goal.

For the first meeting, the CC should start the meeting off somewhat informal, first asking how everyone is. After this, everyone should be encouraged to introduce themselves to each other briefly. These steps can support building human relationships. The CC then should restate the general information concerning the preliminary project proposal. After which, the CC can give an overview of the topics that will be discussed. The CC must promote everyone's opportunity to the participant by encouraging them to speak up when they need to, and asking them to listen and wait for their turn to talk while others are speaking. This encourages respect among participants. The CC should not dominate the conversation yet guide and facilitate it in a productive direction. The CC needs to display listening skills and demonstrate they are listening and considering participant’s thoughts. As a CC, a continuous goal is to encourage the interested parties to become active in developing the project. Conflict resolution is also an important CC competency, the CC must be proactive to avoid unnecessary or unproductive conflict, although debate should be encouraged respectfully. Conflict resolution also requires the CC to be empathetic to the participant and stakeholders needs, this requires some thought to consider the situation from their perspective. Being able to hold different perspectives will assist the CC to build collaborative relationships among involved parties.

Meetings will need to be scheduled often enough to keep interested parties committed to continuous involvement in the development of the project. As well, meetings should be used as a tool for the development of the project by exploring key topics, problem-solving, updating on everyone's progress, and planning of future actions. Aside from meetings, communication hubs are a helpful tool for agile

project development. Applications such as Teams can be used to create a communication and information hub. Teams is a software application, which the CC can create a group channel for the project. In the Teams application, content can be posted, files uploaded and stored in folded, and virtual meetings can be scheduled and held. Software like this puts group members in touch with each other outside of email and meetings. Other applications the research has found useful for centralizing information and communication are WhatsApp, a phone application for creating chat groups, in which messages, pictures, audio, videos, and files can be shared in real time. Also for collaborative group work on documents Google Doc or OneDrive have worked well for the researching in previous experience. With these applications groups can collaborate on word documents, presentations, spreadsheets, and creating surveys, and also folders can be created and the files. These are computer applications that works in real-time on the internet. This could be an advantage for project progress and member engagement.

The CC's job is to support the collaboration of parties to reach a primary mutually beneficial goal. The CC facilitates cooperation, supports collaboration, and guides coordination. The CC is like a central processing unit of a project group, with the continuous objective to ease the workload of the participating parties. One reason that was mentioned, for why people did not pursue multidisciplinary projects was that there was too much workload (Mendelson 2006). This is the reason for the CC position, to open up opportunities between diverse groups of people to activate their expertise and resources towards a mutually beneficial goal. For this reason, a CC must find practical ways to reduce their relations workload. This can happen by the CC taking responsibility for many tasks to reduce their relations workload, such as preparing, advertising, and organizing the storage of important documents; organizing meetings and events, and any other task that can be reasonably outsourced to the CC. The CC must free up collaborating parties to focus on tasks that involve their area of expertise and coordinate their actions with one another in alignment to the primary goal.

6 Discussion

A community's resilience depends on its capacity to adapt to change, resilience and community capacity consider resources inherent to a community and the use of its resources essential in satisfying the needs of the community (Magis, 2010). For this purpose, the role of CC is a viable means to activate the community's potential. This research aimed to answer the following questions:

1. What are the meta-models of the CC position?
2. What competencies would human resources need to focus on, to train and develop an employee for the position of CC?

In regards to the first research question, through using action research combined with reflective practices, the researcher was able to identify and develop 8 models:

1. The Core Principles of a CC.
2. The Realms and Dimensions of a CC.
3. The Relationship and Alliance Hierarchy.
4. Bridging the Community Gap.
5. The CC Visibility field.
6. The CC Journey, Seeking a Contact.
7. The CC and the collaboration life cycle.
8. A path towards strategic alignment.

These models were an effort to explain the CC position from a meta-perspective.

6.1 The Core Principles of a CC

The first model, 'The Core Principles of a CC', developed an underlying philosophy of the CC's role. This philosophy encompasses and connects the CC with a sense of purpose to strive towards, the alignment of people, resources, and goals, to achieve a greater unified effort towards a mutually beneficial overarching goal. This philosophy is important for the CC, so they can develop a universal perspective on the CC position, to guide their thinking and actions as a CC. It is in the researcher's consideration, that this type of philosophy could also have

further-reaching implications beyond the scope of the CC position, as a unifying of people towards prosperity philosophy.

6.2 The Realms and Dimensions of a CC

The second model, 'The Realms and Dimensions of a CC', it explains the CC's convergence between the community and its members. This is useful for a CC to understand because it offers an overarching perspective of the realms and dimensions in which the CC will be acting within a community. This awareness offers areas in which a CC can perform the CC philosophy.

6.3 The Relationship and Alliance Hierarchy

The third model, 'The Relationship and Alliance Hierarchy', is a relationship development map. This is useful for a CC in understanding the path to developing relationships that align with the primary goal among multiple parties.

6.4 Bridging the Community Gap

The fourth model, 'Bridging the Community Gap' depicted a perspective in which the CC could view a community, as both a system, a social network, and together, see a community similar to an organism. This is important because it gives the CC a dynamic perspective of a community. It also further defines the CC's role, as developing bridges between people, connecting dispersed expertise and resources, building multidisciplinary collaboration, and aligning parties towards a mutually beneficial goal.

