Master's Thesis Sustainable Business and Innovation

Network formation in the urban agriculture innovation-ecosystem

comparing the ZFarming niche in Denmark and the Netherlands

Urban Farmers' Aquaponics Urban Farm in the Hague (Zegwaard, 2016)

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Abstract

Due to the problematic and inefficient organization of the current industrial food system, a transition towards sustainable food economies is being realized, particularly via the emerging urban farming (ZFarming) niche. Network formation is an important aspect of niche nurturing in the context of strategic niche management (SNM), and this research provides a new understanding of this process. First, the networking formation process in the ZFarming niche is unpacked. The research presents an integrated framework, introducing specific stakeholder roles and activities for network actors in the ZFarming niche. Second, quantitative and qualitative empirical data has been collected by interviewing a range of stakeholders in the Danish and Dutch ZFarming ecosystems, providing insights in certain trends regarding network formation in these two niches. It can be concluded that the ZFarming niche actors in the leadership, expert and entrepreneurial roles are fundamental in network formation. Especially the emergence of meta-actors, often facilitated by municipalities, is characterising the niche. These network actors create digital platforms for online information environments and mapping initiatives to facilitate geographical linkages in the Netherlands, and physical innovation hubs resulting in spatial clustering in Denmark. Both approaches stimulate knowledge exchange and new collaborative relationships among network actors. They also attract new entrepreneurs to the ecosystem whom are experimenting with novel business models, combining several roles. Consequently, network formation in the Danish and Dutch ZFarming niches is characterised by overlapping roles and intertwinedness.

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Executive Summary[1]

The deeply problematic character of the industrial and global agrifood industry has led to proposals that aim to reintroduce agricultural activities in urbanized regions, as this approach can contribute to sustainable food economies by facilitating short food supply chains. The recent development from social and educational focussed city farming projects to more business-oriented, (semi)-commercial initiatives is an important milestone and indicator for the growth of the urban agriculture niche and the sustainable food transition in general. Additionally, a wide scale of promising technologies and innovations that contribute to sustainable food can be identified (see Appendix A). This range of complementary agrifood technologies and novel food production approaches serves as tools for actors in the sustainable food transition. By deploying these innovations in novel ways via urban agriculture projects, entrepreneurs can realize new business models to enable sustainable and regional food economies, short food supply chains, and expansion of the urban farming networks from local to international levels.

For these reasons, a comprehensive overview regarding urban farming as a sustainable innovation that contributes to the sustainable food transition is given in this thesis. More specifically, the research concerns the network formation process in the (semi)-commercial ZFarming niches in Denmark and the Netherlands. The main research question raised in this thesis is: *How does the process of network formation shape niche protection in the (semi)-commercial ZFarming niche in the Netherlands and Denmark in the transition to a sustainable food system?* ZFarming is a sub-type of urban farming that utilizes existing urban infrastructure to reintroduce the food production function of cities. The (semi)-commercial aspect delineates the types of urban farming initiatives that can be studied in this thesis, by focussing on ZFarming projects with high market-orientation and food production characteristics. Through a combinatoric lens of strategic niche management (SNM) literature, the innovation ecosystem framework, and several stakeholder types in the ZFarming niche, the network formation processes in this emerging niche is unpacked (see image 1). This model contributes to the body of literature regarding SNM's network formation processes in protected niches. These theoretical insights are also utilized to create an integrated analytical framework by which specific roles and activities in the ZFarming networks can be studied (see table 2).

Data for the comparative case study between the ZFarming niches in Denmark and the Netherlands has been collected via a combination of desk research and interviews. The desk research has resulted in a list of stakeholders in both ecosystems. By interviewing a mix of stakeholders, from urban farming entrepreneurs, to professors at

[1] The Executive Summary is written for the people and organizations that have supported this thesis by being an interviewee or via other types of involvement.

universities and civil servants of municipalities, a wide range of empirical data regarding perspectives and insights on actors' roles and the dynamics of the network formation process has been collected. Both quantitative and qualitative information has been gathered in the interviews. The quantitative data served to identify patterns in the network composition, while the qualitative data provides empirical evidence for these observed trends. A total of 24 interviews have been conducted for the comparative case study; 10 stakeholders in the Danish ZFarming niche have been questioned while the Dutch ecosystem has seen 14 interviewees. The data from the interviews have been transcribed and analysed for relevant insights about the network composition and network formation process in the two ZFarming niches.

The integrated analytical framework consists of nine actor roles in the ZFarming niche. The empirical results reveal that the leadership, expert and entrepreneurial roles are most represented in the two studied ZFarming networks, scoring the highest in the quantitative data. The leadership role conceptually refers to network actors that are aiming to build platforms that enable both the attraction of new niche actors as well as collaboration and knowledge exchange among the stakeholders. The empirical evidence reveals that these activities are shaped into physical innovation hubs and digital environments. The concept of the expert role is an important actor type that focusses on generating and sharing knowledge. From the interviews, it appeared that activities associated with this role include conducting research, providing education, and giving workshops and tours on urban farms. Niche actors in the conceptual entrepreneurial role are working on producing food in an urban setting. Based on the empirical data, these actors are commonly searching for new business models, combining several complementary revenue streams. These results indicate that the associated activities of these three roles are important for network formation and ecosystem genesis. Additionally, there are many opportunities for actors in the sales and distribution role, focussing on the logistics and marketplaces for regional food, as this is considered one of the key bottlenecks in the network. Activities related to leadership, entrepreneurship and expertise are widely shared in the studied ZFarming niches.

The results also give insights in the arrangement of activities and roles in the ZFarming niche in the Netherlands and Denmark. It can be stated that there are overlapping roles of niche actors in the two urban farming networks. Many actors are involved in several and varying roles, for instance to spread revenue streams and explore new business models. Most noteworthy, the expert role is an important diversification approach for niche actors, sharing knowledge via workshops, events and tours. Another finding is the intertwinedness regarding network roles in the Danish and Dutch ZFarming niches. Multiple individual actors that were interviewed are involved in two or more organizations in the urban farming networks, stimulating collaborative efforts with a wider range of stakeholders. By providing new information regarding the roles and activities of the niche actors and the arrangement of the networks in terms of overlapping

roles and individual intertwinedness, this thesis has generated valuable insights in the network formation process of the studied ZFarming niches.

Based on the basic network mapping efforts of this thesis, it can be argued that the Danish ecosystem is more spatially clustered in the core of Copenhagen, while the Dutch network is more spread out over various municipalities. However, the rate of changes in the two studied networks is substantial; there is a constant flow of niche actors entering and leaving the network. Thus, it is virtually impossible to generate and present a complete overview by oneself. Governmental institutions may play a facilitating role in these mapping platforms, as is the case in the Dutch ZFarming niche. Due to the availability of municipal mapping projects in the Netherlands, the mapping results in this ecosystem are more comprehensive. However, self-sustaining business, ownership, and governance models for these types of network mapping initiatives are yet to be implemented. The network mapping results show a list of key actors in the two ZFarming niches, providing insights in the organization and formation of the networks. It is argued that these types of digital mapping initiatives are important for network formation, as it enables niche actors to easily find new potential collaborative relationships.

Based on these results, one major similarity and three differences between the two niches are discussed. Due to the relatively small number of inhabitants in the Danish and Dutch metropolises, there are agricultural fringes in proximity to the analysed urbanized regions. These peri-urban areas should be considered in the urban farming strategy of municipalities and ZFarming actors in Denmark and the Netherlands. A first difference in the two networks can be observed from a leadership role perspective, specifically the emergence of meta-actors. These meta-actors aim to create both digital and physical platforms for niche development, through which connections, collaborative relationships and shared learning experiences among ecosystem actors are facilitated. It is found that leadership roles in the Danish network are focussing more on spatial clustering in physical spaces, while the leadership actors in the Dutch ecosystem are concentrated on creating geographical linkages over multiple network levels, from local to (inter)national. Second, from a broad regulatory perspective, it is observed that some Dutch municipalities have created dedicated urban farming departments and jobs for civil servants to facilitate the transition towards regional food economies. Additionally, the City Deal agreement in the Netherlands for regional food is a noteworthy milestone, indicating serious commitment from governmental bodies. In comparison, the Danish ecosystem lacks this type of municipal support. Third, regarding differences in entrepreneurial activities between the Danish and Dutch ZFarming niche, it can be stated that the Danish network actors are more focused on community building, while coopetition can be observed while scaling-up the local Dutch networks to national collaboration. Even though urban areas in Denmark and the Netherlands are similar in terms of geographical make-up, allowing for peri-urban farming, there are several key differences regarding meta-actors, municipal collaboration and support, as well as community-building versus coopetition.

In addition to comparing the two ZFarming ecosystems, the results are also discussed through the lens of three niche protection processes; shielding, nurturing and empowerment. Shielding refers to the process of creating conditions in which the new sustainable technology can compete against incumbents, for instance through subsidies or special regulations. Nurturing is focussed on niche development processes like network formation, learning experiences and shared vision among niche actors. Empowerment refers to process in which the regime and niche are moving closer together. In terms of shielding, due to the new combinations of business activities of entrepreneurs, urban farming initiatives may experience multi-year long processes of arranging the formal and legal aspects with the municipality, slowing down entrepreneurs and thereby the sustainable food transition. Additionally, specific subsidies for urban farming projects are difficult to find or are countered by more substantial subsidies for traditional farming. Hence, there is a focus to create novel business models and revenue streams to become more self-sustaining and reduce reliance on soft-funding. Nurturing processes regarding network formation are characterised by the creation of regional network mapping efforts of municipalities, the emergence of meta-actors in the niches, and the realization of physical collaborative spaces. From the perspective of knowledge sharing, it is argued that both ecosystems have a high representation of expert roles among niche actors. The Dutch ecosystem can be seen from a knowledge-driven learning by searching approach, while the Danish ecosystem can be characterised by community-driven learning by interacting methods. Empowerment processes in the ZFarming niches are identified by the application of traditional innovations in the agrifood industry, such as climate-control systems and LED lighting, in new forms and locations by urban farmers. By discussing the ZFarming niche in terms of niche shielding, nurturing and empowerment, new insights regarding niche protection are provided for urban farming network actors.

Overall, this thesis makes a conceptual contribution to the SNM literature by unpacking the network formation processes in relation to the emerging urban farming industry, specifically the (semi-)commercial ZFarming niches in Denmark and the Netherlands. In conclusion, several key actor roles in this stage of network formation were revealed through the empirical data. The studied networks can be characterised by overlapping roles and intertwinedness. Thus, this research provides a better understanding how the process of network formation shapes niche protection in the emerging ZFarming industry.

1) Introduction

Humanity is facing many persistent problems and crises during the 21th century, hence there is a need for socio-economic transitions. One of these societal shifts is the trend towards more sustainable food economies in urbanizing environments. The current industrial food production system has arguably resulted in many climate-related issues, such as deforestation, soil erosion, biodiversity loss, emissions of greenhouse gases due to livestock, agricultural machinery and transport, among other unfavourable and unsustainable effects (Johnson, 2015; Pollan, 2009; Satterthaite et al., 2010; Sedghi, 2013; van Staalduinen, 2014). Due to the increasing global population, in combination with rapid urbanisation, it has been estimated that 75% of the 10 billion people that inhabit the Earth by 2050 will live in urbanized environments (UN DESA, 2014; UN DESA, 2015, Wagner, 2008). This future scenario pressures the global food system, especially in urbanized areas. Hence, the FAO has predicted that 70% more food has to be produced by mid-century to feed the growing population (Alexandratos & Bruinsma, 2012). Thus, it can be argued that a transition towards more sustainable and city region-oriented food economies is needed.

The urban farming concept, reintroducing agricultural activities in urbanized regions, has gained more attention in recent years, as this food production approach promises sustainable, locally grown, and nutrient rich produce for urban communities and municipal regions (Specht et al., 2015). By utilizing urban agriculture, food production can become more sustainable in terms of water consumption, land usage, and carbon footprint (Hui, 2011; Skar et al., 2015). The purpose of urban agriculture is not only food production, but also to connect consumers with food and their fellow community members. Via educational activities, such as tours through urban farms, the sustainable food awareness of customers is increased, and social cohesion improved (Gladek et al., 2016; Schillingmann, 2017). In order to bring the feeding function back to cities, locally-based food economies are being stimulated, for instance by the European Council making policies, incentives and legal frameworks (De Schutter, 2010; Groesbeek, 2009; Kneasfey et al., 2013; McIntyre et al., 2009). The urban farming approach contributes to the local food resilience of cities, increases wellness of citizen and workers via social cohesion (Jijakli, 2017), and "is a necessary element to achieve the circular metabolism" of a city (Junge and Graber, in Kompare et al., 2014), making it an interesting topic in the transition towards more sustainable food systems in urban environments.

There are various types of urban agriculture, which operate on different scales and can be integrated in the urban landscape in several ways (Junge and Graber, in Kompare et al., 2014; Pearson et al., in Pearson et al., 2010). One approach is *zero-acreage farming (ZFarming)*, in which no additional land or space is required for food production, since

existing urban infrastructure such as vacant buildings, lots, or rooftops are used for agricultural purposes (Freisinger et al., 2015; Specht et al., 2015). According to Thomaier et al. (2015), ZFarming projects may utilize a variety of agricultural techniques, such as soil-based, aquaponics, hydroponics, or aeroponics growing methods, which can be executed in a wide range of locations, such as rooftop gardens and greenhouses, edible green walls, or indoor underground, container and vertical farming with artificial lighting. Appendix A overviews these novel agricultural approaches, technologies and tools for the food transition in the context of the Climate Nexus. Until recently, ZFarming projects mainly had an educational, social, or experimental purpose. However, Europe's ZFarming industry is home to a growing number of ventures, such as Urban Farmers (CH), Tilamur (ES), GrowUp (UK), GrowX (NL), InFarm (DE), and Refarmed (DK). All these commercial projects are important milestones, as it demonstrates the business potential for ZFarming. Such initiatives thus indicate the next phase of technological development and growth for this innovative agricultural practice, attracting mass-media attention and stimulating the diffusion of ZFarming in the context of the global food transition and urban transformations. For these reasons, conducting research in the specific field of (semi-)commercial ZFarming can add to a wider understanding and adoption of this novel food production method. This thesis provides insights for pioneering commercial ZFarming initiatives, thereby contributing to the urban transition towards sustainable and local food production systems, better food education and awareness among consumers, as well as changes in values associated with societal transitions (Skar et al., 2015).

Academic literature about societal transitions includes the body of knowledge concerning *strategic niche management (SNM)*, which is often used within the context of emerging sustainable technologies (Kemp et al., 1998; Raven, 2005; Schot & Geels, 2008). Seeing ZFarming as such, a sustainable technology that is just evolving into the market niche phase with the arrival of the first commercial initiatives, using SNM literature as the basis of the theoretical framework in this thesis seems appropriate. The concept of market niches also links to the ideas regarding the genesis of innovation ecosystems, in which various network actors are collaborating on a common innovation. Hence, the academic work on innovation management often emphasises the importance of network formation, partnerships and collaborative relationships among stakeholders (Dedehayir et al., 2016; Planko, 2018; Stewart & Hyysalo, 2008). Therefore, in the context of ZFarming, Milicic et al. (2017) state that there is an "urgent need for implementing integrated and holistic approaches involving all stakeholders" (p. 1). Goddek et al. (2015) name multidisciplinary as the biggest challenge in commercial aquaponics projects. And Freisinger et al. (2015) stress the importance of collaborating with "a broad, interdisciplinary team of experts, even at the preliminary planning stage" (p. 43). It can thus be concluded that the formation of networks among stakeholders of ZFarming initiatives is essential for further adoption of the emerging sustainable innovation, and its

contribution to the urban food transition. SNM literature offers a lens to analyse network formation in niches during socio-economic transitions.

The aim of this thesis is therefore to study the formation of networks in the emerging ZFarming niche through the lens of SNM and innovation ecosystems. Specifically, the network formation process in the ZFarming niche is studied in the urbanized areas of the Netherlands (Randstad) and Denmark (Copenhagen Metropolitan Region)[2]. Data is collected via literature research as well as semi-structured interviews with stakeholders in the ZFarming sector in both countries. Via a partnership with the Danish Technological Institute (DTI), a Copenhagen-based research and consultancy firm involved in ZFarming projects, an insider perspective for the Danish ecosystem is gained. Via desk research and interviews, various sources of data are collected to conduct the comparative analysis in this thesis.

Preliminary desk research has led to finding literature about ZFarming and relevant theoretical frameworks. Researchers in Germany have conducted several studies, in which various stakeholder groups in Berlin's ZFarming niche are identified and analysed (Freisinger et al., 2015; Specht et al., 2015; 2016a; 2016b; Specht & Sanyé-Mengual, 2017; Thomaier et al., 2014). Moreover, Dedehayir et al. (2016) provide insights in the various roles and activities across the genesis of innovation ecosystems, a field of study that adds valuable theoretical concepts regarding network formation to the SNM framework. Additionally, intermediary activities related to network creation are studied, as it is argued that these activities are essential in the construction of niches (Howells, 2006; Kivimaa, 2014; Schicklinski, 2017; Steward & Hyysalo, 2008). By combining aforementioned literature, an integrated analytical framework is created, operationalizing the analysis of the network formation process of the ZFarming niche.

In short, there is a dire need for a sustainable food transition, and the emerging ZFarming niche offers a promising contribution to this paradigm shift. SNM is a relevant body of literature to analyse emerging sustainable technologies in a transition. Forming networks and creating collaborative relationships is essential for further development of

[2] There are several reasons to study these two countries. First, the Netherlands and Denmark are both known for their innovative environment, respectively scoring third and sixth place on the Global Innovation Index 2017 (Dutta et al., 2017). Second, the Netherlands is renowned for its leading global position of agricultural productivity, being the world's second largest exporter of food by dollar value after the U.S. (Viviano, 2017). From a broader perspective, Denmark's proactive attitude towards sustainability has resulted in a fourth place on Yale's Environmental Performance Index ranking of 2016, while the Netherlands is ranked at position thirty-six (Hsu et al., 2016). Lastly, several studies have been conducted comparing these two countries from a SNM perspective in their ability to adopt sustainable technologies, such as biomass (Raven, 2005) and wind energy (Kamp et al., 2004). Consequently, research aiming to conduct a comparative study between Denmark and the Netherlands in relation to the formation of innovation ecosystems within the two nation's ZFarming market niches, can result in valuable insights that could stimulate niche development in these countries, and adds to the body of knowledge for the global food transition.

the emerging ZFarming niche. These innovation ecosystems are often formed with the contribution of intermediary activities (Howells, 2006; Kivimaa, 2014). The main research question addressed in this study can now be presented as follows:

> *How does the process of network formation shape niche protection in the (semi)-commercial ZFarming niche in the Netherlands and Denmark in the transition to a sustainable food system?*

Several sub-questions have been formulated, which answers contribute to address the main research question:

1. How can the network formation process in the ZFarming niche be unpacked in relation to SNM literature?
2. Which key actors are present in the (semi-)commercial ZFarming niche in the Netherlands and Denmark?
3. What is the arrangement of activities and roles in the (semi-)commercial ZFarming niche in the Netherlands and Denmark?
4. In which ways are the (semi-)commercial ZFarming niches in the Netherlands and Denmark protected?

Answering these questions has scientific and societal relevance. Academically, it contributes to the theoretical body of knowledge of SNM regarding niche nurturing via network formation. The novel integrated framework can be used in future research regarding urban farming stakeholder analysis. Practically, this thesis provides the actors in the Dutch and Danish ZFarming niches with insights and recommendations to successfully develop the innovation ecosystem, which can contribute to a wider adoption of urban farming strategies.

Following chapter presents a more detailed description of the theoretical background, including SNM's niche development models, actor typologies and functions for innovation ecosystem genesis, the role of intermediary activities in network formation, and ZFarming stakeholder types. These various theoretical concepts are combined and presented in a new integrated analytical framework. Next, the research method provides the data collection processes and operationalizes the theoretical concepts into practical indicators for the analysis of the data. The results describe the roles in the Danish and Dutch ZFarming niches and reveals certain characteristics for these networks. The findings are further discussed in terms of the differences and similarities of the two ZFarming niches.

2) Theoretical Framework

The transition towards local and urban sustainable food production, specifically the current development and emergence of ZFarming initiatives, can be framed within the theoretical framework of strategic niche management (SNM). SNM not only aims to understand and explain sustainable technological change, but also to steer and manage this process (Raven, 2005; Schot & Geels, 2008). The key concepts within SNM are explained in relevance to this thesis in section 2.1. Collaborative networks of stakeholders are essential for the development and commercialization of a new sustainable technology. Hence, section 2.2 provides a conceptual framework, unpacking network formation in SNM literature based on concepts of innovation ecosystem genesis. These theoretical concepts need to be framed within the context of ZFarming. Therefore, section 2.3 contributes to a better understanding about (semi-)commercial ZFarming by defining the concept, discussing various types of initiatives, and describing various stakeholder typologies. Lastly, all these models are combined into one integrated framework for network formation in an ZFarming innovation ecosystem, presented in section 2.4.

2.1) Strategic Niche Management

This section clarifies the theoretical background for the *market niche* concept, as mentioned in the research question. To do this, the academic body of knowledge regarding SNM is consulted. The purpose of SNM is twofold. First, it can be utilized in the academic world as a theoretical model for analysing and explaining technological change. Secondly, the findings in SNM literature can be applied as a policy tool, from analysis to management, in order to steer and manage technological changes and societal transitions (Raven, 2005). The usefulness of SNM literature can be observed in the wider context of transition management, the multi-level perspective, and sustainable innovations, in which the concept of niches have a central position. The importance of collaboration and network formation in these niches is often mentioned by SNM scholars (Schot & Geels, 2008; Markard et al., 2012). Therefore, it is arguably appropriate to consult SNM literature for this thesis.

In connection to the multi-level perspective, SNM views transitions from three domains; the landscape, regime, and niche. The macro-level socio-technical landscape is "an exogenous environment beyond the direct influence of niche and regime actors" (Schot & Geels, 2008, p. 545). It contains deep cultural patterns, macro-economics and macro-political developments. Changes in this level occur slowly, over several decades. Next, a patchwork of regimes represents the meso-level, which consist of relatively stable, large-scale systems such as the dominant food, transport, or energy industries. These socio-technical systems also refer to social routines and belief systems as well as

regulative rules and normative roles. Summarily, the regime can be seen as the dominant environment in relation to market conditions, societal perception, and governmental regulations. In this thesis, the socio-technical system is considered to be one regime, namely the agri-food incumbency. It is common knowledge that many socio-technical systems are currently unsustainably organized, such as the energy and food industries. Sustainable innovations aim to change this status-quo. However, these innovations are often confronted with resistance and disadvantageous selection environments because these novelties are commonly not yet technologically and/or economically competitive with existing technologies in the socio-technical system. Hence, sustainable innovations are known as 'hopeful monstrosities', since they are perceived as promising technologies, yet need to progress performance and affordability, quite a challenge in a normal free market environment (Geels & Schot, 2007, Grin et al., 2010). Widespread diffusion of this innovation is therefore not likely without some special regulations in a *protective niche* (Schot & Geels, 2008; Smith & Raven, 2012, Vezzoli et al., 2008). This is why the last multi-level perspective domain, the micro-level of niches, is essential for the adoption of sustainable technologies, and the focus of this thesis.

Niches are protective spaces in which sustainable technologies can be researched, developed, and commercially applied. These protective niches deviate from the dominant socio-technical system, for instance by receiving governmental incentives or subsidies. This protection allows the *technological niche*, in which the innovations are heavily researched and developed, to grow into a *market niche*, where the first commercial application of the sustainable novelty occurs (Raven, 2005). In this market niche, the protection may be phased out, making the innovation slowly more exposed to the regular selection environment. This way, the technology can mature and influence the socio-technical system. It is argued that niche protection can be achieved via three processes: shielding, nurturing, and empowerment (Smith & Raven, 2012). *Shielding* refers to processes that protect the emerging niche against multidimensional selection pressures, such as dominant industry structures, political power, and cultural significance. When the niche is protected via shielding, it can be *nurtured*, which involve processes that support the development of the innovation. This support is mainly focussed on creating a collaborative atmosphere in the niche by building networks and shared visions among niche actors, as well as stimulating learning experiences. When the innovation is sufficiently nurtured, it can become competitive within the incumbent regime. This can be accelerated via *empowerment*, which refers to "processes that make niche innovations competitive within unchanged selection environments (fit-and-conform) or processes that change mainstream selection environments favourable to the path-breaking innovation (stretch-and-transform)" (Smith & Raven, 2012, p. 1034). In other words, empowerment aims to reduce the differences between the conditions in the emerging niche and the dominant regime, increasing the competitiveness of the sustainable technology, thus making shielding processes redundant. Some ZFarming initiatives can be seen as

empowerment for the niche, as it adds urban agriculture practises to traditional revenue streams of incumbents in the agrifood sector, bridging the transition gap. This may create support for the innovation among incumbent actors in the dominant regime. All three protection processes should be coordinated and iterated in order to continuously create optimal conditions for niche development (Smith & Raven, 2012), thereby allowing the sustainable technology to diffuse in normal market conditions and challenging the status-quo. An emerging innovation should be protected via shielding, nurturing and empowerment processes, thus gaining insights in how niche stakeholders fulfil these processes is valuable for this thesis.

This research focuses on network formation in the niche nurturing process. In this thesis, nurturing is seen as niche development and may be used interchangeably. The emphasis is on successful niche development, in which success is defined as the shift from a technological niche into a market niche (Raven, 2005). Three internal processes for successful niche development have been described: common vision, learning, and network formation (Schot & Geels, 2008). In this thesis, the main focus is on the latter process, network formation. Figure 1 provides a graphical overview, unpacking these fundamental concepts in SNM literature in the context of ZFarming.

The first internal process of nurturing is the articulation of expectations and visions. Managing expectations as well as common goals is crucial for niche development as it provides direction to learning processes, attracts attention, as well as legitimates protection and nurturing of the niche. Second, the stimulation of learning processes. Sharing experiences and knowledge is essential for niche development and should take place at multiple dimensions. The third process is the *formation of networks* among niche actors. By creating a cooperative environment, interactions between relevant stakeholders can be facilitated, making the new technology supported by a larger body of actors. Much has been written about the importance of collaboration and the value of innovation networks (Caniëls & Romijn, 2008; Dedehayir et al., 2016; Moore, 1996), yet research regarding the formation of these networks is lacking. By unpacking these network formation processes in the context of ZFarming, this research adds to the SNM literature of niche development.

SNM literature aims to explain and steer sustainable technologies to achieve societal transitions by focusing on creating protective niches. Via shielding, nurturing and empowering processes, the niche can be protected from the dominant environment, allowing the innovation to mature and challenge the socio-technical regime. By creating shared visions, sharing experiences, and forming actor networks among stakeholders, successful niche development can occur.

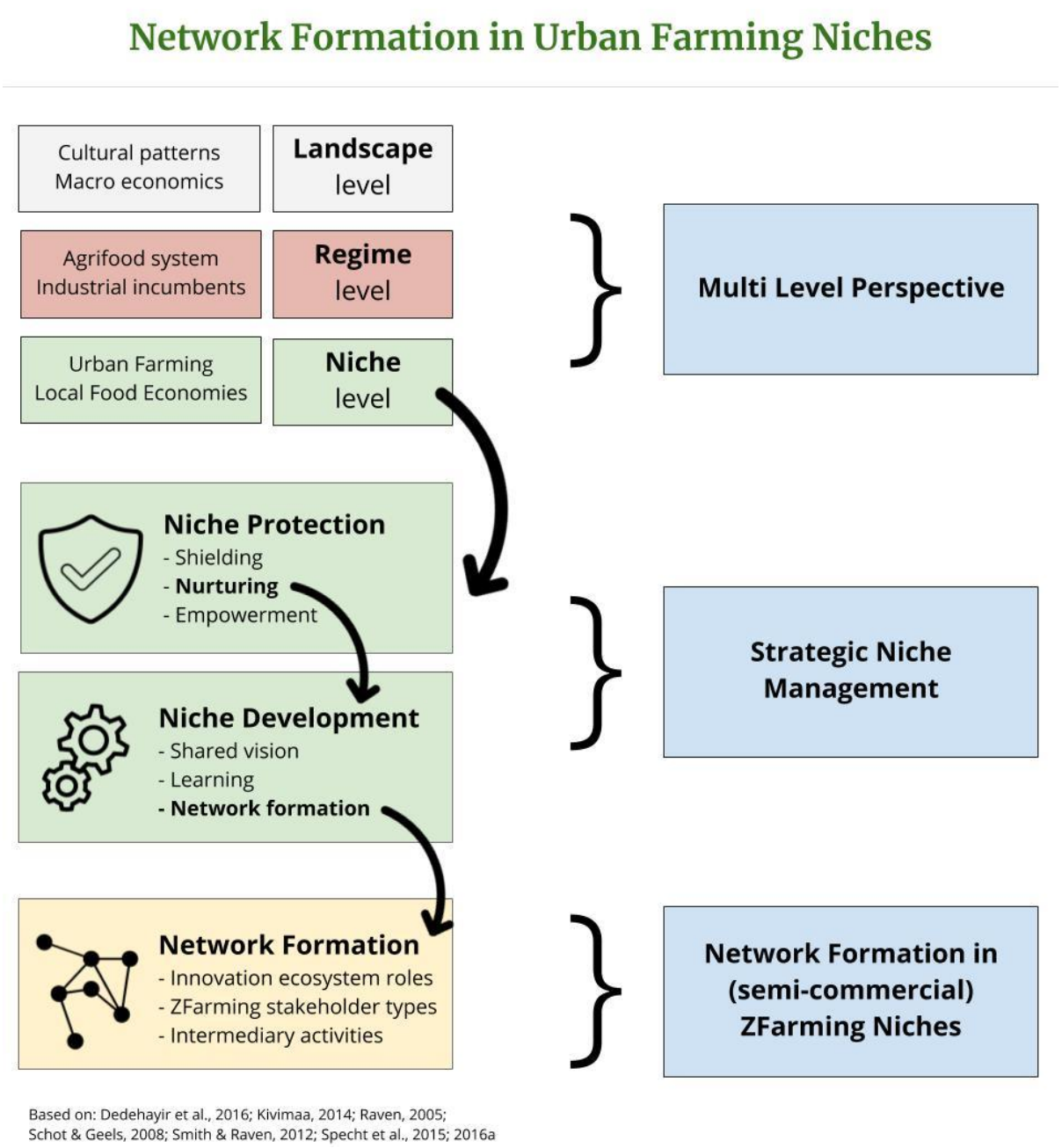

Figure 1: Unpacking network formation processes through SNM's niche protection literature. Nurturing can be seen as niche development, of which network formation is the main focus in this research. Network formation processes in the ZFarming niche can be unpacked via several theoretical frameworks, including innovation ecosystems and ZFarming stakeholder types.

2.2) The Formation of Networks

Having consulted SNM literature to provide a brief overview of protected spaces and key elements for successful niche development, next section will extend further on the need to form networks and realize collaborative relationships among niche actors. Since ZFarming requires a multidisciplinary team of stakeholders (Milicic et al., 2017; Goddek et al., 2015; Freisinger et al., 2015), gaining insights in the creation and arrangement of these

innovation ecosystems is valuable as it can contribute to develop the emerging market niche.

It is well known that a diverse, collaborative actor network is required to stimulate the diffusion of an innovation (Caniëls & Romijn, 2008; Dedehayir et al., 2016; Moore, 1996). Planko (2018) has provided an overview of various approaches for system building in relation to strategic management literature. This list includes the business ecosystem perspective, which argues that "an individual business is merely a part of the business ecosystem it operates in; the health of the business ecosystem determines the success of the individual firm" (Planko, 2018, p. 45). However, Planko (2018) states that literature about the establishment of a thriving business ecosystem is lacking. Dedehayir et al. (2016) have conducted research towards the genesis of *innovation ecosystems*, defined as actor networks characterised by a diverse set of stakeholders that collaboratively work towards innovations. Understanding the genesis of these collaborative ecosystems is important for the involved stakeholders, as the formation of these networks may fail to come into existence due to a lack of resources, activities and favourable conditions (Dedehayir et al., 2016). Dedehayir and Seppänen (2015) argue that the ecosystem's creation phase is marked by two sub-phases: invention and start-up. During the invention sub-phase, the innovation is discovered, tested and premiers the first demonstration of the technology's operation, while in the start-up sub-phase the technology shows its first commercial application. Respectively, these phases are similar to the technological and market niche phases found in SNM, illustrating the compatibility of the innovation ecosystem concepts. The literature regarding innovation ecosystems is a valuable addition to SNM,because it provides more concrete insights to the underlying processes that enable network formation in niche development.

Dedehayir et al. (2016) present an overview of several key roles for stakeholders in an innovation ecosystem, grouped together in four separate classifications. First, leadership roles, which are indispensable for genesis, ensures ecosystem governance, the creation of partnerships, and the distribution of value. Second, direct value creation roles, which refers to stakeholders that collectively deliver, assemble and use key components, products or services. Third, value creation support roles, which can provide fundamental knowledge or are specialized in forming connections between stakeholders to help realize the ecosystem. Last, entrepreneurial ecosystem roles, which facilitate and support the creation of ventures in the ecosystem. Each category contains several specific role typologies, which various stakeholders can enact over time. For instance, the important role of ecosystem leader is commonly occupied by universities or governments in the early stages of ecosystem formation, when the emerging niche is characterized by uncertainty and technological infancy that can prevent private stakeholders from investing efforts in the ecosystem. In time, when market opportunities are more developed and less risky, this role might transition to another actor. Figure 2 presents a visual overview of these groups and roles, as well as their contribution in the various

phases during ecosystem formation. Since the genesis of networks is an important process for niche development, the six roles that contribute to the formation phase of an innovation ecosystem (ecosystem leader, user, expert, champion, entrepreneur, and sponsor) have a special focus in this thesis.

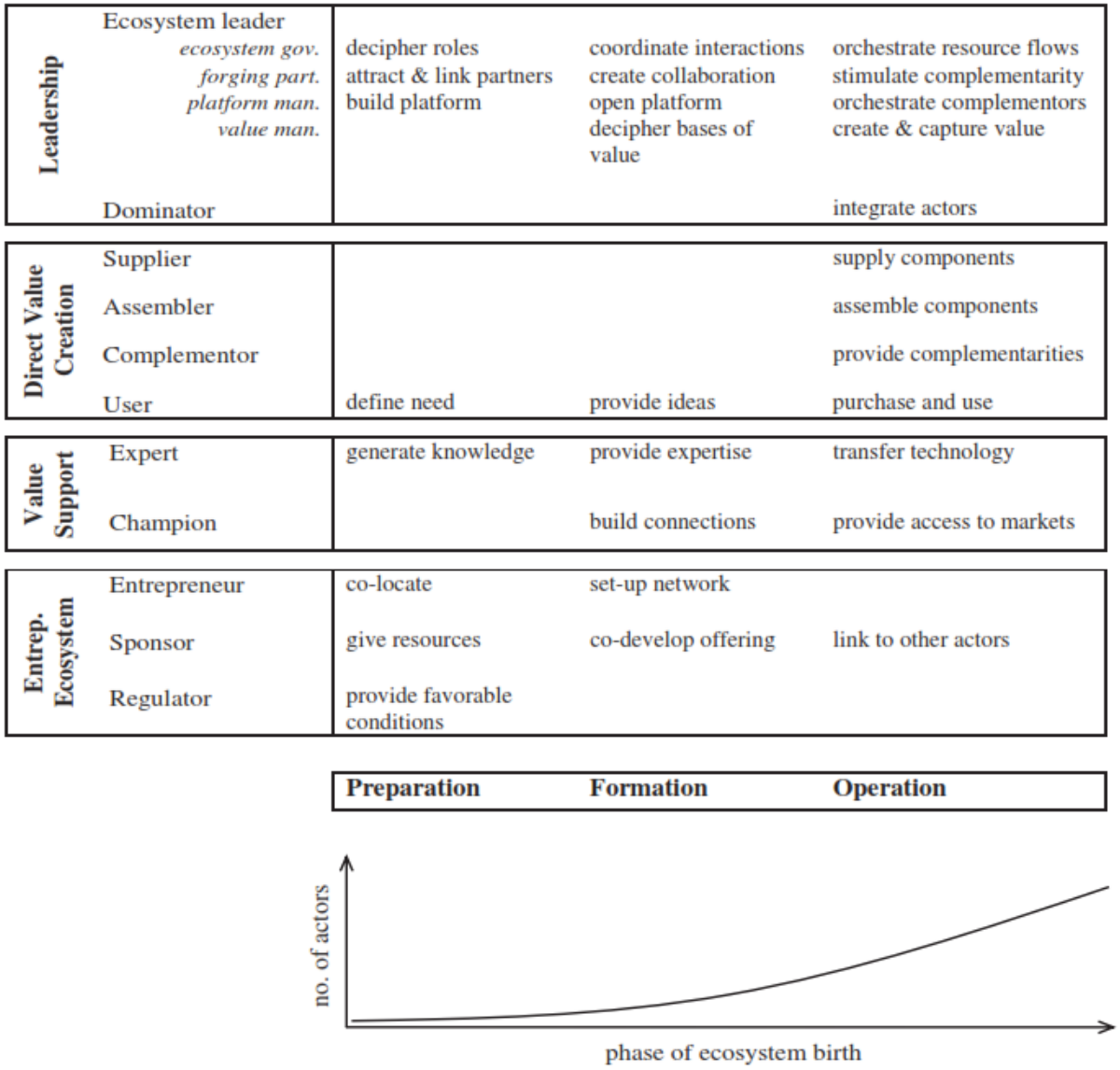

Figure 2: Various roles and activities across the genesis of innovation ecosystems. Taken from Dedehayir et al., 2016.

Additionally, it has been argued that systematic intermediaries play a key role in the formation of actor networks and diffusion of an innovation (Howells, 2006; Kivimaa, 2014; Schicklinski, 2017; Steward & Hyysalo, 2008). In the context of SNM, "intermediation potentially contributes to transitions through disturbing existing structures, practices and behaviours from two levels: (1) niche creation and (2) regime (de)stabilisation" (Kivimaa, 2014, p. 1371). In this thesis, the role of intermediary activities for niche creation has most

relevance. Thus, the concept of *innovation intermediaries* is interesting, defined by Howells (2006) as:

> *"An organization or body that acts an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations"* (p. 720).

It should be noted that this definition stresses the role of an intermediary as interacting between two or more actors, a broker, while this does not necessarily have to be the case. As described in the innovation ecosystem model, and argued by Klerkx & Leeuwis (2009), an intermediary expert role can also interact directly with one actor, for instance by providing consultancy or knowledge to an entrepreneur. This matches with the view of Stewart & Hyysalo (2008), as they argue that innovation intermediaries are engaged in collecting and disseminating knowledge and resources, as well as managing the interaction of stakeholders in an innovation network. According to Kivimaa (2014), these activities can be executed by a range of various actors, such as consultancies, brokers, and innovation centres. In general, innovation intermediary research has mainly focused on the functions and activities of these actors, however studies regarding the nature of their network relationships is lacking (Howells, 2006). Kivimaa (2014) states that while there are several somewhat concrete models related to transition management and the multi-level perspective, intermediaries are commonly not recognized as among the main actors. Yet, the formation of new innovation networks often requires some intermediation, thus Kivimaa (2014) has provided several key activities for intermediaries in the process of building social networks in the context of niche development, as can be seen in figure 3.