6.5 The CC Visibility field

The fifth model, 'The CC Visibility field' demonstrate that the CC is a limited field of awareness, and therefore needs to network with available people within the visibility field to access opportunities. Also, this displays the idea that groups have various resources, and to achieve a greater goal, they can put these resources together, like puzzle pieces. This infers, that the CC's job is to find good-fit groups with complementary resources and expertise to overcome limitations and reach greater goals than they would separately. At the same time, the expertise and resources may be hidden from the CC's awareness, and the must operating with what is already available in their visibility field, to reach back further and identify

opportunities. This is important for the CC to become aware of their visibility field and identify areas in which they need to extend their visibility.

6.6 The CC Journey, Seeking a Contact

The sixth model, 'The CC Journey, Seeking a Contact' is building on the previous model of the visibility field, in this case, it is the journey the CC may go through to seek contact. This is helpful to the CC to be aware that reaching a contact is a process and requires the CC passing through various challenges to reaching the contact person. With this knowledge, a CC can expect that sometimes seeking a contact person will require more exploration and discovery, such as physically going to a likely location and trying to find information and guidance that would clue the CC in the right direction. Also, the CC must realize, this process also has to do with emergent properties of an environment, such as the people and information available, and that such dynamic characteristics of the environment are also time-dependent. With this mind-set, the CC can plan appropriately for the best chance of success.

6.7 The CC and the collaboration life cycle

The seventh model, 'The CC and the collaboration life cycle' explains the life stages of a collaborative project. This knowledge gives the CC a roadmap to plan and help the CC understand what stage of the project they are in, what the next steps and process are, and what important outcomes should be produced.

6.8 A path towards strategic alignment

The eighth model, 'A path towards strategic alignment', is to a guide that a CC can use to build strategic alignment with partners. This model gives the CC an overview of taking interested parties from simply cooperating to collaborating towards a mutually beneficial primary goal. This also brings the CC's awareness that certain aspects of the process require more orderly development, while other aspects will have more emergent properties to be aware of. This guide can be developed into steps that the CC's can adjust to their particular project requirements. The outcome of this is to guide involved parties to participate in developing and taking strategically aligned actions.

6.9 CC Competencies and Activities

In regards to the second research question, through using action research combined with reflective practices, the competencies of the CC position for training and development have been explored. The primary competencies of a CC were found to be human relationship skills including communication, active listening, conflict resolution, and relationship management, as well as social skills respect, empathy, and multicultural competency. The CC also needs organizational skills such as time management, as well as mental and physical organizational skills. Also, research, analysis, problem-solving, and creative thinking skills are important for the CC position. The ability to gain multiple stakeholder perspectives for decision-making is another competency that the CC will benefit from.

6.10 Significance, Limitations, and Further Research Recommendations

The importance of identifying these areas of competency for the CC position is that it gives direction for the training and development for the position. From this training and development strategies can be developed from. This research is significant because, currently, the researcher has not identified any publications concerning a unified "Community Coordinator Theory". The results of this research support further building of the community coordinator theory.

The limitations of these findings are due to being based on a limited research study, and that action research and reflective practices can bias the results to the researcher's perspective. Although this research does open the door to building the community coordinator theory, such findings should be followed up and validated by additional research. Additionally, the lack of experience in the CC position of the researcher could also be a limitation.

The researcher recommends that this research be followed up with qualitative and quantitative research to validate these research findings, identify gaps, improve the current CC models, and develop new CC models. Additionally, multidisciplinary teams of experienced CC's should work together to identify and improve the CC's working methods and develop a practical training guide.

7 Conclusion

Communities across the world risk losing out on precious opportunities due to the community gap between organizations and their dispersed expertise and resources. For a community to develop and sustain itself, it must become effective with its resource usage. Creative resource usage must compensate for its scarcity. This becomes possible when different groups of people with complementary resources and expertise compensate for each other's deficiency and collaborate to reach a common goal. Although, many obstacles are preventing this phenomenon from emerging naturally. The extra hours it takes to coordinate people, the uncertainty of appreciation and reward for one's effort, and the additional workload that a dedicated person must take on to ensure progress and success are too much for most people. Thus, many opportunities are lost because is much safer not to try at all. However, this could all be avoided if communities were to adopt a specialized position dedicated to removing such barriers and tapping into the vast possibility that multidisciplinary collaboration could bring. The benefit that this position could bring could offer much more benefit than it may cost. This position is the community coordinator (CC). The CC enables opportunities between multiple parties by tapping into and connecting valuable resources and expertise to reach an overarching goal that is mutually beneficial to all parties involved. The CC removes the barriers that have traditionally prevented collaboration to happen. The CC facilitates the whole process while giving the experts more time to focus on their expertise. The CC is a position that requires the training and development of multiple competencies and is a field worthy of development in its own right. It is recommended communities invest in developing the community coordinator position. The advancement of the community coordinator position is a step towards enabling opportunities to more effectively utilise a community's capacity while together increasing its resilience.

8 References:

Akram, A., Allan, R., & Rana, O., 2005. Virtual Communities and Community Coordinator. In Semantics, Knowledge and Grid, International Conference on (pp. 110-110).