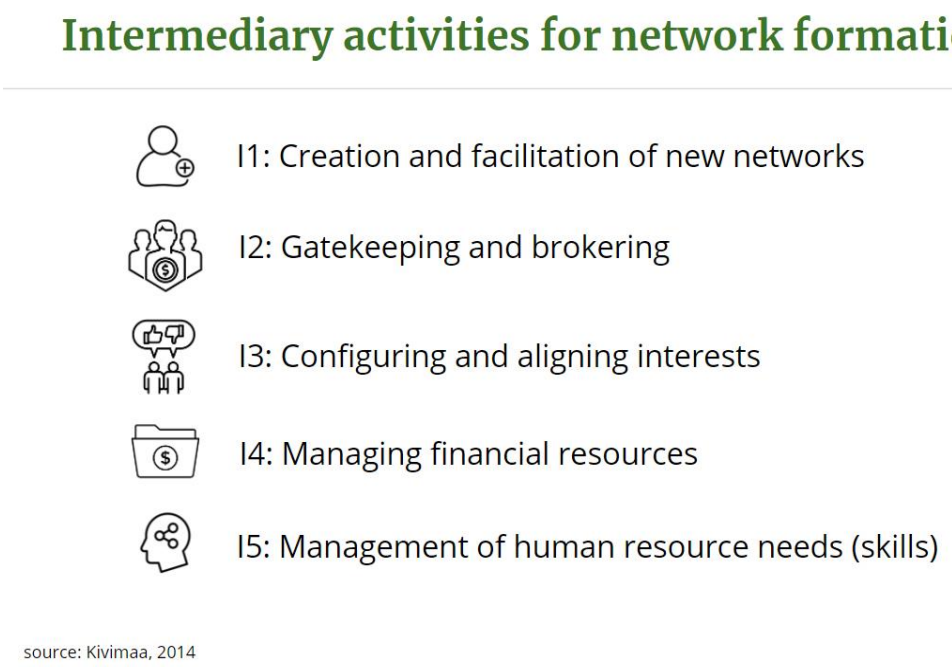

Figure 3: *Various intermediary activities for network formation in niche development. Based on Kivimaa, 2014.*

Since these activities are rather broad, it is assumed that all actors in the ZFarming innovation ecosystem can relate to one or more of these five intermediary activities. By integrating the five intermediary activities for network formation in the theoretical framework, a more concrete perspective of actor roles to build the emerging ZFarming innovation ecosystem is gained.

Network formation and stakeholder partnerships are essential for niche development. Literature regarding innovation ecosystems provides insights in the genesis of these collaborative environments and presents a typology of stakeholders for this process. Intermediary activities have a key role in socio-technical system transitions and can support to form a collaborating network of niche actors via five main activities.

2.3) ZFarming: Definition and Stakeholder Typologies

As mentioned in the research question, this thesis focuses on *stakeholders in the (semi-)commercial ZFarming niche*, which requires some elaboration. Therefore, following section defines this concept, thereby delineating the types of niche actors that can be researched and interviewed in this study. Moreover, a description of the stakeholder typologies within the ZFarming sector is provided to identify relevant niche actors for this thesis.

The term 'ZFarm' (short for zero-acreage farm) was used in the title of a German research project in 2011, which aimed "to investigate the conditions required to grow fruit and vegetables on inner-city buildings" (Freisinger et al., 2015, p. 2). ZFarming refers to the idea that existing urban infrastructure is used for agricultural activities, such as

rooftops, walls, vacant buildings, empty lots, or underground spaces (Specht et al., 2015). Several urban farming techniques, such as aquaponics, hydroponics, aeroponics, or soil-based farming can be applied within this existing urban infrastructure to realize a variety of ZFarming projects: high-tech indoor vertical farms, also known as plant factories with artificial lighting; modular shipping container farms; building integrated agriculture for a balanced environment for working, living and farming; or simple rooftop farms (Freisinger et al., 2015; Thomaier et al., 2014; Kozai et al., 2015). Appendix A includes a comprehensive overview of these novel approaches and technologies that can be utilized by urban farmers.

Research in the field of ZFarming is still in an early stage, and mainly concentrated within the German context. Several aspects regarding ZFarming have been studied in which typologies of the urban agriculture approach are presented (Thomaier et al., 2014), and stakeholder groups discussed (Specht et al., 2015). Moreover, the "perception and acceptance of agricultural production in and on urban buildings" has been studied (Specht et al., 2016a, p. 753), and the "entrepreneurial urban agriculture possibilities from the perspective of potential consumers" has been investigated (Specht et al., 2016b, p. 16). Freisinger et al. (2015) have written a ZFarming handbook for actors in the urban rooftop greenhouse farming space, stimulating entrepreneurial activities in this emerging industry. Aforementioned research on ZFarming helps to understand, classify, and frame this novel agricultural approach in a theoretical context so that it can be operationalized in new research such as this thesis.

Thomaier et al. (2014) defines five typologies of ZFarming, based on two dimensions; the market orientation and strategic orientation. Figure 4 presents a graphical representation of this classification. It should be noted that overlap or combinations of the various categories exist; a ZFarming initiative may be growing produce commercially but can also focus on educational and social aspects by offering farm tours or workshops (Cohen et al., 2012). In this research, (semi-)commercial ZFarming initiatives will be studied, thus only includes stakeholders in the commercial and image-oriented classifications. Commercial ZFarming initiatives aim to be an economically viable farming venture, only focusing on growing and selling produce. Image-oriented ZFarming initiatives commonly have several streams of revenue. Ostergrø, one of Copenhagen's first ZFarms, combines various activities such as a soil-based rooftop farm, restaurant and event space, food education and farm tours, as well as membership and volunteering programs in its community supported agriculture (CSA) project (CreativeMornings, 2017; Chasing Tomorrow, 2017), and can thus be classified as an image-oriented ZFarming initiative. This type can lead to niche empowerment, referring to the process of "either niche-innovations becoming competitive within unchanged selection environments or to niche-influenced changes in regime selection environments in ways favourable to the niche-innovation" (Smith and Raven, 2012, p. 1026). In other words, by realizing image-oriented projects, ZFarming is introduced in a broader context,

and is thus linked to wider processes within a transition, leading to a beneficial market environment for the sustainable technology. The other three types defined by Thomaier et al. (2014) have little to no market orientation and are therefore not relevant in this study. By focusing on commercial and image-oriented ZFarming initiatives, a working boundary for (semi-)commercial projects has been defined for this research.

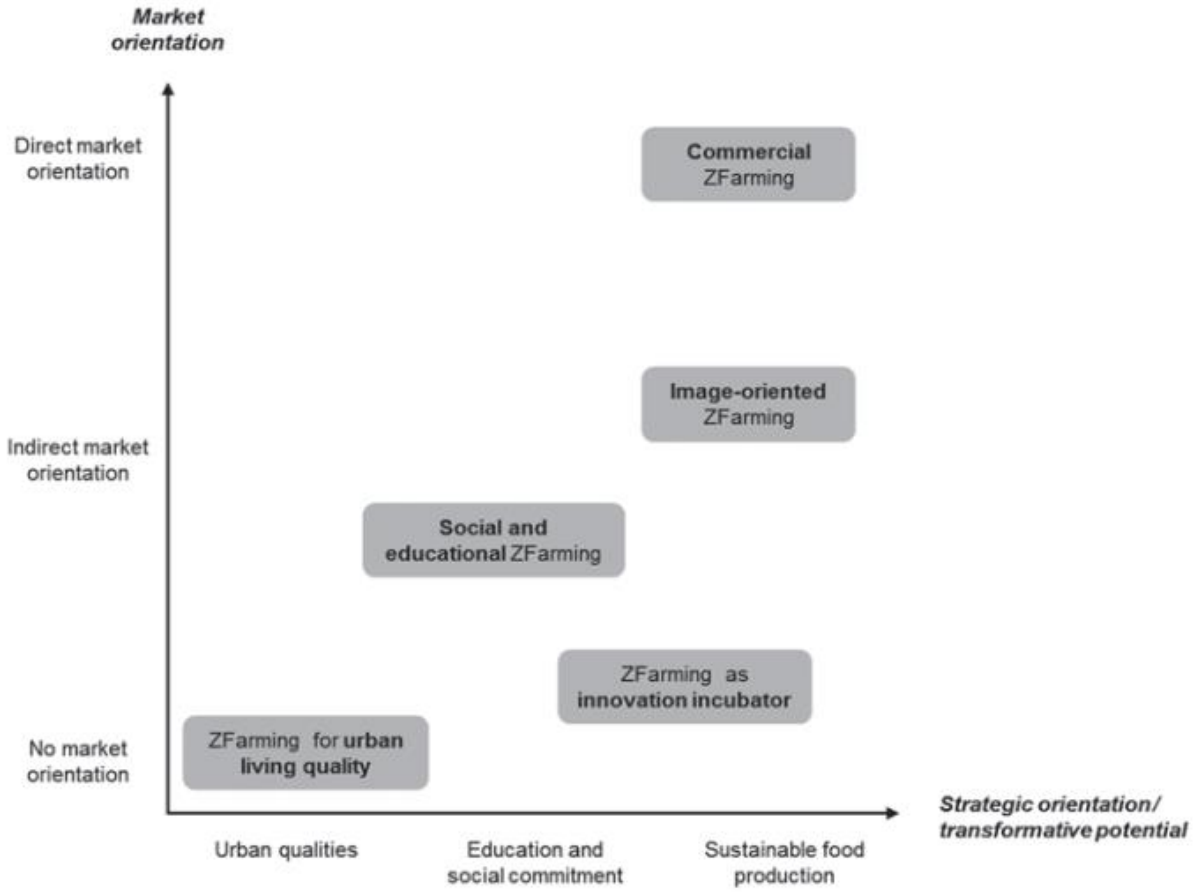

Figure 4: A typology of ZFarming initiatives. Taken from Thomaier et al., 2014.

In recent years, the academic literature about the importance of stakeholder inclusion and analysis has gained increasing attention among the entrepreneurial and academic community (Brugha & Varvasovszky, 2000; Reed et al., 2009). In stakeholder theory, a widely accepted definition of 'stakeholders' is presented by Freeman (2010): "any group or individual who can affect or is affected by the achievement of the organization's objectives" (p. 46). This broad definition forms the basis in this thesis and contributes to classifying various ZFarming stakeholder groups. ZFarming projects are very multidisciplinary, thus several types of stakeholders should be involved from an early preliminary planning stage (de Zeeuw & Dubbeling in De Zeeuw & Drechsel, 2016; Freisinger et al., 2015). Specht et al. (2015) defined and interviewed several stakeholder groups for Berlin's ZFarming niche in order to gain more insights about the perceived benefits and challenges of their involvement in an ZFarming initiative. In latter research,

the following six stakeholders types are described: (1) activists and projects; (2) associations and unions; (3) planning and construction; (4) policy and administration; (5) research; and (6) sales and distribution. Table 1 provides a more detailed overview of this classification. These typologies will be considered for identifying and categorizing relevant ZFarming niche actors in this thesis.

Z-type	**ZFarming stakeholder type**	**Description**
Z1	Activists & projects	Start-ups or initiatives that produce food in an urban setting via the zero-acreage farming concept or educate others about it.
Z2	Associations & unions	Stakeholders that represent a network of actors in areas such as agriculture, architecture, and real-estate.
Z3	Planning & construction	Partners and suppliers providing products and services to build the growing systems, retrofit buildings, or construct new BIA real-estate.
Z4	Policy & public administration	Governmental or public institutions that regulate topics such as urban planning, environment, health, and safety.
Z5	Research	Actors that aim to gain a better understanding about the various dimensions of ZFarming, such as universities, research centres, knowledge brokers and consultancy firms.
Z6	Sales & distribution	Organizations or individuals that buy and distribute the produce, such as logistics, consumers, retailers, restaurants, and farmers' market managers.

Table 1: An overview of various ZFarming stakeholder types. Based on Specht et al., 2015; 2016a.

The section above provides a definition of ZFarming and (semi)-commercial projects and has presented various stakeholder types that serve as a basis for network categorization. Even though ZFarming is a novel field of academic research, many fundamental aspects have already been investigated. This thesis builds upon previous studies by introducing ZFarming in the context of SNM's niche development and network formation process with additional innovation ecosystem concepts.

2.4) An Integrated Framework for ZFarming Niche Actors

Three perspectives to classify stakeholders in the ZFarming innovation ecosystem are described in previous section:

- Roles and activities for innovation ecosystem genesis (Dedehayir et al., 2016);
- Intermediary activities for network formation for niche development (Kivimaa, 2014); and
- ZFarming stakeholder types (Specht et al., 2015; 2016a).

These three theoretical frameworks overlap to a certain extend. By taking the four role categories as described by Dedehayir et al. (2016) as a main classification, the ZFarming stakeholder types and intermediary activities can be arranged according to the overlapping functions. Table 2 presents the integrated framework for this thesis, by which the identified stakeholders in the Danish and Dutch ZFarming niche can be classified and analysed. As can be observed from the integrated framework, some roles in the original innovation ecosystem model of Dedehayir et al. (2016) have been changed or removed to make the framework more suitable in the context of ZFarming. For instance, the supplier, assembler and complementor roles are combined to make a general 'planning and construction' type (Z3), following Specht et al., 2015; 2016a. The 'sales and distribution' type (Z6) has also been added as a separate role to include organisations that provide retail and logistic services. As these activities are essential for network formation in the urban farming niche, these adjustments are added to the base framework of Dedehayir et al. (2016) for comprehensiveness. Other ZFarming stakeholder types have been added in existing roles as examples of actors. For instance, the 'research' ZFarming stakeholder type (Z5) is overlapping with the 'expert' role and has thus been added in the role description. The leadership 'dominator' role has been ignored as activities such as mergers and acquisitions of network actors are not relevant for the current state of the emerging ZFarming ecosystem. The broad intermediary activities are integrated by understanding the individual role descriptions and analysing to what extent these activities are overlapping and used in different forms. For instance, the 'creation of facilitation of networks' (I1) is an important activity in the Leadership, Champion and Entrepreneur roles for varying reasons. Champions facilitate networking for other organisations, while Entrepreneurs build collaborative relationships for themselves, and Leadership roles are realizing networking possibilities with actors that are not yet included in the ecosystem. This difference is important due to the ambiguous nature of the intermediary activities as described by Kivimaa (2014). Having a 'ZFarming innovation ecosystem framework' allows for a new way of analysis regarding roles and activities of actors in the urban farming niche.

It should be noted that one niche actor can have various roles in the network. For instance, during a farm tour at Urban Farmers in The Hague, it was stated that the company is building their own ZFarms in Europe to produce food and educate people about urban farming (Entrepreneur), in addition to also providing other firms with consultancy (Expert) and selling its optimised aquaponics systems (Planning & Construction) (K. Jellema, personal communication, 8 December 2017). The combination of combining several ecosystem roles and thus income streams minimizes certain financial risks, such as loss of revenue due to weather or market conditions, plant disease or growing system failure.

Network Category	Network Role	Role Description and Activities
Leadership	Leadership roles	Attracting new partners to the network, coordinate interactions, align interests, build platforms, and value management. Intermediary activities: creation and facilitation of new networks, gatekeeping and brokering, configuring and aligning interests. (eg. actors that try to manage the ecosystem, make connections, and build platforms)
Direct Value Creation	**Planning & construction**	Supply and/or assemble components for others in the network, provide complementaries. Intermediary activities: gatekeeping and brokering. *(eg. supplying farming systems, real estate, construction, architecture, urban planning)*
	Sales & distribution	Provide marketplaces, managing logistics. Intermediary activities: gatekeeping and brokering. *(eg. local food stores, farmer markets, food-as-a-service)*
	User	Define need, provide ideas, purchase and use. Intermediary activities: configuring and aligning interests. *(eg. consumers, restaurants, supermarkets)*
Value Support	Expert	Conduct research, generate knowledge, provide expertise and consultancy, education via workshops and events Intermediary activities: gatekeeping and brokering, manage human resources (skills). *(eg. universities, consultancies, design labs, **research**)*
	Champion	Actors dedicated to creating collaboration and new networks for others, providing access to markets Intermediary activities: creation and facilitation of new networks, gatekeeping and brokering, configuring and aligning interests. *(eg. networking organizations, innovation hubs, **associations & unions**)*
Entrepreneurial Ecosystem	Entrepreneur	Starts new venture around a vision by co-locating, setting up focused network and collaboration for own venture. Intermediary activities: configuring and aligning interests, creation and facilitation of new networks. *(eg. urban farming start-ups, **activists & projects**)*
	Sponsor	Supports new venture creation by giving resources to entrepreneurs, co-developing offerings of firms. Intermediary activities: managing financial resources. *(eg. investors, strategic partners, accelerators, incubators, semi-public organizations)*
	Regulator	Supports entrepreneurial activity and ecosystem emergence by providing favorable policies, and economic conditions. Intermediary activities: managing financial resources. *(eg. governmental institutions, municipalities, ministries, **policy & public administration**)*

Table 2: An integrated framework to analyse ZFarming niche actors' roles and activities for network formation in the genesis of the innovation ecosystem. Based on: Dedehayir et al., 2016 (base innovation ecosystem model); Specht et al., 2015; 2016a (integrated ZFarming stakeholder types, in bold); Kivimaa, 2014 (integrated intermediary activities for network formation, with underline).

3) Methods

Previous chapter explains the process of niche development by forming innovation ecosystems with the support of intermediaries, provides a working definition of (semi-)commercial ZFarming stakeholders, and presents an integrated theoretical framework. These key concepts need to be operationalized so that a comparative case-study can be conducted through which the research questions can be answered. Hence, the ways by which this integrated framework is practically used in this study is provided in this chapter, in combination with the data collection and analysis methods. The research design consists of a comparative case-study of the Danish and Dutch (semi)-commercial ZFarming niche. According to Yin (1994) case-studies are useful when the research question starts with 'how' or 'why', and when there is a focus on contemporary events. This thesis fits both criteria; thus, it can be argued that a case-study research design is appropriate. Denmark and the Netherlands are quite similar in terms of their positions in various rankings, such as innovative competitiveness (Gretschmann & Schepers, 2016), or happiness of its inhabitants (Gilchrist, 2017). Additionally, these two countries have been studied before in the context of sustainable technology diffusion and transitions through the lens of SNM. The work of Raven (2005) on the adoption of biomass, as well as the academic writing of Kamp et al. (2004) regarding wind energy in Denmark and the Netherlands are important sources of information and indicate the relevance of comparing these two countries in the field of sustainable innovation. Section 3.1 provides more information about these two geographical research areas. For this thesis, two main research approaches are utilized in an iterative process; by combining desk research and interviews, varied information can be gathered and processed in a thorough and systematic manner. By combining desk research to collect academic knowledge (see section 3.2) with interviews to gather quantitative and qualitative data (see section 3.3), insights are gained to answer the research questions.

3.1) Delineating the Geographical Case-Study Areas

Since the innovation of ZFarming is seen in the context of urban transitions, the two most urbanized areas of the Netherlands and Denmark are considered as case-studies. For Denmark, the Copenhagen Metropolitan Region is set as a boundary, as presented in figure 5. With about two-and-half million inhabitants, an area covering 5500 km^2, and a population density of 427/km^2, it is the largest metropolitan area of the Nordic countries (OECD, 2009). As presented in figure 6, the Randstad region will serve as a boundary for the Netherlands. This Dutch megalopolis includes the nation's four largest cities, adding up to eight million inhabitants, spread over an area of 8287 km^2, thus making a population density of 1500/km^2 (Regio Randstad, 2017). It should be noted that actor networks in

niches are not inherently limited to national or regional boundaries; it is possible that transnational actors are involved as well. The boundaries of the chosen regions only account for the interviewee selection of ZFarming initiatives, even though some stakeholders of the project might be located in other areas or countries. For both countries, the selected urban regions account for approximately 45% of the total national population, thus the areas are relatively similar to locate ZFarming initiatives for the comparative case-study.

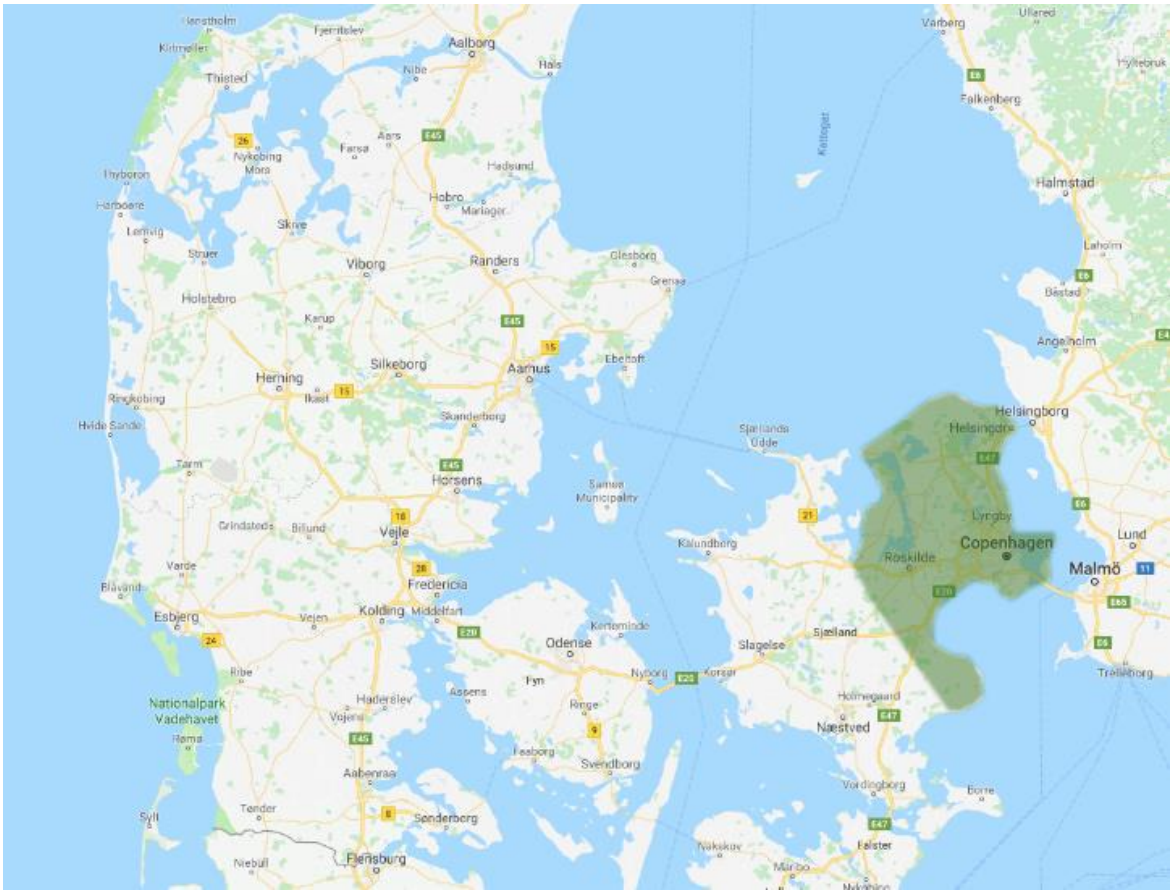

Figure 5: A highlighted Copenhagen Metropolitan Region in Denmark, consisting of the four provinces Copenhagen City, Outer Copenhagen, Northern Zealand and Eastern Zealand[3].

[3] Based on https://en.wikipedia.org/wiki/File:Copenhagen_Metropolitan_Area.JPG

Figure 6: A highlighted Randstad region in the Netherlands, including the four largest cities: Amsterdam, The Hague, Rotterdam and Utrecht[4].

3.2) Data Collection: Desk Research

Desktop research is one of the data collecting processes in this thesis, which refers to gathering data from academic articles, books, and grey literature to gain an outsider perspective of a certain topic. By exploring the literature lists in academic papers regarding the topics discussed in this research, additional articles about SNM, innovation ecosystems and intermediaries were found. Relevant background information about ZFarming has been gained by searching via platforms such as Scopus, Google Scholar, Google News, Google Search and YouTube with the following queries: urban agriculture, urban farming, rooftop farming, aquaponic farming, hydroponic farming, vertical farming, indoor farming, container farming, zero-acreage farming, ZFarming, stadslandbouw, and verticale landbouw. This way, academic papers, journalistic articles, blogs of universities, magazine publications, keynote presentations, documentaries, and videos could be consulted to gain a deeper understanding about sustainable urban food production. One goal of this process was to find interconnections in food innovation and short food supply chains. Appendix A is a result of the iterative desk research, as it led to insights by which the interviewees could be asked questions related to varying activities and recent

[4] Based on https://www.topomania.net/mapinfo/Basiskaart%20Nederland

developments and trends in the ZFarming and regional food industry. Since the market niche of ZFarming is in an early phase and constantly updating, new information has been found via desk research throughout the entire thesis process.

Next to contributing to general knowledge presented in this thesis, and influencing interviews, the desk research also supported the network mapping of the ZFarming niche. As a range of ZFarming initiatives and key stakeholders were mentioned several times in the desk research process, a basis for the network mapping was formed. By thoroughly researching these initial niche actors, for instance by visiting official communication channels such as social media or partnership pages on websites, additional niche actors were discovered and added to the list. By systematically iterating this research process, an initial mapping of the key actors in the ZFarming niche was achieved, which have been contacted for interviews in which more information and other important stakeholders could be found, leveraging the snowball effect, and creating an iterative mapping process.

The desk research process serves a multitude of functions. First, the collected academic literature offers a lens through which the quantitative and qualitative data can be analysed. Second, it provides a continuous flow of information in the rapid developing ZFarming market niche and the sustainable food industry as a whole, creating a better understanding of the topics and issues that are currently a part of this emerging ecosystem. These insights add to the interviews by asking relevant questions and addressing topics that matter for network formation in the ZFarming niche. Moreover, the desk research has contributed to mapping out the innovation ecosystems by systematically adding newly found niche actors to the overview, thus creating a list of actors that could be contacted for interviews. Lastly, the key insights from Appendix A were discussed in the interviews in an attempt to achieve *engaged scholarship*, referring to the direct practical application of this thesis' results by the ZFarming stakeholders.

3.3) Data Collection: Interviews

The second data collecting process consists of semi-structured interviews with main stakeholders of the ZFarming niche. Since the semi-structured interviews generates the bulk of the data in this research, the questions should be precisely formulated to collect relevant and useful data. Hence, a validation process has been conducted by using the first three interviewees as test-cases with an initial set of questions. Since the interviews are semi-structured, the interviewee can include information not directly asked via the questions. This helps to adjust the initial questionnaires to better suit to the purpose of the research and the practical reality as experienced in the field. After three interviews, the set of questions for the interviewees was adjusted towards creating more of a conversation and an exchange of knowledge, rather than a strict interview. During the validation interviews, the interviewee was asked to fill out a score for the quantitative questions. This self-scoring process created an unfavourable flow in the interviews, so after these initial validation interviews it was decided that the interviewer would fill out

these scoring points based on the answers related to the stakeholder roles and the outcomes of the desktop research. Confirmation of the scores was achieved by asking the interviewee for agreement. By conducting validation interviews, the set of semi-structured questions have been iteratively edited to better suit the data collection process.

The interviews with the actors in the ecosystem have been conducted with a set of questions based upon the integrated framework, consisting of both quantitative and qualitative question types. Appendix B presents these questions, covering a range of topics related to the actor's roles and activities in the network, as well as questions regarding niche protection processes. An important outcome from the interview is to receive data about an actor's own view regarding their role within the innovation ecosystem. To get this information, an actor was asked questions related to that role, based on the identified activities and role descriptions as presented in the integrated framework. For instance, questions related to the actor's degree of policy making or governmental influence were asked to indicate the scores for the regulator role. The scores for these roles ranges from 1 (not involved in role activities) to 5 (main organizational focus). The scores were attributed by the interviewer according to the actor's current activities and organizational importance, as well as future ambitions of these activities and roles. An overall percentage score was calculated by comparing the cumulative scores to the maximum amount that could be given. For instance, from a sample group of 10 interviewees, the maximum score of a specific role would be 50 if all interviewed actors indicate this role as a primary focus (5 points), which would result in an ecosystem role percentage score of 100%. This way, quantitative data is collected concerning the actor's own role in the ecosystem, allowing to see trends in the network formation process of the niche. The main aim of the quantitative data is to support the qualitative data that is collected throughout the interview, providing more insights in the concrete activities, contextual information, and events of the network formation process in the ZFarming niche. By collecting both quantitative and qualitative data about the innovation ecosystem via interviews, valuable insights are gained regarding the organization and formation of the network as well as the effective partnerships within it. These insights may lead to business opportunities for niche actors by fulfilling additional network roles or changing strategic positions in the ecosystem, thereby further developing the emerging ZFarming niche.

In total, 24 interviews were conducted with network actors in the Netherlands (n=14) and Denmark (n=10). In general, these actors serve central positions in the network and are therefore well connected. Additionally, most of these interviewees have a good perspective and overview of the niche, allowing to answer questions more in depth. Table 3 presents an anonymized overview of these organizations in Denmark, while table 4 lists the interviewees in the Netherlands. Unfortunately, the total amount of interviews conducted for this research is less than thirty interviews, which is widely acknowledged for reaching thematic saturation (Baker et al., 2012; Ragin, 1994). Thematic saturation

occurs when the stopping criterion is reached, which is generally defined as the moment when three consecutive interviews do not generate new data. However, some thematic saturation has occurred in this research as some interviewees would repeat what others has said, for instance about the need for new business models, information platforms, and local food distribution. The interviews were recorded via a smartphone and transcribed using the Express Scribe software. Analysis of the raw information collected from the interviews has taken place by layout techniques, highlighting relevant answers to discover overarching themes. This enabled to easily find useful empirical data and relevant quotes by searching the document for these highlighted topics. It should be noted that the interviewed organizations are both incumbents with many years of business experience, as well as start-ups that have been operational for a few months or years. This indicates a dynamic structure in the network formation process. It also makes network mapping efforts challenging as the ecosystem is quickly changing due to the rise and fails of start-ups. On the other hand, it could be argued that the incumbents in the network leads to a certain degree of stability due to the long involvement and sometimes decade long experience in the emerging field of regional food economies and short food supply chains. Via 24 interviews with a wide range of ecosystem actors, qualitative information and supporting quantitative data has been collected for this thesis.

Code	**Description**
DK01	Planning & construction - Supplier of experimental growing systems
DK02	Expert - University
DK03	Entrepreneur - Urban farmer
DK04	Entrepreneur - Urban farmer
DK05	Entrepreneur / Leadership - Circular economy hub
DK06	Planning & construction - Supplier of aquaponics systems
DK07	Entrepreneur - Urban farmer
DK08	Sponsor - Accelerator program, investor
DK09	Planning & construction - Supplier of seeds
DK10	Regulator - Local government

Table 3: An overview of Danish interviewees

Code	Description
NL01	Entrepreneur - Urban farmer
NL02	Entrepreneur - Urban farmer
NL03	Planning & construction - Supplier of aquaponics systems
NL04	Expert - University
NL05	Expert - University
NL06	Regulator - Local government
NL07	Sales & distribution / Leadership - Managing various SFSC platforms
NL08	Planning & construction - Reseller of container farms
NL09	Planning & construction / Expert - Supplier of climate control systems
NL10	Entrepreneur - Urban farmer
NL11	Sponsor - Accelerator program
NL12	Entrepreneur - Urban farmer
NL13	Entrepreneur / Planning & construction - Restaurant
NL14	Champion - Network organisation

Table 4: An overview of Dutch interviewees

4) Results

This chapter presents the key results of this research, based on findings in literature via desk research and qualitative data from 24 interviews with network actors in the Netherlands (14) and Denmark (10). Since the focus within the interviews was on understanding the ecosystem roles and network formation processes, section 4.1 presents the insights of the *quantitative scoring* for the representation of the roles in the innovation ecosystems. Based on these supporting quantitative results and the accompanying qualitative data, some clear patterns, such as overlapping roles and intertwinedness in the network could be observed, which is discussed in section 4.2. Concluding, section 4.3 offers a summary of the most important findings in this chapter.

4.1) Roles in the ZFarming Innovation Ecosystems

The next section provides the results of the quantitative data of the case study. For each of the eight roles, the scores from the network sample are presented. These scores are illustrated via quotes and experiences of the various activities from the interviewees. Since no actor was interviewed that could be considered primary a user from the direct value creation category in the integrated framework, this ecosystem role is not included in the results. Table 5 presents an overview of the role scores in the two ZFarming networks, while figure 7 and figure 8 illustrate these results in a visual way for the Dutch and Danish innovation ecosystem respectively. Appendix C provides a full overview of the scoring based on all the individual actors. It can be observed that the leadership, expert and entrepreneur roles are scoring high in the two networks, indicating that the associated activities are important aspects of the daily operations within the network sample of the 24 interviewees. Additionally, there are many opportunities for the sales and distribution role, as some food producing actors in this role wish to outsource their current logistics activities.

Dutch Ecosystem			Danish Ecosystem	
Network Role	**Score**		**Network Role**	**Score**
Leadership roles	67%		Leadership roles	74%
Planning & construction	60%		Planning & construction	68%
Sales & distribution	50%		Sales & distribution	56%
Expert	71%		Expert	72%
Champion	64%		Champion	56%
Entrepreneur	67%		Entrepreneur	74%
Sponsor	47%		Sponsor	36%
Regulator	56%		Regulator	38%

Table 5: An overview of the analysed quantitative data, collected from 24 interviews with actors in the Dutch and Danish ZFarming ecosystem. The scores indicate the overall involvement of the ecosystems regarding the various activities for a specific stakeholder type.

Figure 7: A visualization of the role representation score in the Dutch ZFarming ecosystem.

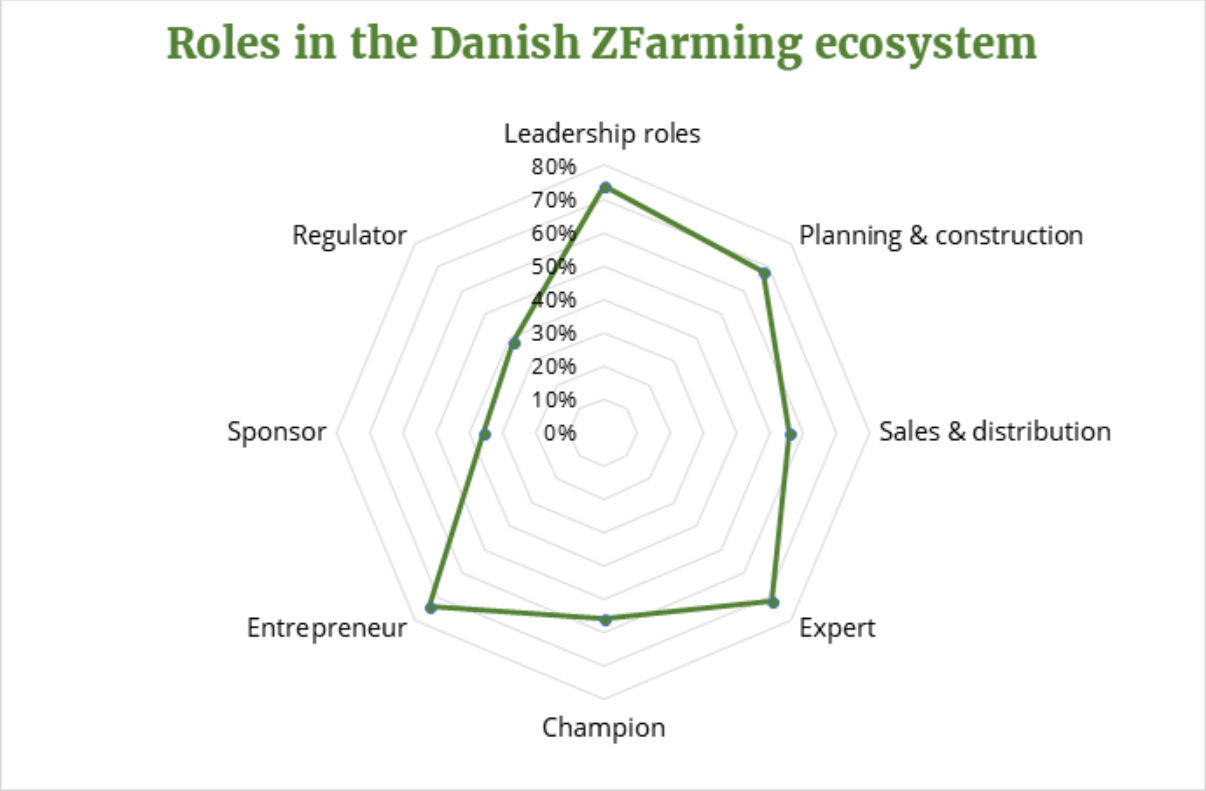

Figure 8: A visualization of the role representation score in the Danish ZFarming ecosystem.

4.1.1) Leadership Roles

In both network samples, the leaderships roles have a high representation, scoring 67% in the Netherlands, and 74% in Denmark. This indicates that many stakeholders in the researched ZFarming ecosystems are involved in leadership activities, such as building platforms, facilitating collaboration, and defining roles in the innovation network. DK05, DK08, DK10, NL06, NL07, NL08 and NL11 all score five points in this category.

NL06, being one of the few Dutch municipal departments dedicated to urban farming, argues that the city administration of Amsterdam has a major role in developing the niche. In the view of this actor, the municipality should provide information and subsidies to entrepreneurs and consumers, make regulations and policy changes that support the innovative combinations of waste, food and circular economy, as well as connect network actors in collaborative relationships.

> *"I see it as an important task of the municipalities because we have more of an overview than other actors, and because we do not have a direct interest"* (NL06).

Additionally, the urban farming city administration stresses that the topic of food touches various departments of a municipality, such as spatial planning, health, energy, water, and waste management, which should also connect internally within the governmental structures. Most people within the city administration are working on their own projects, thus some people should receive or allocate the time to make those connections - not only within the municipality but also with other governmental levels, such as provincial and national institutions. The idea that municipalities should be leading is also supported by NL05. Together with four municipalities, the researcher has co-authored the *Agenda Stadslandbouw* (Agenda City Farming) in 2013, in an attempt to bring local food production and urban farming to the focus of city administrations. "That proclamation has been signed by 27 municipalities in the Netherlands" (NL05). By involving city administrations in the transition and niche development process, the grassroots, bottoms-up initiatives can be supported by top-down policymaking and collective governmental agendas in the innovation ecosystem.

In the interview with NL06, it was explained that the municipality of Amsterdam has created a Food Vision back in 2014. One of the main goals published in that document was to set up a central information platform for urban farming and local food economies. "That was the need of an overview, connecting all the initiatives that were there" (DK06). By allocating some funds, and focussing on *co-creation*, bringing in several partners, the government initiated a process to fulfil that clear need from the niche actors. However, the project came to a halt after a few months, "that had to do with unclarity about roles, responsibilities, budgets, all sorts of things. [...] There was an evaluation, and the *conclusion was that the municipality had to be more leading in this process*" (NL06). After rewriting the project and the conditions, as well as broadening the project team with more

network actors, these challenges were overcome, leading to the launch of a digital information platform to provide an overview of the local urban farming network and to facilitate connections among the ecosystem actors. After a year of supporting the multi-stakeholder information platform, named *Van Amsterdamse Bodem* (From Amsterdam's Soil), the governmental budgets were diminished. The lack of a working business model for this type of activity threatens the continuation of the central information platform.

> *"This is of course also the quest of Van Amsterdamse Bodem: how do you find a business model to keep it in the air? The need to share information, to be visible, and strengthen each other is present. But who pays the bill for that?"* (NL06).

NL07 also aims to connect the network actors in the urban farming niche via digital platforms, with the main goal of realizing and facilitating short food supply chains. Based on a decade-long experience in this field, four levels of networks were described in the interview:

- Level 1: Local, me and my friends;
- Level 2: Regional, me and my partners;
- Level 3: National, a collective of regional networks;
- Level 4: European, a group of national ecosystems.

According to the platform builder, level 1 and level 2 networks are emerging everywhere. This corresponds with the research sample, as all actors indicated that had their own small networks. However, creating national, level 3 networks, is more difficult.

> *"[Level 3 is] the arena which is really about the transition. Then I meet the other cooperatives, which are known to us and which I know personally, but we do not manage to come to agreements to organize the logistics collectively, [or] work from one central ICT platform"* (NL07).

NL07 argues that the European subsidy programs do not support these national or European network scaling activities, as it would disrupt the market, which is against the law. Moreover, in the experiences of this interviewee, the actors in the collaborative regional food networks (level 2) are hesitant to give up a piece of ownership for the national collective (level 3). "So, the actors who started it eventually thwart" the development towards a national collaborative network to organize the growing amount of local food economies (NL07). In the Netherlands, actors scoring high on the leadership role are attempting to create digital information platforms and aim to facilitate (inter)national-wide networks of local food economies.