APA. 2020. APA Dictionary. American Psychological Association. https://dictionary.apa.org/

Atiles, J. H. 2019. Cooperative Extension Competencies for the Community Engagement Professional. *Journal of Higher Education Outreach and Engagement*, *23*(1), 107-127.

Billings, D. 2006. Journaling: A strategy for developing reflective practitioners. The Journal of Continuing Education in Nursing, 37(3), 104-105.

Boynton, T. 2001. Applied research using alpha/theta training for enhancing creativity and well-being. Journal of Neurotherapy, 5(1-2), 5-18.

Cambridge Dictionary. 2020. Community; Coordination; Relate; Organize Coordinate; Collaborate; Develop; Facilitate. https://dictionary.cambridge.org/

Chaskin, R., P. Brown, S. Venkatesh, and A. Vidal. 2001. Building community capacity. Chapter 1, p. 7. New York: Aldine de Gruyter.

Chiesa, A. 2009. Zen meditation: An integration of current evidence. The Journal of Alternative and Complementary Medicine, 15(5), 585-592.

Clarkson, M. B. E. 1995. A stakeholder framework for analyzing and evaluating corporate social performance. Academy of Management Review, 20: 92-117.

Coghlan, D., and Brydon-Miller, M. 2014, The sage encyclopedia of action research, vol. 2, SAGE Publications Ltd, London, [Accessed 2 March 2020], doi: 10.4135/9781446294406.

Dennis, A. R., Minas, R. K. & Bhagwatwar, A. P. 2013. Sparking creativity: Improving electronic brainstorming with individual cognitive priming. Journal of Management Information Systems, 29(4), 195-216.

Donaldson, T., & Preston, L. 1995. The stakeholder theory of the corporation: Concepts, evidence, implications. Academy of Management Review, 20: 65-91.

Freeman, R. E. 1984. Strategic management: A stakeholder approach. Englewood Cliffs, NJ: Prentice-Hall.

Hinde, R. A. 1976. Interactions, relationships and social structure. Man, 1-17.

Indeed. 2020. Social Skills: Definition and Examples. Career Guide, Career Development. https://www.indeed.com/career-advice/career-development/social-skills

Jha, K. N. & Iyer, C. K. 2006. What attributes should a project coordinator possess?. *Construction Management and Economics*, *24*(9), 977-988.

Katz, S., O'Donnell, G. & Kay, H. 2000. An approach to analyzing the role and structure of reflective dialogue.

Lai, C. H. & Huili Lin, S. 2017. Systems theory. The international encyclopedia of organizational communication, 1-18.

MacIntosh, N. 2020. Organizational Skills for Your Resume. https://www.monster.ca/career-advice/article/organizational-skills-resume-examples

Magis, K., 2010. Community resilience: An indicator of social sustainability. Society and Natural Resources, 23(5), pp.401-416.

Mendelson, M. 2006. Confessions of a Learning Community Coordinator. *Liberal Education*, *92*(3), 56-59.

Merriam-Webster. 2020. Community; Coordination; Relate; Organize Coordinate; Collaborate; Develop; Facilitate. https://www.merriam-webster.com/

Toros, K., & Medar, M. 2015. Social work students' thoughts on self-reflection: A qualitative study based on reflective journaling. International Journal of Humanities and Social Science, 5(3), 89-96.

Whitehead, H. A. L. 1997. Analysing animal social structure. Animal behaviour, 53(5), 1053-1067.

9 Appendix A: Work Reflection Dairies

9.1 Week 1

This week I have begun my practical training with the Learning Lab at TAMK. I am not sure what to expect and am open-minded to learn new things. I am to start working as the position of a Community Coordinator (CC). I don't know that much about being a CC but the term seems to imply that I am to work with the community and develop a collaboration between various parties. This week was mainly focused on the practicalities of starting a new job, such as developing the work contract and going over objectives and expectations of the job.

For my objectives I will be working on several different initiatives as a CC, the primary initiative is to develop a project team for a "Historical Culinary Experience Event" and create a report what a CC is. My secondary objectives are to support sustainable development projects in TAMK such as the Sustainability and Impact Club of Ykampus and the Learning Lab's Sustainability Open Space and to support a network link between the two initiatives. A third initiative will be to support the development of a podcasting studio in TAMK and link opportunities for podcasting back to the sustainability initiatives.

I have met with J my supervisor and he has discussed and mentored me about the CC position and especially the Historical Culinary Experience event. I have at least three primary parties to try and coordinate, the International Business Experience Economy course, the Restonomi department, and the Historical Department at the other university. For now, I am just trying to understand the concept and how I would explain it to these parties to encourage participation. I will start to look for contact people and also begin to gather information about CC.

Other practicalities included using information technology to join the workplace environment and organize and communicate information. I downloaded the application Teams to my computer and created a work folder "Community Coordinator Project". This is a good way to make my work and progress visible to my supervisor, and anyone else interested in what I am working on at the Learning Labs.

I feel that as a CC there is a bit of uncertainty I will have to navigate and planning I will need to do to achieve success.

9.2 Week 2

This is the second week of my practical training CC role. I am still a bit unsure of this Historical Culinary Experience Event project I am to coordinate. My questions are what will I say to make it more of a concrete concept and how to explain it to the potential parties. I created a basic description of how I could best explain the concept and I shared it with J. My understanding was increasing, but I also needed to sell the concept a bit more, so I worked on creating a pitch for the concept and discussed it with J.