In Denmark, the city district of South Harbour in Copenhagen also recognizes a leading position for the municipality, as it was argued that bringing network actors together and facilitate collaboration among them is an important activity for local

governments (DK10). Copenhagen municipality has chosen the urban neighbourhood South Harbour as a key area to stimulate circular economy initiatives. One of the projects to stimulate circular economy in South Harbour was realized in collaboration with Climate-KIC, launching a start-up competition for circular economy innovation.

> *"Copenhagen municipality have many other projects going on with circular economy and also with food production. […] This project has kind of two levels; one level is me helping the three winners [of the competition] establish their business out here in South Harbour and also attracting other start-ups and creating sort of a living lab hub out here in South Harbour, a platform. But also just a network of people working in the field, a network that can help each other thrive"* (DK10).

Another example of the municipal leadership in Denmark can be gained from the interview with DK02, in which the municipality of Albertslund was brought up. The city a formulated strategy to stimulate urban farming and short food chains, however "the politicians that made the strategy dumped it onto the people in the administration, but they did not really know what to do with it, [and] did not have specific resources. So there is some good intentions, but there is not the organization" to really push these municipal efforts forward. Since the interaction between city administration and municipal politics are not streamlined, the organization of municipal strategies to stimulate urban farming and local food economies can be improved. Building networks, connections and information platforms for network actors in the urban farming and local food market niche is arguably one of the main activities for local governments or municipalities such as NL06 and DK10 in this early phase of the ZFarming innovation ecosystem.

The three finalists in South Harbour's start-up competition received modest budgets to develop their ideas and business plans further, supported by DK10 and Climate-KIC. Two of these finalists are working on solutions applicable to the field of circular urban farming, including DK05. Like the city district administration, the start-up also acknowledges the importance to create a physical location, an innovation hub in which several entrepreneurs can work together on circular solutions, enabling connecting resource flows and waste streams. In other words, the new start-up is aiming to create an *"infrastructure-as-a-service"* for circular innovation, so that companies in that hub, are provided with electricity, heat, a network, working space, et cetera. "The project that I'm seeing is this service platform that helps people to step into this urban farming or circular economy field" (DK05). Merely creating a digital platform that serves to connect the local food innovation ecosystem is not enough, "it is the physicality I'm after" (DK05). The physical platform approach of this Danish start-up is similar to the Dutch food and circular economy innovation hub initiatives such as The Ceuvel, BlueCity and The New Farm. Next to digital platforms to connect network actors, creating physical locations and

entrepreneurial hubs is also considered to be an important aspect of the leadership role (DK05, DK10).

Based on the network samples interviewed for this thesis, it can be stated that the leadership roles and its relevant activities are developed and spread over several stakeholders, both in the form of governmental institutions and businesses. Most of these initiatives aim to create digital and physical platforms to stimulate collaboration, attracting new network actors, and governing the ecosystem.

4.1.2) Planning and Construction Roles

The roles and activities related to the planning and construction category are reasonably well developed among the network actor sample in the two innovation ecosystems, scoring 60% in the Netherlands and 68% in Denmark. DK01, DK03, DK06, NL02, NL03, NL08, and NL09 scored five points, as they are actively focused on producing or distributing growing systems that can be used to produce food in an urban setting, while DK09 grows and sells organic seeds for urban farming initiatives.

DK01, focussing on agriculture in offices and buildings, stated that "part of our mission is to make local food production sexy, so more people will do it". Hence, DK01 is aiming to create aesthetically pleasing plant growing systems that are off the shelf, using parts of Ikea for instance. "So, you don't need to have a lot of skills and equipment, because then people won't do it, especially not if it is an office project". Besides aesthetics, price is also a factor in building growing systems. Just as leadership actors are struggling to find suitable business models for their platforms, the issue of economic viability also plays a role in activities within planning and construction. "When it comes to sustainability and urban farming, it has to be a mechanism that is self-supplying. We are very close with the [aquaponics] technology [...] but what we have not seen yet is a proven business model" (DK06). NL01 is constructing its own growing towers and systems to produce microgreens, arguing that the available vertical farming systems on the market are too expensive, which leads to higher prices for the produce. The goal of NL01's systems is "to be as cheap as possible" with the flexibility and options of adding sensors and data-collecting instruments for increased productivity and yields. In NL01's words: "I want to keep it as simple as possible, because I would like to expand to other cities and I think many of these types of projects are too technical". NL02 is distributor of an American vertical growing system in Europe and uses these towers to grow fresh mint. NL02 has stated that the goal is "to be an enabler of shorter food chains". By having actors in the ecosystem that produce or distribute growing systems that are affordable, aesthetically pleasing, and easy to build, local food production and short food supply chains can be enabled. The number of actors involved in these activities in the network samples can be classified as sufficient, even though there are business possibilities for more actors in this role.

Another topic that was recurring in the interviews is the balance between automation and ecological growing approaches in the urban farming niche.

> *"That is kind of the trade-off, because you want to be very efficient, and have automation and have AI and big data to help you become even more productive. But there is a trade-off because I also think what urban farming is about, is bringing the food production to the people, so they have more transparency and have more knowledge, and have more hands-on approach to what they eat. […] As soon as you start having robots growing your mushrooms and your vegetables in the cities, you might end up just having some of the same problems as the industrial agriculture has done wrong for the last 70-80 years"* (DK03).

NL02 and NL09 are proponents for controlled agriculture environments, as it is scalable and predictable. When there are proven climate-recipes that can be copy-pasted from one growing system to another, it is easy to produce the same vegetables in The Hague, Rotterdam and Amsterdam. "You know exactly beforehand what the output is, because I have control over all the variables. […] I am measuring everything, so I know what is happening, so I can also predict the yields". However, NL08, an organization who has distributed container farms for one and a half years but stopped this activity due to a lack of sales, provides insights in the financial case for these systems. "[As] the costs to produce in a container are a factor ten higher, compared to what is done in the Westland, so the effect of growing in the city has to count". The Westland is one of the main agricultural areas in the Netherlands and major food export regions globally, praised by its high productivity due to the highly technological greenhouses. Hence, having a ten times higher production cost in a container farm, compared to the Westland is challenging the economic sustainability of these urban farming growing systems. Even though the controlled environment approach helps to scale local food production in urban regions, the commercial and economic aspects are currently still difficult. Hence a balance between technological and ecological synergy should arguably be considered in urban food production efforts.

Network actors who are involved in planning and construction activities are somewhat present in the analysed ZFarming niches. However, these organizations struggle with balancing technological possibilities and ecological synergy, as well as have difficulties in creating viable commercial applications and business models for the utilization of the various growing systems.

4.1.3) Sales and Distribution Roles

Many interviewees, including many food producers, have stated that logistics and distribution channels for the locally grown produce are lacking and needed (DK02, NL01, NL02, NL03, NL05, NL06, NL07, NL12). This sentiment is reflected in both ZFarming

network samples, as there is a lack of sales and distribution activities, scoring 50% in the Dutch niche and 56% in the Danish ecosystem. DK04, DK07, NL07, NL10, NL12 and NL13 all scored five points in this category. DK04, NL10, and NL12 are food producers who take care of their own distribution at the moment but many of them want to outsource this task, while DK07 and NL13 have restaurants that serve locally grown food. NL07 scores five points in this stakeholder type, as it is one of the few dozen companies in the Netherlands that is focussed on building new distribution systems, serving as a regional hub for thousands of farmers in a radius of 75 kilometres from Utrecht. “You just notice that consumers want it [local food] delivered at home, and we are doing that. So, we are working on setting up a bicycle delivery network”. Distribution of local produce is currently part of the activities of urban farmers, yet many of them want to outsource this activity to dedicated local food distribution businesses.

NL05, having conducted research in the field of local food economies for over 10 years, argues that *distribution “is one of the most important bottlenecks”*. NL06 agrees and adds that the reason this aspect is a bottleneck “because it probably differs from the big system it is based on now”. NL02 has stated “in my opinion, the first gains can be made in logistics; eventually the produce has to move from here to the city.” Additionally, NL01 remarks “that some business customers do not want to have more than one or two suppliers”. So, it is important to aggregate the produce of several farmers in one hub, so that it can be delivered “as one whole” (NL01). The work of NL07 and similar local food distribution hubs, such as Københavns Fødevarefællesskab (KBHFF) in Denmark, try to fulfil these needs from the ZFarming niche, however there are opportunities for more actors in this role.

4.1.4) Expert Roles

The expert role is well represented in the two innovation ecosystems, scoring 71% in the Netherlands, and 72% in Denmark. Many stakeholders in the sample group are active in conducting fundamental or applied research (DK02, NL04, NL05), involved in educational programmes (NL03, NL07), or offer workshops, events, or consultancy services to spread awareness and knowledge about urban farming and local food systems (DK01, DK06, DK09, NL10, NL12). There is, however, a clear need for collaborative information systems. In the words of DK01: "There is no platform for sharing knowledge [...] and that is a shame". NL05 and NL06 argue that the knowledge about agricultural and horticulture in the Netherlands is world-class, and there is a market need from the consumer “but how to organize that in between, that is the black-box” (NL05). By having a collective knowledge base, networks actors do not have to reinvent the wheel and can build on previous initiatives, experiences and insights, this is currently lacking in the ecosystems.

Academically, the Netherlands is known for its extensive knowledge on agri-food technologies and greenhouse growing. However, according to DK02, funding research in the field of urban agriculture is difficult in Denmark: “We have been struggling to find the

right type of project where we can get sufficient funding for starting PhDs and post-docs in the general area of urban farming". In the Netherlands, the national government has reserved €11M for an experimental plant science facility called the Netherlands Plant Eco-phenotyping Centre (NPEC). This decade long project, should provide valuable insights about the influence of the external environment (the phenome) to plant growth and food production, supporting the indoor growing approach in the ZFarming niche (University Utrecht, 2018). Even though funding may be difficult to receive, academic research is being conducted in the two ecosystems, and a new generation of students are educated in plant science, climate-controlled food production, and other fields of study that are applicable for the ZFarming niche.

Open innovation and the open access to information is also a noteworthy topic in the two innovation ecosystems in relation to the expert role, as some new urban food producing entrepreneurs have received most of the necessary knowledge to start a urban farm from public sources. NL01 has watched Youtube videos from a channel called *GrowingYourGreens*, explaining "step for step how you can grow microgreens". NL02 has built the open-source food computer, created by MIT's OpenAg initiative, based on free and available information on the internet. Additionally, NL02 has been educated via the Upstart University, an online course to empower a next generation of hydroponic or aquaponic farmers. NL12 has gained many valuable information to start growing oyster mushrooms on used coffee grounds from a book by Paul Staments and a few workshops organized by other mushroom growers in the region. In Denmark these learning processes also take place, as DK07 and DK09 have partnered up to give workshops on fermentation, for instance. Moreover, DK01 and DK06 are sharing expertise in the field of building aquaponics systems, among other topics. These examples illustrate that the knowledge transfer processes occur both on an international, global scale with theoretical information via videos and courses online, as well as internally in the regional ecosystem to learn the practical side via workshops.

Based on the information gained from the interviewees, it can be stated that the expert roles and the related activities are well developed within the ZFarming networks, even though improvements can be made to access this knowledge in more convenient ways, for instance via open-source information platforms to share experiences and data within regional networks.

4.1.5) Champion Roles

The activities regarding the champion role are averagely executed in the network samples. The Dutch ZFarming ecosystem scores 64%, with NL05, NL11, and NL14 indicating it is a main activity. In the Danish innovation network, the overall scoring is 56%, with DK02, DK08, and DK10 as top scoring actors with four points. Almost all interviewees are networking to find suitable collaborative relationships for their own interest, but there are not many dedicated networking activities to connect two parties outside the actor's direct

interest. DK07 and DK09 are considering creating an umbrella organization that can serve a focused champion role, but at the moment of the interview, these ideas were not put into concrete actions yet. It should be noted, however, that many actors have indicated that they informally connect two parties with each other if a suitable moment arises, for instance on conferences and events or by organizing these gatherings of actors (DK03, DK04, DK07, DK09, NL03, NL04, NL07). NL14, a network organization with over 2200 members, views their members as the basis, "and to support those companies do business, we organize the network". Other actors agree with this approach, such as NL11, an accelerator program that transforms the technical proof of concept of start-ups in the agri-food industry into proof of markets. NL11 argues that "eventually introducing these start-ups in the ecosystem, network and to as many companies as possible, creates the most value." Having actors in the network that are actively connecting other stakeholders with each other is valuable and essential, and both ecosystems seem to develop these roles. In the words of NL14:

> *"The technological industry by itself will not have impact, you need to organize the entire network, because only the entire network can make progress"*.

The ZFarming ecosystem in the Netherland and Denmark contain a sufficient number of actors involved in the activities of the champion role. Networking is considered an important (informal) activity, and some efforts are made to create umbrella organizations that can dedicate resources to fulfil the activities of the champion role.

4.1.6) Entrepreneur Roles

The entrepreneurial activities are well represented among the interviewed ecosystem actors, scoring 67% in the Netherlands and 74% in Denmark. The network sample in this research includes many entrepreneurs and start-ups that are focussing on urban food production, such as NL01, NL02, NL10, NL12, DK03, DK04, and DK07. This group is growing, particularly in the niche of growing oyster mushrooms on used coffee grounds (NL10, NL12, and DK03). Due to the vast amount of available practical knowledge, proven business models, relatively low initial investment costs, and high market interest, this specific type of new entrepreneurship seems easy and safe to start. One recurring topic among the interviewees was the search for new business models, particularly from entrepreneurs. However, entrepreneurial activities do not only arise from start-ups, also incumbent players are innovating and investing in the emerging ZFarming niche. From a market organization and consolidation perspective, NL08 argues that "from the 80 [indoor farming] start-ups that are here, 70 will likely fail. […] And those other 10 will be bought by companies like Amazon". DK08 is another example of this type of intrapreneurship as it is currently pivoting from being a major player in the (fossil) energy industry to becoming a general partner for sustainability. "We see sustainability as our marketplace, so we will

broaden from energy into food and waste handling. […] What most customers are looking for, or lacking right now, is actually a partner who can take care a more broader sustainability agenda". Hence, they have set-up an accelerator program and investment fund to attract, support, and become part of the projects of new entrepreneurs, such as DK04's aquaponics rooftop project on top of a mall owned by a company that has nearly 200 shopping mall locations in Europe.

> *"We only invest in companies in which we can have a very active role. […] We are looking for partnerships, we are looking for an active business collaboration. […] We are there to take part of it and actually create something"* (DK08).

By combining new start-ups and entrepreneurial activities to partnerships with established organizations, significant niche development and scalability may become a reality. The results in this stakeholder type indicate that there are entrepreneurial activities in the ZFarming innovation ecosystem by new start-ups as well as incumbent organizations.

4.1.7) Sponsor Roles

The sponsor role is scoring the lowest engagement in the interviewed network sample, with 47% in the Dutch ecosystem and 36% in the Danish ZFarming network. DK08, NL05, and NL11 see the associated activities in this category as one of their main focus points. DK08 and NL11, both being accelerator programs, support and sponsor the entrepreneurs in the ecosystem with essential networks, business tools, training and some investment capital. Other actors, such as NL07 and NL14, are also supporting entrepreneurs grow. In the words of NL07: "We have spent some money to others while we could have used it well ourselves, we are no investment fund. We did invest money in instruments and offered opportunities". NL14 helps the entrepreneurial ecosystem by connecting entrepreneurs to more established businesses: "If we come across new ventures […] then we try to organize a sort of mentorship at bigger companies. […] By embracing them, we can offer them a large network." Moreover, the governmental institutions interviewed in this thesis (DK10, NL06) indicated that some subsidies and other financial benefits are available for new entrepreneurs on several governmental levels. Denmark's *Innovationsfonden* was mentioned a few times during the interviews, however the application procedure is said to be time consuming. Moreover, the entrepreneur does not know whether these efforts are being rewarded by actually receiving funds after the long application process. Additionally, the Innovationsfonden is focused on exporting the technology abroad, while most ZFarming initiatives are not in that phase yet as their efforts are concentrated on starting-up the new venture instead of scaling out internationally. Moreover, new initiatives such as EIT Food are a adding new accelerator programs and sponsoring activities to the ZFarming niche, a promising

development. Even though the sponsor role in the ecosystems is not yet very well developed for start-ups besides network introductions, there are possibilities for scale-ups in the ZFarming niche.

A few Dutch entrepreneurs (NL01, NL02, NL10, NL12, NL13) have found funding from friends and family, via crowdfunding campaigns, and through private investors, arguing that this way of funding a entrepreneurship brings a lot of freedom. A noteworthy example is the crowdfunding campaign of NL13, as it provides insights in a new way of funding ZFarming initiatives. In the early phase of this project, receiving a loan from the banks appeared difficult, as the market for a rooftop restaurant serving sustainable and local food and offering rooftop vegetable gardens was very new in the city. NL13 then decided to crowdfund their business idea via Crowdaboutnow, a platform that aims to attract people from the local community instead of crowdfunders interested in making a solid ROI of their investment. After 289 people joined as the community of the project, making the crowdfunding campaign successful, the banks approached NL13 for the remainder of the needed initial capital. By relying on crowdfunding first, building a community, thereby proving that there is market interest for the ZFarming initiative, it may become easier to find investments at traditional institutions such as banks.

Sponsoring activities are minimally available in the ZFarming ecosystem in the Netherlands and Denmark. There are some accelerator programs, subsidies and investors in the network, but it is in an early phase and sometimes difficult to find and apply for entrepreneurs in the urban farming networks.

4.1.8) Regulator Roles

The number of actors involved in the regulator role in the interviewed network samples for this study vary between the two case studies. The Dutch ecosystem scores 56% while the Danish network scores 38%. The innovation ecosystem in the Netherlands has more companies indicating that they are trying to influence or steer the regulatory frameworks as an extra activity in their operations, while the Danish actors that were interviewed are generally less involved in this type of activity. DK10, NL06, and NL07 scored the maximum amount of five points, indicating that regulatory activities are part of their daily tasks. Since DK10 and NL06 are local governments, this score is not surprising as both actors are actively listening to the needs in the market niche and trying to solve regulatory obstacles and challenges. NL07, however, is actively working on influencing European regulations for short food supply chains. This actor has written a proposal in 2013 to share insights in the importance of regional food networks. Even though the proposal was too radical at the time for the Dutch ministries, these ideas have since then become “formally part of a regulatory framework in the European Commission, so that is still very early in the starting phase” (NL07). Furthermore, NL07 argues that the bottoms-up movement is actively growing, so it is time to combine these grassroots activities with top-down regulations and policies to accelerate the sustainable food transition. Activities in the

regulatory role are currently still mainly executed by local governments, with the help of a few actors that communicate with these municipal institutions to help them gain a better understanding of the needs from the market niche.

4.2) Organisation of the Dutch and Danish Zfarming Ecosystems

Based on the interviews and literature research, it can be stated that the ZFarming networks in both countries are still in an early stage as the technological niche is slowly transforming into a market niche. The networks are complex, as roles, visions, activities, definitions, business models, regulations, and collaborative forms are being created and tested. The general sentiment among the interviewees indicates a growing interest in ZFarming and regional food economies from both municipality and national governmental levels, as well as from incumbents, start-ups, and consumers in the agri-food sector[5]. The network mapping efforts of this research, provided in section 4.2.1, illustrate this complex ecosystem of actors. NL13 argues that the general interest in this emerging niche is growing because it "touches many hooks that are really interesting in today's society [such as] urban farming, administrative reform, start-ups, [and] bottoms-up initiatives". However, there is not a clear guidance or general shared vision, as the actors in the network have varying interests and reasons to be involved in this niche, which ranges from generating public awareness for sustainable food (DK01, DK06, NL03, NL13), to improving circularity in the food supply chains (DK03, DK05, NL03, NL10, NL12), to actively trying to manage and organize the growing ecosystems and networks (DK10, NL06, NL07, NL14). Agriculture and food is a broad concept, which can be observed from many societal perspectives and governmental departments - such as health, education, social cohesion, water, and energy - making changes in this field difficult to streamline and organize (NL05). As NL08 simply puts it, "everyone is searching", referring to the wide range of uncertainties and opportunities in this emerging niche. The next sections shall therefore present the key findings of this thesis that illustrates this search process among ZFarming ecosystem actors. Section 4.2.2 discusses the two networks in terms of overlapping actor roles, as many niche actors are concentrated on several business activities that are associated with different ecosystem roles. Section 4.2.3 will shine light on this topic from the perspective of network intertwinedness, since several individual interviewees are involved in multiple organizational actors in the ecosystem. Based on the interviews, the organization of the Danish and Dutch ZFarming ecosystems is complex, which is illustrated in the network mapping, as well as observable via the overlapping roles and intertwinedness of the niche actors.

4.2.1) Mapping of the Dutch and Danish Zfarming Ecosystems

[5] Based on statements from DK02, DK03, DK06, NL03, NL08, NL09, NL13, NL14

One of the objectives in this research was to create a network mapping of the ZFarming ecosystem. This effort was not meant to realize a complete overview with all the actors but served several purposes. First, the mapping created an overview of network actors which could be contacted for an interview to collect quantitative and qualitative data. Second, it provides insights in the geographical positioning of the ZFarming ecosystem, which can help in the network formation process. In this way, the mapping efforts aims to create a topic for conversation in the interviews, in which the response and appreciation of the actors regarding to having such a tool for network formation purposes could be observed.

Figure 9 presents the mapped out Danish ecosystem, while figure 10 overviews a portion of the Dutch network. A first observation can be made in terms of localisation of the networks in the two countries. While Denmark has a concentrated core of ZFarming initiatives in the inner rings of Copenhagen, the city landscape in the Netherlands is arguably more spread out over several sizable urban municipalities. Since Amsterdam, The Hague, Utrecht, and several other cities have created open maps that overview the urban farming activities on a municipality scale, these urban areas have been populated with more actors in the map than other cities. The municipality of Almere, which has ambitious plan for urban farming and regional food economies, is also working on such a mapping initiative with over a hundred projects (NL05), however, this map has not been included in this research effort. An important observation is that the municipality of Copenhagen, or one of its city districts administrations, are not really involved in official mapping efforts. According to DK10: "There have been several attempts, I am not sure if anyone of them are still active. […] I have seen maps of initiatives".

The response on these maps among the interviewees was generally positive, as most actors from the network sample found it useful to have the overview, allowing to easier form potential collaborative relationships. NL03 "would love to see more connections in the entire network. […] In my opinion, we need to collaborate more. […] I think your overview helps greatly" to see where these connections can be made. However, it is acknowledged that maintaining and updating these maps is rather difficult. A colleague of NL06 is responsible to map out the urban farming initiatives in city district Amsterdam West and has collected more network actors in that area than the general overview of the municipality of Amsterdam. Hence, NL06 argues that "there are too many things happening. […] To really map it out and update it, is nearly impossible". According to DK09, "there has been many steps towards making […] a formal network of urban farmers" in Denmark but argues that it can maybe do without these formal umbrella organizations. As mentioned in section 4.1.1, the expenses and human resources needed to create and maintain a central, up-to-date interactive map are difficult to fund. There are examples of user-generated information platforms that are reliable and self-sustaining, such as Wikipedia or Dutch bird mapping initiatives, which can be learned from. Additionally, initiatives such as The Open Food Network are making an international

open-source platform with mapping features for short food supply chains, supported by an underlying foundation. However, due to the increasing usage of the platform, the organization has stated that "Governance arrangements for the Open Food Network are currently under review with our growing international community, and the Foundation's role may evolve in this process" (Open Food Network, n.d.). New business, participation and governance models for these types of mapping initiatives should be investigated, since having an overview of network actors fulfils a need among the interviewees.

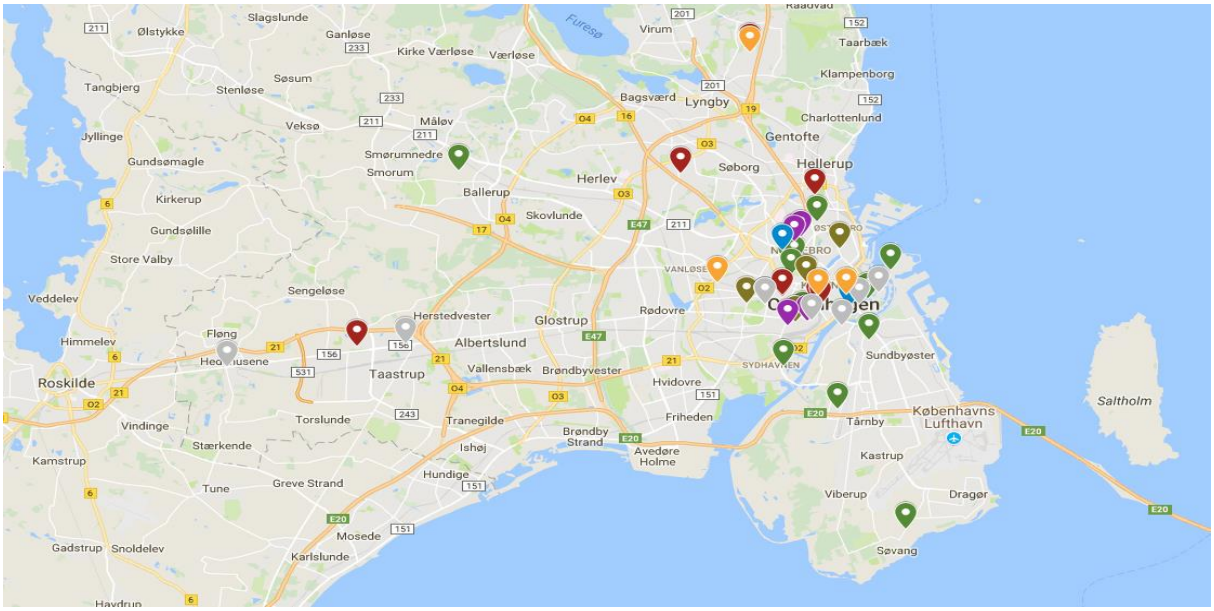

Figure 9: A geographical mapping of the Danish ZFarming ecosystem[6].

Figure 10: A geographical mapping of the Dutch ZFarming ecosystem[7].

[6] An interactive version of the Danish ecosystem map is available.

[7] An interactive version of the Dutch ecosystem map is available

4.2.2) Overlapping Roles in the Dutch and Danish Zfarming Ecosystems

When observing the results of the quantitative data, it can be argued that a few roles are carried out by a wide variety of network actors. The associated intermediary activities - such as the creation and facilitation of networks, gatekeeping and brokering, configuring and aligning interests, managing financial resources, and managing human resources - are linked to multiple roles in the integrated framework. This correlates with the high scores of the leadership, expert, and entrepreneur roles, meaning that the associated activities for these roles are widely shared among actors in the two network samples. In other words, the intermediary activities regarding gatekeeping and brokering information, configuring and aligning interests, and the creation and facilitation of new networks seem to be carried out by the majority of the organizations in the networks in this phase of the network formation in the innovation ecosystem. The next section provides more insights in these overlapping roles and activities in the two ZFarming innovation ecosystems, based on the network actor's need of collaborative platforms and new business models.

Since nearly all actors in the research sample are looking for new partners and suppliers to extend operations, it can be argued that the network formation in the ZFarming niche is heavily self-organized within the ecosystems. However, this networking process is, to a certain extent, facilitated by actors scoring high in the leadership role. Considering NL07's model of four levels of networks, the efforts of creating both online and offline platforms or collaborative environments are enabling local networks (level 1) to extent and grow to regional networks (level 2). In both the Dutch and Danish ecosystems, this is achieved by separate efforts of governmental organizations and initiatives of businesses. In Denmark, for instance, DK07 and DK09 have discussed a potential collaboration to create an umbrella organization. This urban farming association for the Copenhagen area would stimulate knowledge sharing, network formation, and overall growth of this emerging field. The Danish city of Aarhus has already founded this type of organization via the Green Embassy (DK02). Called *Smag på Aarhus* (Taste of Aarhus), this initiative seems similar to Dutch regional information platforms like *Eetbaar Utrecht* (Edible Utrecht) or *Van Amsterdamse Bodem* (Of Amsterdam's Soil). According to a rooftop farmer, making an umbrella organization is "something we really need in Copenhagen [...] because I feel a lot of people enter the scene through us, we are the receptionist, but we don't have the full perspective of what is going on either" (DK07). As described in 5.1.1, the Dutch ecosystem has many regional information platforms, and there have been actionable efforts to realize a national version too. These information and networking platforms are often realized with the support of the local government. "The city administration of Amsterdam had a basic task to inform what could be done with city farming, the municipal policies, subsidies, that is all municipality Amsterdam. Next to that, a lot is happening outside the municipality, [such as] initiators who want to do and show a lot of things" (NL06). Having a dedicated organization or platform to create an

overview of the network, exchange information and experiences within the ecosystem, and connect with other network actors is an important need within the two ZFarming market niches. The intermediary activities of the most represented roles, gatekeeping and brokering, configuring and aligning interests, and the creation and facilitation of new networks, match with this need of an information platform.

In addition to the general need of networking and sharing information within the ZFarming niche networks, there is a common trend to explore new business models by diversification of activities and revenue streams (Silva & Pfeiffer, 2016). This trend can be observed in the case study sample; many individual interviewees and organizational network actors have several and diverse roles, sometimes among various sub-networks. DK07, for instance, produces food in an urban setting via a CSA model, offers workshops, consultancy, and educational training programs, and manages a restaurant serving their own fresh produce as well as food from other farmers in the region. A Dutch aquaponics systems builder argues that the diversification strategy leading to various revenue streams is necessary to run a economically viable business in this emerging industry (NL03). One popular and easy method to diversify business activities is to share information and knowledge in the expert role. As discussed in section 4.1.4, many entrepreneurs in the ZFarming niche share expertise via workshops, consultancy services, educational programmes, and events. Having these activities next to urban food production or building growing systems keeps many of the start-ups afloat, as new business models are being created and tested. The need for new business models is a recurring theme among the interviewees, in all stakeholder types. “At this moment sustainable production asks for more expenses, or at least new business models - that is the entire playing arena of innovation” (NL14). In search of new business models, organizational activities and resource flows have become more diversified in the ZFarming niche, which may have resulted to overlapping roles in the innovation ecosystem.

4.2.3) Intertwinedness in the Dutch and Danish Zfarming Ecosystems

In addition to overlapping roles and activities in the ecosystems, there is also intertwinedness in the two networks. In the context of this thesis, intertwinedness is referring to the individual level of connectedness of the interviewees, as some of the individuals that were interviewed are part of several organizations in the network, not only the organization represented for the interview. Two examples of these extra organizations from the Dutch ZFarming ecosystem include the *Transitiecoalitie Voedsel* (Transition Coalition Food) and *Stadslandbouw Nederland* (Urban Farming Netherlands). NL07 and NL11 are part of the former, “a new coalition of Dutch pioneers in the world of agriculture, food, nature, and health [...] an integral approach to the transition of the current food system to a system in which sustainability, health, transparency and true cost are central, with perspective for the farmer” (Lageweg, 2018). The association consists

of more than 100 organizations and is growing quickly. By being part of this coalition, network actors can organize themselves collectively, increasing the amount of outreach and political influence to achieve the common goals. NL05 and NL06 are involved in the Stadslandbouw Nederland initiative, which has flowed from a previous project named *Stedennetwerk Stadslandbouw* (City Network Urban Farming). The goal for this initiative is to organize a national network for actors in the urban farming space. Moreover, interviewee NL05 is also working for two educational institutions, further intertwining the connections in the network. In Denmark these collective initiatives are also present. One interviewee growing mushrooms from used coffee grounds, for instance, is part of a business council for circular economy, stating "We sometimes do not really fit into the boxes that the policy makers have [as] we are trying to push the ideas of what waste is and how to treat it. So we are somewhat involved in that, [but] we are not politically active in a politician kind of way" (DK03). Several individual interviewees are involved in multiple organizational actors in the ZFarming ecosystem, illustrating the intertwinedness in the network.

4.3) Summary of Results

In this chapter the collected and analysed data from desk research and interviews was provided. Section 4.1 presents an *overview of the quantitative scoring* for the representation of the roles in the innovation ecosystems, as described in the integrated analytical framework. The leadership, expert and entrepreneurial roles scored the highest. These scores indicate the involvement in the associated activities per role among the interviewed actors of the ZFarming networks. Additionally, a clear need for sales and distribution roles could also be observed in the ZFarming ecosystems, specifically the logistics of local and urban food. Several urban farmers have indicated to outsource the logistics of their urban grown produce in the future, and several interviewees working as researchers see distribution as a bottleneck for niche development, a possible interesting field of future research.

The results of the network mapping efforts are described in section 4.2.1. By creating the geographical network map, potential interviewees could be identified and contacted. Additionally, it supported the interviews with a topic of conversation regarding the need and perceived value of these types of network mapping initiatives. Most interviewees were interested in these types of informational platforms, as it would help find partnerships and collaborative relationships. However, a self-sustaining economic and governance model for these informational platforms and mapping initiatives is yet to be proven.

Based on the quantitative results and the accompanying qualitative data, two clear patterns could be observed. First, as many organizational actors in the research sample are involved in several activities spread over several roles, there is a pattern of *overlapping roles in the ecosystem* (section 4.2.2). This is mostly observed in the leadership, expert and

entrepreneur roles based on the associated intermediary activities of these ecosystem stakeholder types. The overlapping roles can arguably be contributed to the need of a central and open information platform in the niche, as well as the search among network actors towards novel business models that combine several streams of revenue. The second finding that is discussed is the *intertwinedness of the network* (5.2.3). From an individual level, several network actors are involved in several organizations in the ecosystem, representing different roles and interests. By being part of several organizational actors, an individual can reach multiple networks, expanding the reach of influence and collaborative relationships, thus leading to intertwinedness in the network. This chapter presented the most important empirical insights, however, some more results are discussed in the next chapter in relation to different perspectives.

5) Discussion

This chapter aims to link the empirical insights from previous chapter to the theoretical understandings within the SNM and innovation ecosystem literature as well as research comparing sustainable technology diffusion in the Netherlands and Denmark. Based on the collected data, some key differences between the Dutch and Danish ZFarming ecosystems are found, presented in section 5.1. First, the spatial and geographical aspects of Denmark and the Netherlands are discussed. Moreover, the Danish and Dutch ZFarming ecosystems are compared in terms of the leadership, entrepreneur, and regulator roles. Next, in section 5.2 the three internal processes for niche protection in SNM literature - shielding, nurturing, and empowerment - are described in relation to the results of this thesis. Lastly, the limitations and shortcomings of this thesis are discussed in section 5.3.

5.1) Comparing the Dutch and Danish ZFarming Ecosystems

The following section presents a comparison with the most noteworthy differences and similarities between the formation of the two networks in the ZFarming niche. From a spatial and geographical perspective, the Dutch and Danish urban farming areas are similarly small compared to metropolises on the American or Asian continents, allowing for local food production in peri-urban districts instead of indoor growing. As noteworthy differences between the roles in the ecosystems could be observed in the activities associated with the leadership, entrepreneur, and regulation archetypes, these differences in network actor roles are emphasised in this section.

5.1.1) The Spatial Niche Model and Geography of Local Food

The case study areas are quite similar in terms of the spatial context, allowing for similar approaches in deploying urban farming technologies, also in the fringes of urban hotspots. Since much of the urban farming literature is focused on indoor growing examples from the United States or Asia, the ZFarming niche actors in Europe may arguably receive de-contextualized and abstract global knowledge that might not be suited for the spatial conditions in these smaller urban areas. Living in a city with 10 to 20 million inhabitants is rather different than the capital cities of the Netherlands or Denmark, which have a tenth of that population. Hence, there is available agricultural and rural land just on the outskirts and edges of the city, a mere hour drive from the centre of Amsterdam or Copenhagen. In the context of many megacities, these spatial agricultural edges are not common. Thus, in the literature from those geographical areas, peri-urban regions are not commonly suggested as possible urban farming locations. Indoor farming

initiatives and vertical growing technologies might be more suitable in the megacities located in more populous countries, while cities in tiny nations such as Denmark and the Netherlands have local food production possibilities in peri-urban environments. An interviewed rooftop urban farmer agrees with this statement and argues:

> *"I think why commercial urban farming is not breaking through in Denmark is because it is such a small market. […] It is only 5 million people, it works in New York where there are 20 million people eating lettuce a day. […] So, you cannot apply the American or the Eastern business models in small markets like the Danish market or the Dutch"* (DK04).

This idea of de-contextualized knowledge, between influential books on urban farming based on practises in The States and applying this information in a European setting, matches with academic research on geographical variations in niches and the differences in network dynamics by Sengers & Raven (2015). Their research presents two niche models in this context: a conventional local-global niche model and a *spatialized niche model*. The former model confines local networks to a single project in a specific geographical area, while the latter views "networks as multi-scalar arenas where international, national and regional interests are negotiated to facilitate the development of projects" (Sengers & Raven, 2015, p.171). In terms of knowledge sharing, the local-global niche model views local knowledge as practical and contextualized, and global knowledge as abstract and de-contextualized. According to the spatialized niche model, knowledge is exchanged along with the actors operating globally by connecting localities. In other words, by viewing the niche from a spatialized perspective, more nuance in the various network levels is given, while the local-global niche model is more rigid in separating geographical boundaries. These theoretical geographical niche models help to understand certain phenomena in the Danish and Dutch network formation process.

One clear example in this context is the idea of 'local food' in the United States compared to the Dutch or Danish contexts, which varies widely in distances (NL09). Whereas a radius of 300-400 kilometre is typically considered 'local' in North America, a range of 50-75 kilometre is commonly used in the Netherlands (NL08). "If you would set out local [food] in the Netherlands to America, then everything in the Netherlands is local" (NL03). Therefore, relatively small urban areas like Amsterdam or Copenhagen with agricultural land on the outskirts, can use these edges to produce food that is consumed within that city region, creating shorter food supply chains and stimulating the ZFarming network building processes. However, many of the farmers in these peri-urban areas are distributing via the incumbent system in which wholesalers, logistics, and retailers are involved, leading to more expenses, increased food miles, and nutritional degradation of the produce compared to regional food economies with short food supply chains (NL05). Additionally, these farmers are usually growing with traditional methods on soil, while more sustainable greenhouses and hydroponic systems could also be deployed in these

peri-urban farms. Even though there are agricultural fringes in peri-urban areas, the urban farming methodologies and technologies to create short food supply chains are not commonly leveraged.

5.1.2) Leadership Role: Meta-actors, Spatial Clustering and Geographical Linkages

Activities associated with the leadership role are characterized by the organization and expansion of the network by creating platforms, adding actors and aligning their interests (Dedehayir et al., 2016). In both case studied ecosystems, actors are involved in these activities, indicating the emergence of what Raven (2005) calls 'meta-actors'.

> *"In the beginning, the actors' commitment to the niche is limited; they do not yet have many vested interests and withdrawal does not result in large losses. Furthermore, the role of actors in the network may be unclear: supplier-producer-user relationships have not yet stabilised, it is unclear who the user is, and firms lack long-term security of supply. In the course of time, when actors have gained more experience, the role of actors and their relations becomes clearer. There may also be specific meta-actors that coordinate interactions in the network (e.g. platforms) and stimulate expansion of the network"* (Raven, 2005, p. 40).

The Danish actors in the leadership roles are focused on creating physical hubs, meta-actors in which initiatives in circular economy and food innovation can be combined. This is quite similar to a few meta-actor organizations in the Netherlands, such as the Ceuvel, BlueCity and The New Farm. In both the Danish and Dutch ecosystems, the initiatives to start a meta-actor organization have received municipal support, indicating the important role for local governments in the leadership role. The development of physical innovation hubs shows that the Danish ZFarming niche is developing similar infrastructure and experimental platforms to that of the Dutch ecosystem a few years ago. The Dutch actors in the leadership role are, at the time of the interviews, more concentrated on building digital collaboration and information platforms in an attempt to realize meta-actors that aim to connect local food economies together in regional, national, and transnational ecosystems. These activities relate to the spatial niche model perspective, as described by Sengers and Raven (2015): "Local experimental projects are embedded in both field-level structures and territorial structures. The local and global are entangled: the local is global when place-specific projects are connected through transnational linkages" (p. 171). Even though the need for these meta-actor digital platforms also exists in the Danish ecosystem, there are no concrete plans to realize it. Since the Dutch ZFarming niche might have been ahead in developing physical and digital meta-actors, the question remains whether Denmark's ecosystem will follow the same trajectory or whether it is steered in by different underlying aspects in the niche.