I found the email information of the Experience Economy teacher here at TAMK. I sent her an email about the project first since I felt the topic would be more intuitive to her and she would be a good first party to meet with. I had received a reply from her and we planned to meet the following week. I also sent a message to the student union of Restonomi, and have set up a meeting for the following week as well.

This week I also went to the Sustainability and Impact Club meetings. It was nice to meet such enthusiastic people and discuss the matters surrounding the topic of sustainability. I spoke to the club leader V about collaborating with them on creating Instagram content for the club. She showed interest in the idea, although gathering a picture was difficult since I did not want to disturb the ongoing discussion, plus I should ask for permission, which not everyone wanted to be in a picture. I will think on how to proceed with this later, as it is not the top priority at the moment and maybe later I could find a member of the group who would be interested to collaborate on this effort. For now, I will just focus on integrating and building trust and membership within the group.

This week I also began searching for material on CC. I found that the subject matter was not as clear as I thought it might in the literature, but there seems to be cross over from different areas of coordination such as a project coordinator, and also it seems to be spoken about a bit in the information technology field. I am trying to synthesize available knowledge to develop my understanding of what

a CC is. I created a preliminary model that looks like a network structure that I discussed with J to get his feedback and see if the model was intuitive for fresh eyes.

9.3 Week 3

This week I started by meeting with Z, the Experience Economy teacher about the historical culinary experience event. The meeting was scheduled from 9-10, and I had booked the room at the Learning Lab to host it. I arrived early to prepare. I was thinking it would be important to manage some aspects of the environment to support a good atmosphere for discussion. I also had been writing down potential questions to ask, sort of like semi-structured interview questions. I wanted to try and get Z's perspective on what the concept meant to her. I was a bit nervous because I did not have enough content to last a one-hour discussion on the topic. But I said what I could to explain the concept without putting too many limitations on what it could be. The open questions were met with enthusiasm. The meeting was not as long as I thought it had to be, but it was around 20 minutes and ended on a positive note, with the interest of further potential collaboration.

I also met with another potentially interested party this week. I meet with A, from the Restonomi Student Association. I found out the previous week that for this meeting the Learning Labs room was not available for booking and there was also some big event going on at TAMK so I had to figure out where to hold this meeting. I remember the info desk helped me before with this, so I checked with them and manage to get a room for the event. I arrived at the room early to make sure the environment was organized and professional looking for the meeting. I arranged the desks to create a table and set the seats in a way I thought wouldn't feel awkward. When we met, I explain the concept and asked the questions like previous. This time I was meeting with two people and they were also students. They had much less to say, and the meeting was quite brief. I wasn't sure if it was good or a bad thing, perhaps it was most efficient this way. They said they would vote on the matter with the student union and get back to me with the results.

I think meeting in person is important because it feels more personal than just an email. I feel like people see the matter of concern is more important to take some time to physically meet and discuss it. I feel I understand the concept a bit more

after meeting and discussing it with people as well. This was also a good learning experience for coordination and planning, as well as some social and professional skills that I was practising such as communication, and cross-cultural competency. Also taking notes is a very important task, I had been relying on notes to help manage information during discussions. I feel this shows the person also that what they have to say is important enough to write down and remember. This has helped me later organize my experience into summaries that I could send to my supervisor after the meetings.

I also was asked by my supervisor to think about what are the major milestones of my developing project. I created a project timeline for the historical culinary experience event and added some major milestones I needed to reach, such as meeting all interested parties, coordinating a brainstorming and planning meeting, create project plan draft, revise, and deliver final project plan to the stakeholders. I meet with J to discuss the timeline and together we revised the timeline to something we both felt was reasonable. I feel like the project timeline is a good tool to use to stay on track with objectives. It is good we planned it early in the project.

The rest of the week I was going to the sustainability meetings and reflecting on what I had been learning to develop further models of the CC. Reading the literature about related theories and similar concepts is helping clear my mind about how to think of my position and how to act as a CC.

9.4 Week 4

This week I focused on reflecting on my previous experiences, and the literature that I had already read. I find that reading something multiple times helps me notice things I missed or think about what I had learned in a new way. I worked on developing another model about the CC and how they operate in an environment. I found that there are certain barriers to the CC based on their field of awareness. In order to reach collaborative parties and activate their resources they need to find a link to the right person within that system. I have been working to develop my thoughts on this concept.

I had previously been looking to contact a member of the history department, I found they have a programme at the other university called the Historical department of excellence. I had sent an email last week but still no response. I was worried that the email did not make it to the inbox of the person I found and I could not risk the project falling behind. I thought instead of just relying on an email I should make plans to visit the other university and find out if it is possible to meet someone from the department. I went to the info desk at the main building and then at the second building they sent me to. I had then located the department, but no one was there, the hallway was empty. I decided maybe I could knock on a door and try to talk to someone. Still no one available. Then I saw a guy and asked him if someone was available to talk to. I was told everyone was at a meeting for the next hour. I decided I would wait at the bench nearby. I used the time to gather my thoughts and wrote down all the points that I thought was important in their context. After about an hour and a half, I checked the hallway again. Finally, I saw someone and asked for their help. They asked several potential people if they were available until we finally found one. I then discussed the concept, got the persons contact info, and left my contact info.