One of these varying niche aspects may be found in the way learning processes are facilitated by network formation activities of actors and meta-actors in leadership roles. While the Danish ecosystem is more focused on spatial clustering and local communities, the Dutch network is aiming to create regional and national geographical linkages among actors. Both approaches contribute to the network building process of the niche as it allows to connect ecosystem actors and share information among them, attracting new organizations to the network. Taking into account previous research conducted into the development of sustainable technology niches in Denmark and the Netherlands, Kamp et al. (2004) studied the learning processes in the wind power niche, concluding "that in Denmark, learning by interacting was the most important learning process, while in the Netherlands it was learning by searching" (p.1625). Learning by searching refers to an innovation ecosystem that facilitates conditions in which a technological guidepost, standards and regulations, or appropriate scientific theory guides the direction of search. In the Dutch ZFarming network, the scientific knowledge on agriculture and plant science is considered world class, hence it can be argued that this "systematic and organised search for knowledge" (Kamp et al., 2004, p. 1627) guides the developmental direction of the niche. The emphasis on information platforms by meta-actors in the leadership role, in an attempt to create regional, national and international geographical linkages, can be contributing to an underlying knowledge-driven aspect of the Dutch niche. Learning by interacting refers to the conditions of openness, mutual interest in the learning process, and (spatial) proximity in the network - conditions that can be found in the physical locations in the Danish ZFarming ecosystem. By utilizing learning by interacting, the Danish wind-sector niche has grown into global dominant actors in the wind energy industry (Kamp et al., 2004). Hence, an argument can be made that learning by interacting and spatial clustering can be an important approach in network formation processes. While the leadership roles in both ZFarming ecosystems are working on creating platforms to facilitate the network formation processes, the Danish niche is focused on building local physical hubs, community and spatial clustering, while the efforts of the meta-actors in the Netherlands are also aiming for digital information platforms and knowledge sharing, as well as realizing regional and national geographical linkages.

5.1.3) Regulator Role: Municipal Urban Farming Departments and City Deals

Activities in the regulator role support entrepreneurial activity and ecosystem emergence by providing favourable policies and economic conditions (Dedehayir et al., 2016). In the context of this section, however, this definition is broadened to encompass city administration organization and general governmental involvement as well. Two main points are discussed in the following paragraphs. First, the emergence of dedicated civil servants and municipal departments for urban farming. Second, the collaboration between municipalities and local governments via the *UK City Deals Model* or other

approaches. With regards to these aspects of the regulatory role, some differences between the Dutch and Danish ecosystems can be observed from the collected data.

Even though it is a recent development, some the cities in the Netherlands are creating dedicated city administration departments for urban farming. Cities like The Hague, Amsterdam, and Ede all have full-time civil servants to facilitate and stimulate ZFarming niche building. This is not yet the case in the Copenhagen area studied in Denmark. Even though some civil servants in Copenhagen are full-time employees for circular economy projects, the specific field of urban farming does not have these human resources yet (DK10). Though, it should be noted that the municipality of Albertslund in Denmark has a working vision and actionable plan for urban farming, stating "Albertslund municipality is building a citizen- and consumer-driven approach to urban farming" (Albertslund Kommune, 2016). By creating a food cooperative, the small Danish municipality is actively working towards a food system with communal ownership and democratic governance. "In the municipality they have central offices and warehouses of this coop, which have flat roofs. In their vision, the coop can incorporate urban farming as part of their offering" (DK02). In sum, it can be stated that in both the Dutch and Danish ecosystems, an increasing amount of municipal human resources are working on facilitating the urban farming niche by active involvement in the network, though the Netherlands has many dedicated city departments while this municipal involvement is just emerging in Denmark.

A second interesting development from municipality actors is the collaboration between city administrations in the context of the regulatory role. During the interviews with Dutch ecosystem actors, the *Citydeal Voedsel* (City Deal Food) was mentioned several times (NL05, NL06). The City Deal model originates from the United Kingdom, in an attempt to make city regions more autonomous. "City Deals give local areas specific powers and freedoms to help the region support economic growth, create jobs or invest in local projects" (United Kingdom Government, 2013). The Dutch ZFarming ecosystem has seen an agreement of twelve city administrations by signing the 'City Deal Voedsel', a shared actionable plan to create city-based food economies. The interviewees from the Danish network did not indicate these types of programs. By making use of the City Deal model, several Dutch municipalities have more possibilities to facilitate and stimulate the urban farming niche.

5.1.4) Entrepreneur Role: Community and Coopetition

The entrepreneurial role refers to actors involved in activities regarding starting new ventures around a vision by co-locating, setting up a focused network and collaborative relationships for the new business (Dedehayir et al., 2016). Based on the interviews, it can be argued that the Dutch entrepreneurs are more focused on commercial applications of urban farming technologies, while the Danish entrepreneurs in the ecosystem emphasised community, sharing, and collective ownership more. According to DK08:

"There is a lot of community. And it is very easy to make communities around stuff". DK03 agrees and states that "there is a lot of interest in it [urban farming], and there are a lot of people in Denmark embracing the community-style of organizing". DK06 is a proponent of the cooperative structure, creating shared value among the stakeholders: "there is a farmer and a community supporting him, and not just by buying his food; they support him every month and they receive a [food] box". These observations also link to the biomass niche development in Denmark in the 1980s, when "farmers began to establish biogas plant cooperatives" (Raven, 2005). The community focused approach is quite typical for the Danish niche development and network formation process.

Based on the network sample in the Dutch ecosystem, it can be stated that the entrepreneurs are more anxious about collaborating with competitors. This so-called *coopetition* dilemma can be illustrated by for instance NL03, stating "we are all happy that other parties are working on it when we meet each other, but I think that there is also a bit of the old thinking in the way, like 'I am not going to share too much of my own thing with you, because it might result in losing money'". According to Planko (2018), "little research has been done on how competitors manage coopetition processes at the network level to reduce risks from collaboration and increase its potential benefits". However, Brandenburger & Nalebuff (1997) published a book about the topic of coopetition in which game theory is proposed to navigate the complexes of collaborating with competitors. So, there are certain coopetition strategies available for the Dutch ZFarming entrepreneurs.

Lastly, as mentioned throughout in section 4.1, both the Dutch and Danish entrepreneurial environments are experimenting with new business models. "If we talk about which important role urban farming can play, then is that in those new business models combining city functions with food production" (NL05). These city functions can shift from more technological and commercial development stimulation, to more socio-economic functions, as was the case with the biomass niche (Raven, 2005). Research by Raven and Verbong (2007) adds that niches generally do not have one function, instead the protected spaces balance out various functions over time in various regimes. Even though the ecosystem in the Netherlands is arguably a bit more competitive than the community-oriented Danish niche, both entrepreneurial networks are struggling to create and implement novel business models to balance economic sustainability, coopetition and function. "It is rethinking business [...] that is the biggest hurdle of all" (DK04).

5.2) Niche Protection and Development

A last objective for this thesis is to gain insights in the niche protection and development processes. Based on the results, each internal process of niche development shall be discussed, providing insights in the shielding, nurturing and empowerment aspects of niche growth in the Danish and Dutch ZFarming ecosystems.

5.2.1) Shielding processes

Shielding processes aim to protect an emerging niche against pressures from more matured and dominant industry structures or political power. “An analyst interested in shielding would question how such a support program came into place, who had lobbied for it, how, and so on” (Smith & Raven, 2012, p. 1027). To resist the external market pressure, an emerging niche can for instance receive government subsidies, favourable policies, or special city planning arrangements (Smith & Raven, 2012). From the information collected in the interviews, it can be stated that these conditions are increasingly developed in both innovation ecosystems. However, there are some caveats and challenges in relation to slow regulatory reforms and the legality of novel circular business models. Additionally, subsidies are a major tool for niche shielding. However, issues such as the time-consuming process of finding and applying for subsidies, subsidies leading to challenges in profitability, as well as the substantial subsidies for the traditional agri-food industry result in the questionability of the effectiveness regarding these subsidy programs.

In both the Danish and Dutch network samples, some actors indicate regulatory issues regarding lacking city planning (DK07, NL13) and waste management (NL12), making their operations illegal. According to a rooftop farm in Copenhagen, one municipal department, the Climate Neighbourhood Office, played a major role in finding the rooftop location and connecting the initiative's team to the private owner of the roof (DK07). Consequently, the project could fairly quickly start construction and begin a pilot. However, since the roof was planned on paper as a parking lot by the city administration, the urban farm was technically operating illegally until a new location for the parking lot was found. Yet, the project is promoted to illustrate the green and innovative character of Copenhagen and is easily findable online due to a sizable number of articles and write-ups about the project. “We just make a very good example and we are super illegal. […] We have been fighting about this for four years now” (DK07). Related to the city planning issues of DK07, one interviewee working at the municipality of Copenhagen, argues that there are challenges regarding price for locations and land for urban farming projects in the urban metropolis.

> *“I think one of the things holding urban food production back, here in Copenhagen, is also just the price of land here. So, it is almost impossible to find somewhere where the price is not abnormally high. And that is one of the things Amsterdam can do differently, they can price it and own the land in another way than Copenhagen does. So, they can have another system for renting out. And even though I am working for the municipality, I cannot magically find land for people”* (DK10).

In Amsterdam, The Hague and Haarlem examples can be found in which the municipality supports the entrepreneurial ZFarming activities with discounted rental expenses for a

plot of land or municipal-owned building. This process of special city planning arrangements, however, can take multiple years to organize. The rooftop restaurant and community garden project of NL13, for instance, also had challenging years to arrange the location on top of a municipality-owned parking building. Being inspired by London's extensive rooftop usage trends, the entrepreneurs wished to accomplish a similar experience in the Netherlands. However, since the concept of using rooftops for social and food related purposes is still very new in the city of Haarlem, the land-use planning of the municipality was conflicting with the ideas of the entrepreneurs. Eventually, after many talks over a four-year period, an agreement was reached, resulting in the construction of a rooftop restaurant that aims to subtly inspire sustainable food habits for its customers. Since the rooftop of the parking garage was owned by the municipality, NL13's example is different than the non-municipality owned rooftop of DK07, which allowed for quicker, yet illegal, construction of the project. Yet the Dutch municipality was able to change its city planning quicker than the case in Copenhagen. Another notable example of hindering regulations can be found in the story of an urban mushroom grower that is producing illegal food by transforming used coffee grounds into edible products:

> *"I am actually breaking the law, because I grow on waste, used coffee grounds is seen as waste. […] I talked to the city administration about it. […] And they agree, but those laws are made to protect the consumer. […] So you cannot change that easily"* (NL12).

Some regulatory frameworks and legal issues regarding city planning and circular waste management are arguably bottlenecks for niche development, slowing down entrepreneurs and thus the growth of the network formation process. Hence, it can be stated that there are some challenges in the shielding process that should be overcome in order to realize more favourable conditions in the niche that suit the novel circular business models and locations of ZFarming entrepreneurs.

Another important approach in the shielding process are subsidies and financial benefits for niche actors (Smith & Raven, 2012). Subsidies are available in the ZFarming niche via various levels of governmental institutions; from European funds to national subsidies and municipal budgets (NL06, NL11). However, as briefly discussed in section 4.1.7, it can be difficult to find suitable subsidies. "I think subsidies are a jungle. There are innovation subsidies, but specifically for food are difficult to find. And what is available in food, is more focused on the old way" (NL03). "At the Province of North-Holland and the Municipality of Haarlem, I did not find in which subsidy budget we could position ourselves into. […] Eventually it is not about that what you are going to do completely suits a subsidy, but you just have to adjust to a subsidy and do that" (NL13). Hence, the entrepreneurs decided to fund the rooftop restaurant via crowdfunding and traditional bank investment options, instead of making use of available subsidies. A provider of short food supply chain platforms, argues that subsidies to form national networks are missing,

for example subsidies that enable "investing in collective logistics, professionalising the marketing, optimizing data and ICT tooling" (NL07). Collaborating on a larger scale requires extra investments, which is difficult to realize for most network actors, so subsidies in this field could be explored. Subsidies that suit the novel approaches of ZFarming initiatives are lacking and difficult to find, therefore some network actors are finding other means of financing, not utilizing subsidies as a niche shielding mechanism.

Moreover, not all network actors are enthusiastic about subsidies and argue to focus on economic sustainability and new ways of doing business. "You do not know whether it is self-sustaining if you are always working with subsidies" (NL01). "I'm not a proponent of subsidies, that is one-time dependency" (NL05). Others argue that subsidies for locally grown produce is not necessary "because you have the value of the product and the storytelling, so if you need that you are not doing your business well enough. […] We just have to become better business people" (DK04). This also links to the misconception that creating sustainable impact cannot or should not lead to profits and should thus partially rely on subsidies. "It is much more interesting to make businesses who support sustainability, because in that way you will actually grow sustainability much faster than just doing some subsidy schemes. […] What we are aiming for is building, supporting, and growing stuff. We actually take pride in saying you can be sustainable but you can also make money at the same time" (DK08). Instead of on relying on subsidies, some network actors argue that business model innovation should be a priority, allowing economic sustainability to realize environmental and social impact.

A last point of interest within the subsidies approach to niche shielding, is subsidies for regime players and incumbents. As food is a broad topic and touches many departments of municipalities, subsidies to support urban farming initiatives might be difficult to organize. Even though some subsidies are available for actors in the emerging ZFarming niche, the subsidies for the traditional agri-food industry are more substantial.

> *"Traditional greenhouse growers are super innovative but receive little incentive to commit to long-term investments from the market. […] Additionally, they receive a lot of subsidies on non-renewable energy. […] The lights that are hanging in those greenhouses are not really energy-efficient, but that does not matter to the farmers. Why would they spend a tenfold on LEDs, when there is no real price benefit on the energy savings?"* (NL08).

In Denmark some subsidies are more favourable for traditional farmers too, as the funds dependent on the amount of land and hectares the farm has. "So, if you are a really big pig farmer you will have a lot of money from the EU. Compared to a small business, doing a little bit of urban farming, it is very little" (DK09). Since one of the main benefits of urban farming is to reduce the land-usage footprint of food production, these types of farm size-based subsidies are restricting the development of the ZFarming niche. Subsidies are

available in the ZFarming ecosystem; however, the effectiveness of these funds is questionable due to more substantial subsidies for traditional food production.

Concluding, it can be argued that the shielding and niche protection processes in the forms of regulatory and legal structures, as well as subsidy programs have been applied in the Danish and Dutch ZFarming ecosystem. However, there are issues with the speed of implementing new policies and reforms regarding city planning and circular waste management, leading to allowed illegal activities of urban farmers. Additionally, the slow speed of city administration reforms leads to slow development of ZFarming initiatives, taking more than four years to come to an agreement with the municipality about a location. Subsidies are an important tool for niche protection. Even though some network actors have utilized subsidy programs, others are arguing that this type of soft-money is not needed when new business models are used. Moreover, the usage of subsidies for traditional agri-food still are substantially higher than the introduced subsidy and financial programs for urban farming and short food supply chains, resulting in a lack of innovation and sustainable development in these subsidized industries. Hence, subsidies as a shielding mechanism should be revaluated and restructured to suit the needs of the urban farming niche.

5.2.2) Nurturing processes

The second internal process for niche protection is nurturing, or niche development. In the words of Smith and Raven (2012): "An analyst interested in nurturing would emphasise how the program enables the further growth of the niche, such as how it enables learning, or draws in new entrants" (p. 1027). Niche protection is a prerequisite for enabling nurturing processes (Schot & Geels, 2008). SNM literature has described three internal processes for niche development, or nurturing. First, network formation, as the focus of this thesis, is the most important process. It indicates how new actors are attracted to the ecosystem and collaborate with other network actors. Second, the process of learning, sharing experiences, tools and empirical evidence with other niche actors contributes to niche development as it allows to stand on the shoulders of giants, not having to re-invent the wheel. Thirdly, creating a shared vision is essential in niche development as it allows network actors to align interests and combine resources to achieve the common goal. Having discussed the shielding and protection mechanisms in previous section, the following paragraphs present the nurturing processes in terms of network formation, learning experiences, and a shared vision among the ecosystem actors.

Network formation, as the main research focus of this thesis, has been discussed in other sections of this report. Section 4.2.1 presents mapping efforts and informational platforms in relation to network formation, arguing that by having a central geographical overview helps to connect to other ecosystem actors. The regional mapping initiatives and information sharing websites of municipalities such as Amsterdam, The Hague, Rotterdam, Utrecht and Almere are found to be useful among the interviewed network

sample in the Netherlands. However, no standardized categorization method is used to identify various types of stakeholders in these interactive geographical maps. Some of these municipal overviews only include food producer, while others also include retailers and local food distribution actors. Besides these shortcoming, the municipal mapping activities and information platforms indicate that some Dutch city administrations are involved in the leadership and champions role archetypes, in addition to the regulator. This contributes to the overlapping role characteristic of the ZFarming network, as described in section 4.2.2. Moreover, the efforts of realizing national network mapping webapps and collaboration platforms such as *Stadslandbouw Nederland* and the *Transitiecoalitie Voedsel*, indicate the emergence of meta-actors as described by Raven (2005). The arrival of meta-actors in the ZFarming ecosystem indicates that the network formation process is somewhat maturing. Besides digital networking platforms, these meta-actors are also forming in physical entities such as BlueCity, the New Farm and the project of DK05 as described in section 4.1.1. By creating entrepreneurial hubs specialized in urban food innovation and circular economy, meta-actors are creating collaborative environments in which actors can operate collectively, strengthening the network - for instance by connecting waste streams, using compatible IT systems, and arranging distribution cooperatively within the network. These meta-actors do not only attract new start-ups, also incumbents are collaborating on projects in the ZFarming niche and expanding the network. Dutch companies like Philips Lighting and Priva as well as Danish actors such as DK08 are key partners for indoor and greenhouse-based ZFarming initiatives. By having larger multinational organizations entering the niche, the network arguably gains more legitimacy, access to established networks and significant financial capital. Even though section 5.2.3 discusses the interaction between the niche and regime in more detail from an empowerment perspective, it should be noted that incumbents and regime players play an important role in network formation and nurturing processes of the ZFarming niche. Consequently, it can be stated that the activities regarding network formation are mostly observed in the creation of platforms, attracting new partners to the network, both start-ups and incumbents. Via these platforms and meta-actors, regional and national interests can be aligned in the network (Dedehayir et al., 2016; Kivimaa, 2014). The process of value management for ecosystem leaders, as described by Dedehayir et al. (2016), is not yet developed in the studied Zfarming ecosystems. The development of meta-actors in the ecosystem indicates dedicated actors that are concentrated on the network formation process in the ZFarming niche, realizing new collaborative relationships between incumbents and start-ups in the ecosystem.

Next to network formation processes, shared learning experiences are also an important aspect in niche nurturing (Schot & Geels, 2008; Smith & Raven, 2012). In the case of the studied ZFarming ecosystems in Denmark and the Netherlands, many learning experiences could be identified. This is mainly exemplified by the observation that many actors in the studied networks are involved in activities associated with the expert role;

offering keynotes, workshops, educational programs and informal knowledge sharing experiences. As mentioned before, diversification of business activities contributes to overlapping roles in the network. However, in the Dutch ZFarming ecosystem some challenges have been identified in terms of coopetition, collaborating with competitors, as described by Planko (2018). A last point of discussion is the information platforms that are being developed and tested, mainly in the Dutch ecosystem. These digital spaces allow niche actors to share experiences, insights and knowledge with others, stimulating open innovation. Even though some actors have already received all the information via the internet to start an urban farm, a dedicated platform for the emerging niches in short food supply chains and sustainable regional food economies is a wish for a number of network actors. The learning experiences in the studied networks are focused on sharing knowledge from an expert role as well as via information platforms stimulating open innovation, however managing the process of coopetition can be challenging.