After this experience, I realized that sometimes you just need to go into the environment where you could meet a potential contact and be available and put effort to find one. When you do not have any link from someone you know, this could be a good method because I think the first meeting in person with someone new can help build trust and credibility. This experience also got me thinking of a new model in which the CC operates through their journey of seeking a contact person. I started to make drafts of this concept as well. I also ended the week attending the Sustainability Open Space of the Learning Lab. I agreed to lead the next session with a few volunteers from the session.

9.5 Week 5

This week I had sent a follow-up email just to thank the person for their time and remind them about the project. This succeeded, in they replied about how they would discuss the project in their next meeting and get back to me. Now I would just be waiting for their reply. I updated my supervisor and the other interested

parties of the situation. I later received an email from Y that would be their departments representative. We arranged to meet the following week at her university.
Now that I was waiting on the response I then focused on further developing the CC models and theory. I also discussed the previous week's meeting with J. We talked about how to move forward, such as the need to plan a workshop later for the interest parties to plan and develop the project together. I think letting them participate together helps build relationship and trust and opens communication while brainstorming and planning the project helps develop ownership and commitment to the project to take on responsibility.

I also attended sustainability and impact club meetings. I found another member interested in social media and content creation, we agreed to work together on the club's content creation. We set up a meeting to discuss our objectives. We decided we would make a content creation storyboard on Onedrive to help us organize and collaborate on content creation.

I also had a meeting with the sustainability open space team to plan our process for the next workshop. I learned the importance of asking open questions and allowing others to share their perspective. This was helpful to build a common understanding of our objectives and plan to move forward. We decided we need a program structure to develop with an agenda. We used Onedrive to organize a word document and a PowerPoint to contribute our thoughts to our workshop plan.

I also meet up with Anssi this week to set up the podcasting room. We gather supplies and unpackaged and set up equipment. We developed the equipment layout in the room and prepared it for later operation. We realized that the computer we had would not work for our operations so we have to wait for a proper computer before further progress. It was nice to take action in setting up the room, it gives me an idea of what I will be working with to facilitate the podcasts. I also had shared with the sustainability and impact club there could be a possibility to participate in podcasts about sustainability topics in the near future, and that I would keep them updated. It's interesting to see how developing different social and professional networks in one project can have overlaps in other projects that

provide access to resources. I think it would be much more difficult to search out participants randomly than to access the resources of the network that I am already developing. I can see having a network can be a powerful resource.

9.6 Week 6

This week I met with Y from the Historical Center of Excellence. I had prepared for the meeting by reflecting on my other previous meetings and wrote down what I thought were the most important points of interest in the history departments context. I had found out that the history department was researching the “Lived Experience” of Finland. I felt like this was a really good fit for the project and emphasized on this area of interest that they would have the opportunity to bring to life their research through the historical experience event. Y responded well to this perspective, and through the open questions I asked, I found she had plenty of ideas for the project and potential organizations to coordinate. After the meeting, I updated my supervisor and we discussed the situation. We talked more about developing a workshop for project development.

I learned from this experience preparation is always important and creating a dialogue the aligns with the context of the interested party rather than just keeping it generic is also important. I also thought about how important it was to consider multiculturalism as an element in this experience. I want to respect my contacted people, and this requires I consider that my cultural background is different from theirs. I think one important aspect that I focused on was regarding communication. I have been told many times since I have come to Finland that Finns appreciate silence and that is normal for them. In my culture of the US, silence can be considered awkward, and this compels people to fill the silence with conversation. In my multicultural situation, I realized it is important to give people time to think and some silence is ok. I think this also let the Finish people feel more comfortable when dealing with me. I ask questions and let people talk and think, and I just listen. Later on, the ownership of the project will be transferred to them, so it is important as well to let them build up ownership of the concept instead of just say what I think. This was a good experience to practice cross-cultural competency.

Later this week, I found out we received the computer for the podcast room. I went to help set up the software and learn how to use it. After figuring out the setup, I created a user manual of the podcast software so that other people could use the equipment. This took quite some time, and I had to think about each step

of the process and how could the user manual explain what to do when no one else is there to explain. I sent the draft of it to my supervisor, and I think it would be a good idea for someone to test it out to see if it works ok or what information might be missing.

I ended the week developing a process for the next sustainability open space meeting. After the previous meeting, not much had been progressed. I decided I need more information on hosting a workshop. I felt that from my previous experience perhaps design thinking could be an inspiration. I read all about design thinking and came up with an inspired workshop process that could facilitate concept creation using sustainable development goals as a framework to help narrow focus to important areas of sustainable development. I met with the team members about the process version I created and together we went over it and revised it.

9.7 Week 7

Over the weekend I had a Sustainability and Impact Club meeting about the Instagram content and developed this week's post. I started the week attending the sustainability and impact clubs weekly meeting. I shared with members that later today we would be having a Sustainability Open Space meeting as well. The meeting was discussing the need for sustainability to become more visible at TAMK and that the university could use the Sustainable development goals as a framework to build upon.

Later that day, I went to prepare for leading the sustainability open space meeting. The team members have arrived as we previously discussed and arranged the room and set up drinks and snacks. I had gone over the presentation slides earlier in the day to make sure they work well and look good in our setup. Now I was going over the slides with my team and also getting J's feedback. We made some minor adjustments regarding activity time. We then waited for the guests to arrive. I decided adding music could help ease the social tension, which we later reflected was a good decision. As guests arrived, some team members lead them in, and I greeted them and started some small talk while we were waiting. I think this helped the people feel less awkward well waiting for the program to begin. At 10 minutes past the meeting time, we decided to begin. We used an icebreaker activity to help socialize everyone and get them more comfortable. I learned that

easing social tension is important for giving people a good experience and supporting their participation. As we went through the main body of the process I watched as our experimental process unfolded. We guided participants through the very general through several levels of narrowing their focus using sustainable development goals and open questions. Open questions are really good for generating participation, gaining unique perspectives, and tapping into the resources people already have. We ended the program with a visualization and presentation activity. I was surprised how well it all went and the creative outcome the groups developed.

It seemed we did pretty well for our first workshop, but we still needed some time to digest our thoughts and reflect on them. We agreed to meet J the next day for a debriefing discussion. We reflected on what went well, what was challenging, what we could improve upon, and what we could take away. We agreed the process was pretty well in general, but the time of the activities worked well for a small group of people, but perhaps it wouldn't be the same for a larger group. We agreed that further collaboration past the session by participants might be too much to ask, although some showed interest in the podcasting, many seemed nervous when we asked if they would sign-up to do a presentation about their concept the following month. I talk to a participant I knew from the sustainability and impact club later about this and he made me aware of the assumptions I had about human behaviour and my thoughts of those interested in sustainability. I was thinking that people interested in sustainability were passionate to make a change, but I was not thinking about if they wanted to do extra work without much in return, like an incentive to make their time feel worth it, such as credits. He suggested the idea that coupling the sustainable open space as having a part in the sustainability and impact club could be a way about this since they would be getting credits for participating in the club.

This idea an important lesson I keep thinking about during this practical training experience, how to work with human behaviour and not against it? If I want to access collaborative opportunities and coordinate people, I need to work with them in a way that is already meaningful to them. This is something I will reflect upon throughout this experience, how to work with human behaviour, it is the social aspect of community coordination.

I also worked more on developing the Historical Culinary Experience Event this week. I was trying to figure out how to coordinate interested parties for a meeting. I looked at some meeting planning apps but decided I would make my own shared document excel with meeting dates and times for them to fill in. I sent on the emails, custom to each party's context. I am waiting on their reply now and to see how this all works. Will I be able to find a good time 2 weeks out that works for everyone, or is this not enough advanced notice, or maybe they could be just very busy at these times. This will be an interesting step in the CC journey.

I also have been working on CC models for the theory of the report. I took the concept like the customer's journey and combined it with a system and networks perspective to give an overview of the contact seeking phase of the CC. I have been reading about theoretical frameworks and thinking about how to bring this concept together. From what I learned there is a social networking aspect of it and also a system and process side of it. I will think about these concepts to develop the report.

9.8 Week 8

This week's focus has been on my reflecting on what I have learned so far to create. I have been considering that I had to reconsider my approach to scheduling the first group meeting with the interested parties. It is time to try setting it for another date. In the meantime, I came up with a few questions to send to them, perhaps I can get a clearer picture by trying to piece together their thoughts and expectations. I have also been focusing on my theoretical framework, does it involve systems, social networks, and stakeholders. I will keep looking into the available literature to develop my understanding. I also met with my supervisor to discuss facilitating the first meeting with historical culinary experience event partners. He told me about the possibility that dialogue has to guide a conversation in a constructive direction. This sound logical, and I will think more about what key points I should cover in this meeting. I also checked on the progress of the podcasting operations this week, ventilation construction had taken place, now the room should be ready for a test run soon. Finally, I had read earlier about social sustainability and community resilience, this seems to be an important area, and had reread the article several times.

9.9 Week 9

This week I focused on the community coordinator report. This week was the focus on researching and reflecting on my thoughts and experience. I began to develop the results section with models I have been working on. Also, I have written the methodology section, about how I am combining action research and reflective practices. I believe that cognitive priming of the literature has expanded my understand of what a community coordinator theory could be. Additionally, meditational practices, have aided in my mind digesting the large volume of literature I have been consuming. I complete the literature review this week. I ended up citing some things about community resilience as well in the introduction. This week I had been waiting again for a unified schedule date for HCEE meeting but again, all schedules conflict. I feel like this is delaying the progress of the project. Having all members select days they are available seems logical and democratic, but behind the scenes, I don't know if it is as effective as it seems logical. Although as I haven't much experience I will try it one more for a further date into the future. Perhaps my timing was too soon for everyone. Although, I am now considering the possibility of a virtual meeting as it is more convenient for everyone to meet online than to physically to plan to go somewhere.

9.10 Week 10

This week I attended the Sustainability and Impact club, as it was about urban gardening a subject I am interested in. In the end, we took some group photos together for their website. My primary focus had shifted this week, as I had a presentation at the Responsible Business Seminar, concerning my thesis topic, Vertical Tower Farms as a solution to food security and sustainability challenges. For this reason, my schedule was unavailable for two days. Although, the circumstances in the world were already rapidly changing. The coronavirus had spread worldwide. I had already been feeling a bit stressed because of my workload, my practical training, thesis, and presentation, but I do this for the challenge and opportunity to push myself to develop. Although this situation was extra stressful and dangerous. I had to take action and decided that I will distance work for the time being.

9.11 Week 11

My progress had been challenged this week with the mounting workload and stress of a global pandemic. Now everything must be down virtually. It's a good

thing I decided to take the extra course last semester regarding virtual multicultural project groups on the Zoom Platform. I am already familiar with many apps like Zoom, Teams, OneDrive, Google Docs, WhatsApp, etc. However, I will try to do my best, even if my work progress becomes slower. This week I had met with J to discuss my projects. This was a good time to reflect on my progress and experiences so far. We also had a group meeting about the sustainability open space, since we can no longer physically meet. We decided we would try to create a session virtually. For this, we tested out Zoom and Teams to see which would work better on my not so great student Wi-Fi. Zoom was the best option for this, now we needed to practice using it. After we got familiar with it, we had to agree on the topic. Since all the chaos going on, I volunteered to transform my previous presentation on my thesis topic into a video we could present. We also considered using an app called pallet which we could screen share using the zoom, and topics could be presented in posted notes that participants could add their comments on. This was a potential tool for facilitating the discussion. Over the weekend, I spent extra hours preparing the video, e.g. organizing and writing the script, practising and recording the audio, and video editing. This process was more challenging and time-consuming than I first thought, but the product would be something that I could continue to share in the long-term. We also decided that we could make a YouTube channel for our sustainability open space project. Which I then uploaded the video on for the presentation.

9.12 Week 12

This week was focused on preparing the sustainability open space session coming up the following week. We met and practised the meeting on Zoom several times. I realised that it was silly to screen share a video on YouTube when it's taking up extra Wi-Fi from Zoom. We also agreed to that a team member with better Wi-Fi would be the backup host and also screen shares the video, which I sent in a file. I had developed some poster concepts to advertise the event and made an intranet blog post advertisement which would broadcast our activity in the student and staffs email. We also advertised on our social networks about the event. I had received bad news this week regarding the HCEE. A member had to withdrawal from the project due to the chaos the coronavirus has caused to the school system. To me, this was hard news to take, as I had been trying to coordinate a meeting for several weeks, and now I wondered if I had acted too slow.

I replied to their email assuring them I understood, that I would keep them updated on the projects progress and that the door would still be opened for them later on when things settle down more. I decided to hold off on any further action until I could discuss the matter with my supervisor the following week and after the sustainability open space meeting.

9.13 Week 13

This week was the first virtual session of sustainability open space. I had requested my wife turn her computer and phone Wi-Fi off during this to ensure proper Wi-Fi signal. The introduction went well, although I was a bit nervous, I had written down my talking points just in case I couldn't think clearly. There were about 20 participants. The video played well as we had practised. Gaining engagement took a little bit of encouragement, but after the participants got warmed up, they got decently engaged in the topic. It felt good after the meeting that all the effort had been rewarded with raising awareness about important issues and a potential solution, my thesis topic on vertical tower farms. It was also nice to find a way to combine my thesis and practical training. The next day I met with E and J to debrief on the session and to coach me on my practical training. We decided that I would give more responsibility to the other group members for the next session so they could develop their competencies. We also discussed the high labour cost to produce the results and agreed that it is not something we could likely do for each session, but it was good anyway because we were resilient to come up with something on such short notice, amid the pandemic circumstance.

9.14 Week 14

This week began two sustainability open space meeting for this month. We discussed an alternative approach, and I informed the members they have creative freedoms to lead this next session while I will support and coach them along. I decided that it has been too long in between meeting the HCEE interested parties for the first time and we are yet to coordinate our first meeting. Additionally, we already lost a potential party to the chaos of the situation. I had to take a chance. I decided that at all costs I must meet with any of them if at all possible, and by the end of this week. I created a zoom chat meeting date for Friday and sent invitations to the interested parties. At first, I only got my supervisors acceptance, but in the middle of the week, Y had accepted. Even if was only her, that was

better than losing another interested party. Now my dilemma is what am I supposed to do for this meeting. I don't understand this event that well. I meditated and reflected. I realised, I just need to research and find anything that is somehow similar and I need to combine that with any possible background experience I have to make a basis for the meeting agenda, and something to build the project from. I remember going to a renaissance fair when I was in the US a few times and enjoyed it. Also, I had been to a few October Festivals. That was it, I needed to look more into the development of those events, and also search for anything about culinary events and especially concerning Finland. It was three days until the event. Finally, I had a thought, I should just put my thoughts down in and just restate the preliminary project proposal, but also adding my connection of the event to similar cultural events, and some thoughts about collaborating, the major milestone, which was an autumn course, and the possibility of summer projects that J and I had discussed previously. Somehow just documenting this information and thoughts made an artefact that the involved parties to share and comment on. I put my best effort to make the document look professional using PowerPoint, it was like a hybrid between a word document with the nice formatting features of PowerPoint. I uploaded this document to the Teams folder as the first document shared thereafter I got my supervisors comments and made revisions. I somehow came across the term information package as I was talking to my wife about what I was doing. This became the artefact to build the meeting upon. Friday was the meeting, I had been working towards this for a month now with delays and losing an interested party. There was a lot of pressure to do it right, and yet, I was not exactly sure what that was. I came up with an agenda for the meeting I would try to create a dialogue around. When the meeting began, it was on Zoom, I greeted everyone, asked how they were, and gave everyone a chance to introduce themselves. I was happily surprised to see A had joined and brought an associate Ari. I had recommended that we all have our video on at the beginning so we could all get familiar. I was a bit nervous, so I used my notes to help me remember what I wanted to discuss. I figured going over the information package could be a way to get the perspective on these matters. There were some moments I felt like I was a bit awkward but awkward or not this meeting had to take place. As I went through the information package the participants began to have thoughts and comments they wanted to share. The most important outcome was that we built some relationship altogether and that we discuss the possibility

of summer projects which turned into our key point of the meeting. Additionally, the participants gave the feedback that the project was not yet that clear, in which my supervisor asked if I could take some responsibility to create a project proposal based on our meeting, which they agreed.

9.15 Week 15

This week had been dedicated to getting the project proposal completed as soon as possible since the project had already a major delay. The week began with a debriefing of the meeting with J. He had helped me critically reflect on the meeting and the key takeaways of that should make its way to the project proposal. Following this, I had a series of notes to transform into a project proposal, yet I had not written a formal project proposal before. I dedicated much time to read about this type of document. after two days this and developing not very appealing drafts I had to stop and meditate, digest all these thoughts and experiences and organize my mind while allowing relevant thoughts to surface and pass through my mind. I then began just free writing it from the beginning, but this time, everything was much more organized. I had the continuous realization that developing events is balancing the imaginary and creative side with the reasonable and logical side and that these nonexistent projects develop from a certain degree of creativity and hype. I had finished the document and asked for my supervisor's comments before I shared it. From the following meeting, my supervisor gave me the comments that it needs to be easy to get the main information quickly. The outcome of this meeting was the suggestion of an executive summary, and the key highlights of the document to be next so that someone tired and busy can get these key points and pass it on to other stakeholders in their parties. After these revisions, I uploaded it to Teams and also emailed it to the interest parties. I then scheduled a follow-up meeting for the next Friday.

9.16 Week 16

To begin this week, I had already got the invitation for Friday's meeting accepted by one member, and by mid-week, all members had agreed to meet. This next meeting will be focused on the next major milestone of the project, creating summer projects to support the autumn semester implementation of the project for the designing of the event. In the meeting, the outcome was that I would take responsibility to define the summer project description by the following week and advertisement would begin as soon as possible. The session was recorded at the request of another potential supportive party to the summer project. I also made

an online document with the key areas of focus that we would cover during the meeting, which I had recorded key points in their relevant sections as the meeting proceeded. I also needed to plan with my sustainability open space for the session the following Monday, so we met and went over our thoughts for the meeting. The previous meeting it was suggested that we discuss COVID-19 and sustainability. We had agreed to cover this topic, and I had requested one member make a poster. I used this posted to make the next intranet blog post advertising our event, and sent out emails to the previous attendees. We agree that the workload needed to be divided. Someone should design the pallet based on the topic areas we determined, and each of the members would be responsible for being their topics discussion leader. We also managed to get two guest experts to join and give their perspective on the situation.

9.17 Week 17

This week began with the sustainability open space session. It had gone better than expected thanks to our practice and planning I believe. The outcome is a video of the session we added to our YouTube channel and a blog post that one of the guest experts published about the session. This week was busy as I focused on creating the summer project descriptions for both the history students and the service business students. To do this I reviewed the recording of the previous meeting several times to take additional notes. I had to research into the history side more so since I was unfamiliar with this field and their curriculum approach. To make sure the students doing the summer projects received credits that would be valid to their study path, I researched about history curriculum, course and project descriptions, and what some of the key competencies they are expected to learn. I then synthesized this understanding into the orientation of this summer project. For the service business students summer project description, I did the same, although as an international business student, and having taken some tourism and event planning courses I was somewhat more familiar with what I needed to do. I completed the two descriptions by the end of the week and had asked for their party's feedback.

9.18 Week 18

This week has been dedicated to completing my report on the community coordinator theory. I should reflect on the model I have created and revise their previous description and add it if there is none. There are eight models I had to cover, then I wrote about the competencies of the CC position, and some tasks, tactics,

and strategies I believed would be important for the training and development of a new CC or for human resources to have a basis to build the position from. After this, I researched how to write a discussion section, which then I reflected on what I had developed in the results section. After rereading the document many times, I completed the discussion section. This left me with just the conclusion and abstract to create. I research several articles about writing a proper conclusion section and completed that. I was already familiar with writing an abstract, as that was how my vertical tower farm presentation got accepted to the seminar. At the beginning of the week, I had received an email from Y that her associates gave many comments to the summer project description. Additionally, she was able to get approval by her decision-makers that she could be a supervisor for the summer projects. It made me feel good to support another person in creating an opportunity. My next steps are to reflect on the comments and send them back for revision. Once they are approved by the decision-makers, we will begin the advertisement for the summer project, as soon as possible, since it is early May. I plan to create a follow-up meeting after the final summer project descriptions are to be advertised. We need some meetings to create clarity about all the practicalities of implementing the summer project. So those will be my next steps. And the CC journey continues...