A last element of the niche nurturing is creating a shared vision among network actors. Generally, it can be stated that most actors in the ecosystem do have a similar broad vision; circular, regional and more sustainable food chains. The approaches to reach this vision widely vary. However, it can also be stated that creating a shared vision for the future of food economies is difficult since it affects numerous aspects of society, such as city planning, food production, health, fair wages, and ecological impact. Even though these topics are spread over various municipal department and national ministries, the Dutch ecosystem has seen an agreement of twelve city administrations by signing the 'City Deal Voedsel', a shared vision implemented in a collective program to create regional food economies. Another important observation in terms of having a shared vision among network actors is the distance from farm to plate in the case of local food. While some actors in the Netherlands argue a radius of 50-75 kilometres is acceptable, other countries such as the United States use a much larger local area of several hundreds of kilometres. There should not be a judgement in relation to these definitions, but it is an aspect to consider in the ZFarming niche. Consequently, it can be stated that there is a general shared vision and interest in the field of sustainable urban food systems, the City Deals approach help to realize collective municipal action.

5.2.3) Empowerment processes

A third internal process for niche growth is empowerment, referring to reducing the gap between the regime and niche. In the words of Smith & Raven (2012), "an analyst interested in empowerment will question how the establishment of the program is used by niche advocates to argue for more enduring forms of institutionalisation; mobilise the program as 'evidence' for maturing of the niche, and so on" (p.1027). The gap between the regime and niche can be overcome via two empowerment processes; fit-and-conform, making niche innovations competitive in the regime, and stretch-and-transform referring to the adoption of niche innovations by regime actors in the dominant markets. Based on

the result of this study, it can be argued that both these processes occur in the Danish and Dutch ZFarming niches, sometimes in overlapping ways. The following paragraphs illustrate these processes in the networks in more detail.

Interactions in how the niche influences the regime are important in the diffusion of sustainable technologies, as can be observed within the studied ZFarming niches. "Urban farming is based on technologies from the traditional agriculture and horticulture" (NL06). However, actors in the urban farming niche applied these non-radical technologies, such as climate control, greenhouses, and LED-lighting, in novel ways. In turn, these niche methods are influencing regime players, updating more traditional greenhouse production systems with more sensors and different artificial lighting. An interviewed researcher from the Dutch ZFarming ecosystem is involved in the *LED it be 50%* project, aiming to "deliver the knowledge how to transition from conventional lighting to LED lighting" in greenhouses for tomatoes in the Westland (NL04). In both the Danish and Dutch ecosystems, many technology providers are regime players, such as DK08, Priva and Philips, partnering up with both traditional agrifood companies as well as urban farming niche actors. By implementing existing regime technologies in innovative ways, ZFarming niche actors not only reduce the resistance of incumbents towards these technologies, but also explore and experiment with novel business opportunities. These processes may influence and interest regime players to adopt these technologies in new ways too, which empowers the niche.

Another example of the empowerment process can be found in the way storytelling of food products and creating consumer dialogue is expanding from the niche to the regime. "What entrepreneurs take from urban farmers is searching for contact with the end-user and consumer via social media and other ways, to make themselves more visible" (NL05). Connecting with the consumers and storytelling is one of the approaches by which urban farmers aim to create a local food community. According to a researcher in the Danish ecosystem, the game-changer "would be if we could have the large vendors like Coop, or some of the others, [...] buy into it this. And say 'we want to tell the story, we want to transmit these products'" (DK02). Amazon, as owner of biological supermarket chain Whole Foods, is a good example of the influence of incumbents and large vendors on the sustainable food niche, aiming to fulfil the demand for more local food. Storytelling is a major focus for Whole Foods, because "everyone wants a piece of the natural, organic market because of its strong consumer demand" (Bryant, 2015). Both incumbents and niche actors are exploring new ways to tell stories about their food and connect with consumers to create dialogues.

A final noteworthy observation in the empowerment process is the introduction of small growing systems and more focus on local food among restaurants and eateries in both the niche and regime. An increasing number of restaurants are installing small indoor growing boxes in which herbs are grown or have a sizable urban farm for fresh green leaves and herbs (NL13). Projects like The Green House restaurant in Utrecht are

notable in this context, because it only sells food produced in the Netherlands and the building has a greenhouse to produce some vegetables and herbs directly on-site. The project was funded and realized by R Creators, a consortium of several companies, in an attempt to create a circular food experience. The restaurant on-top of DK07's rooftop farm is also selling local and organic produce in collaboration with peri-urban farmers in Copenhagen. "It is a global trend that everyone is going back to local identity, they want proximity, nearness, transparency, and generic products do not encourage food trust" (DK04). As the demand for biological and local food increases, niche and regime actors are experimenting with new restaurant formulas, bringing fresh and regional produce to the consumer's plate.

In sum, previous section illustrates the empowerment process via three perspectives; the novel application of agrifood technologies in the ZFarming niche, storytelling and consumer interaction, and the movement towards more local herbs and food in restaurants.

5.3) Thesis Limitations and Future Research

Research has its limitations and may discover interesting topics for future research. This thesis also has a few shortcomings and can raise new research questions for academics in the future. First, the collected quantitative data should be examined with care. Second, even though the mapping efforts presented in this thesis might be inconclusive, it may serve as a preliminary source to conduct a social network analysis of the ZFarming niches. Third, research regarding the difference in network formation processes of a more populous urbanized region might present useful learnings. Lastly, studies concerning the bottlenecks of the ZFarming networks, distribution and regulation, might provide a contribution for possible scalability and role balance problems of the niche.

One of the shortcomings in this research was the approach to collect quantitative data through interviews. The initial interviewees were asked to fill out a scoring form to indicate the level of involvement in the identified ZFarming stakeholder archetypes, while the interviewer explained these roles. This method resulted in a disruption in the flow of the interview, as interviewees were not enthusiastic about using a laptop during the conversation. Additionally, there was some confusion about the roles due to overlapping characteristics of the activities. Thus, after the initial interviews it was decided to score the interviewee based on the answers resulting from questions regarding the actor's activities that are associated with specific roles. Therefore, due to this self-scoring method by the interviewer, the results collected from this data in the form of the role percentages and the spider-diagrams are to be carefully interpreted.

Even though the geographical mapping of the actor networks revealed insights regarding the localisation of the Danish and Dutch ZFarming niches, the former being more clustered, while the latter spread over multiple municipalities, this result may be skewed. The delineated geographical area of Denmark's urbanized region extends further

from Copenhagen. However, few ZFarming actors were found outside Copenhagen's city layers. As the researcher of this thesis was less integrated in the Danish culture and was unable to consult Danish information sources directly, the desk research to discover Danish network actors was limited. Additionally, since a social network analysis of the partnerships within the niche was out of the scope of this research, it would provide a promising research case to generate valuable information about the collaborative relationships of the network actors.

Another possible research opportunity would be to compare the relatively small sized urban regions in Denmark and the Netherlands, with larger metropolises such as Tokyo and New York in terms of network formation within these ZFarming niches. By having a better understanding about varying sizes of city regions, the urban farming movement and sustainable food transition may be diffused quicker.

Lastly, one of the insights from this research in terms of network bottlenecks, are related to the activities of the sale and distribution and regulation archetypes. Even though regional food hubs, bridging the gap from farmer to consumer, exist in both the Danish and Dutch niches, the adoption of these services is still minimal. Regulation was also found to be a bottleneck, as urban farming initiatives may take several years of regulatory hurdles to legally operate. More research in how these network bottlenecks could be overcome would provide valuable insights, contributing to solve potential scalability and role balance issues of the ZFarming niche.

5.4) Summary of Discussion

Based on the collected data, some key differences between the Dutch and Danish ZFarming ecosystems are found and presented in section 5.1. First, the spatial and geographical aspects of Denmark and the Netherlands have been discussed. It is argued that due to the relatively small population size in the two analysed urban areas, in reference to megacities such as New York or Tokyo, it is possible to deploy urban farming technologies and approaches in peri-urban areas. Moreover, the Danish and Dutch ZFarming ecosystems are compared in terms of the leadership, entrepreneur, and regulator roles. In brief: the leadership role is characterised in terms of the emergence of meta-actors; municipal actors in the regulatory role are installing dedicated urban farming departments and civil servants as well as collaborate via the City Deal model; and entrepreneurs are challenged by the balance between community building and coopetition.

Next, in section 5.2 the three internal processes for niche protection and development in SNM literature - shielding, nurturing, and empowerment - are described in relation to the results of this thesis. Regarding shielding, it is argued that slow regulatory reforms regarding city planning and waste management are hindering the development of the niches, as certain novel business activities are considered to be illegal or may take years to arrange agreements with local governments. Moreover, although

subsides are available for niche actors, there is a tendency to not utilize this shielding mechanism as these urban farming subsidies are difficult to find, and the traditional agriculture industry receives more substantial subsidies, making the innovation subsidies less attractive. Hence, ZFarming niche actors focus more on the creation of new business models instead of relying on soft-funding opportunities. The network formation process is characterised by the emergence of meta-actors in the ecosystems; organizations or platforms that are dedicated to network building, connecting actors, and stimulating collaboration as well as managing interests over various levels from local to international networks. Learning experiences are created by network actors in the expert role, sharing information and insights via workshops, educational programmes, and events. Additionally, the development of information platforms and physical collaborative spaces supports the process of knowledge exchange. Processes and activities regarding niche empowerment are characterised in terms of new applications of incremental or existing technological innovations by urban farming actors, the increasing importance of storytelling and creating dialogues with consumers, as well as the trend towards more hyperlocal food production in terms of small indoor growing systems and on-site gardens at restaurants and food vendors.

Section 5.3 presents the limitations of this research in addition to promising topics for future research in the ZFarming niche. It can be argued that since the quantitative data collected through interviews is based on self-scoring, the scores of the roles in the niche should be considered with care. Even though the geographical network mapping results may provide a somewhat inconclusive indication of the key actors in the niche, it does present a base for future research regarding social network analysis. Additionally, academic exploration into the bottlenecks of the ZFarming niche, specifically the distribution and regulation roles, might generate valuable insights to achieve a balanced innovation ecosystem.

6) Conclusion

In this thesis, the emerging (semi-)commercial ZFarming niches in Denmark and the Netherlands have been researched through the lens of strategic niche management (SNM) literature. The (semi-)commercial ZFarming niche refers to urban agriculture projects that focus on food production with a direct or indirect market orientation and utilize existing infrastructure of urbanized areas. Specifically, the conduced study has generated new insights in how the network formation processes in these two ZFarming niches shapes niche protection and how this contributes to the sustainable food transition. The main question formulated for this thesis was:

> *How does the process of network formation shape niche protection in the (semi)-commercial ZFarming niche in the Netherlands and Denmark in the transition to a sustainable food system?*

This research question can be interpreted in multiple ways. Therefore, several sub-questions have been proposed, providing specific fields of focus for the main research question. The sub-questions include both theoretical and practical perspectives to generate valuable insights for both the academic world as well as the actors in the ZFarming networks. The major themes in these questions are: 1) unpacking network formation in SNM literature, 2) gaining insights in the key actors and the geographical mapping of the network, 3) analysing the roles and activities of these key actors through interviews, and lastly 4) understanding how the two niches are protected. By providing conclusions and key insights based on the generated knowledge through this thesis, the main research question can be answered via the sub-questions.

The first sub-question was formulated as: *How can the network formation process in the ZFarming niche be unpacked in relation to SNM literature?* Strategic niche management is a useful body of literature and presents a valuable set of concepts through which the introduction of promising new technologies and social practises that contribute to transitions towards a sustainable society can be understood and managed. However, the key concepts can be abstract and overlapping, making it difficult to connect or practically use the various concepts, such as network formation processes for niche development. Hence, in this thesis, an integrated analytical framework has been presented to unpack network formation processes in relation to the ZFarming niche. The first layer of the conceptual model is the multi-level perspective, a general concept that defines three interacting levels of socio-economic transitions via landscapes, regimes and niches. In the context of this thesis, these are the dominant cultural habits, the dominant organization of the food industry, and new approaches such as the urban farming niche, respectively.

The concept of the niche can be further unpacked in terms of protection and development. First, three niche protection processes can be identified; shielding (creating favourable market conditions), nurturing (creating an environment for niche growth), and empowerment (stimulating two-way adoption of practises between the regime and niche). Second, a niche can be further analysed from the nurturing process, or development perspective. This includes internal niche development processes such as network formation, learning experiences and creating shared visions among niche actors. These three niche development processes can then also be unpacked via specific and concrete activities of niche actors. In this thesis, only the network formation process has been unpacked to this specific layer in SNM literature. This is achieved by combining various theoretical models and frameworks related to innovation ecosystems, stakeholder typologies for ZFarming, and intermediate activities for network formation in niches. Having unpacked all these processes provides an actionable framework to analyse and understand the network formation process in the ZFarming niche, though it may be applicable for research in the broader scope of urban agriculture.

A second focus area in this thesis was to generate insights regarding the key actors in the network formation process, formulated via the sub-question: *Which main actors are present in the (semi-)commercial ZFarming niche in the Netherlands and Denmark?* By geographically mapping out the Danish and Dutch networks based on information in articles and listings in partnerships from related urban farming projects, the main actors could be identified. It should be noted that the influx of new entrants in the ZFarming niche is substantial, and some actors are leaving the space after a certain period[8]. The demise of key actors in the network indicates volatile market conditions and leads to continuous changes in the niche. Hence, the network mapping efforts provided in this thesis are an incomplete, indicative snapshot of the Danish and Dutch niches. However, it was discovered that there is a need from network actors to have an up-to-date overview. Hence, several Dutch municipalities are facilitating the creation of regional maps, even though struggles with financing these digital environments and meta-actor organizations exist. Novel business models, crowdsourcing strategies, and information verification structures should be explored to create self-sustaining platforms that list the actors in these networks.

Based on the research in this thesis, it can be stated that the Dutch municipalities commonly take a leading role in the network formation process of the ZFarming niche, which is reflected in the City Deal agreement. The local governments are supported by universities and knowledge institutions in these regions, such as Utrecht University, Wageningen University and Aeres Hogeschool Almere. Incumbent companies from the climate-controlled greenhouse sector (Philips, Priva) and new entrepreneurs that connect

[8] One of the flagship urban agriculture projects in the Netherlands, Urban Farmers in the Hague, has declared bankruptcy over the course of this thesis, illustrating the economic challenges in the emerging market niche.

network actors (Amped, The New Farm, BlueCity) are also key actors in the Dutch ZFarming niche. The Danish ZFarming niche can be defined as being in an earlier stage of niche development than the Dutch, as the network formation process is less formalized. There are no City Deals or municipal departments dedicated to facilitating urban food economies in Copenhagen, though the municipality of Albertslund has formulated an urban food vision. The Copenhagen metropolitan area is focussing more on circular economy, in which sustainable food and urban farming does have its place, as illustrated by the finalists of the Climate-KIC circular economy competition. Knowledge institutions such as Copenhagen University and the Danish Technological University are providing valuable education, research and advice to shape the niche. The Danish network formation process can be characterized by community building and proofs-of-concepts (Ostergro, SLOW, Aquaponics.dk), while the first experiments with scalable commercial projects are being conducted (Refarmed, Beyond Coffee). Overall, it can be concluded that municipalities, knowledge institutions, and frontrunning entrepreneurs are some of the main actors present in in the (semi-)commercial ZFarming niche in the Netherlands and Denmark.

Having insights in the key actors that shape the network formation process of the Danish and Dutch niches, the third sub-question dives deeper in the specific roles of the actors in the niche: *What is the arrangement of activities and roles in the (semi-)commercial ZFarming niche in the Netherlands and Denmark?* As mentioned in previous paragraph, the key actors in the network formation process are municipalities, knowledge institutions and early businesses in the emerging urban farming industry. Based on the results of this thesis, it can be stated that the interviewees in both niches can be identified the most in the leadership, expert and entrepreneur roles. This finding corresponds to the main actors in the network as described in previous paragraphs. Activities in the leadership refers to efforts to build platforms and attract new network actors in the niche. Municipalities and several frontrunning entrepreneurs take a leading role in these activities. The expert role refers to actors that generate and diffuse knowledge, as is illustrated by the importance of universities and educational institutions in the niches. This role is also adapted by businesses that do their own research, and share knowledge via workshops, tours and online courses. The entrepreneurial role refers to actors who are producing food in an urban setting, bringing back the feeding function of cities and arranging partnerships and collaborative relationships to operate their own venture. Two other noteworthy roles can be identified in the ZFarming niches: sales and distribution, and the regulator. The former role refers to network actors that serve as a middle man, distributing the locally grown food from the producer to the consumer, taking care of logistics and the marketplace. According to the findings, distribution is one of the key challenges for the urban farming niche. The regulator's activities include policy-making and regulatory reforms to create new legal conditions for the innovative agrifood practises. Since growing mushrooms on used coffee-grounds or utilizing rooftops for

agricultural purposes are new business approaches, the legal and regulatory frameworks need to be updated to facilitate the growth of the niche. In short, it can be stated that the arrangement of activities in the Danish and Dutch ZFarming niches is mainly centred around the leadership, expert and entrepreneurial roles, and is characterised by a lack of actors' activities in the sales and distribution, and regulator archetypes.

Taking a step back in the unpacked theoretical model of network formation in the urban farming niche, the fourth sub-question considers the overall protection of the ZFarming niche: *In which ways are the (semi-)commercial ZFarming niches in the Netherlands and Denmark protected?* Shielding, nurturing and empowerment are the main themes in this inquiry. First, typical shielding processes, such as subsidies and regulatory conditions that protect the niche from the common selection criteria in the industry, can be identified in the ZFarming niche. However, since these subsidies can be difficult to find or time-consuming to apply for, there is a general focus on improving business models instead of relying on soft-funding opportunities. In overlap with the regulation role, the legal conditions the ZFarming niche can be improved, as it can take many years before special arrangements for agricultural rooftop usage are agreed with municipalities. Additionally, some innovative business practises are considered illegal, as the current policies are not optimized for urban agriculture principles. Nurturing processes in the niche are emerging, such as the increased growth in network formation and the willingness to collaborate with other network actors. Empowerment processes are characterised by the new application of existing incumbent technologies, such as using traditional climate-controlled systems for greenhouses in urban indoor growing businesses. Niche protection is an iterative process, in which changes in shielding, nurturing and empowerment practises are constantly developed, and the ZFarming niche is going through some early iterative cycles.

Concluding, it can be stated that the process of network formation is shaping the niche protection and development in the (semi)-commercial ZFarming niche in the Netherlands and Denmark in a few characterizing ways. The network formation process in the ZFarming niches is mainly led by frontrunning enterprises and municipalities, supported by knowledge institutions. Together, these actors form meta-actors, creating digital and physical platforms which attract new entrants and collaborative relationships. Even though local governments are supportive of urban farming, new subsidy structures and regulatory frameworks are difficult to realize. Yet, the urban food networks are growing and connecting via spatial clustering and geographical linkages. When these food networks are interconnected from local to international levels, it can restructure the industrial food system, contributing to the sustainable food transition.

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Appendix A) Sustainable Food Transition within the Climate Nexus

Sustainability is often studied via the Triple Bottom Line perspective, or the People, Planet, Profit dimensions. Time, a fourth dimension, can be added, allowing the other dimensions to be studied in both long and short-term periods (Lozano, 2008). Another perspective is formed by Biggs et al. (2015), arguing that to achieve a "sustainable balance between natural supply and human demand", the interactions in the water–energy–food–climate nexus should be combined with the sustainable livelihoods framework, ensuring 'environmental livelihood security'. ELS is related to concepts like the circular economy and the donut economy, focussing on the interactions of sustainable and decentralized food, energy and water networks and a balancing out with demand.

The sustainable balance between energy, water and food in society is also known as the *Environmental Nexus* (Biggs et al., 2015). The Australian government used this model for its National Outlook Report, as illustrated in figure A1 (CSIRO, 2015). Next sections shall briefly explore the observable complementary trends regarding the sustainable progress made in the energy, water and food areas, with a more detailed focus on agricultural innovations and food technologies, to achieve a flourishing Environmental Nexus.

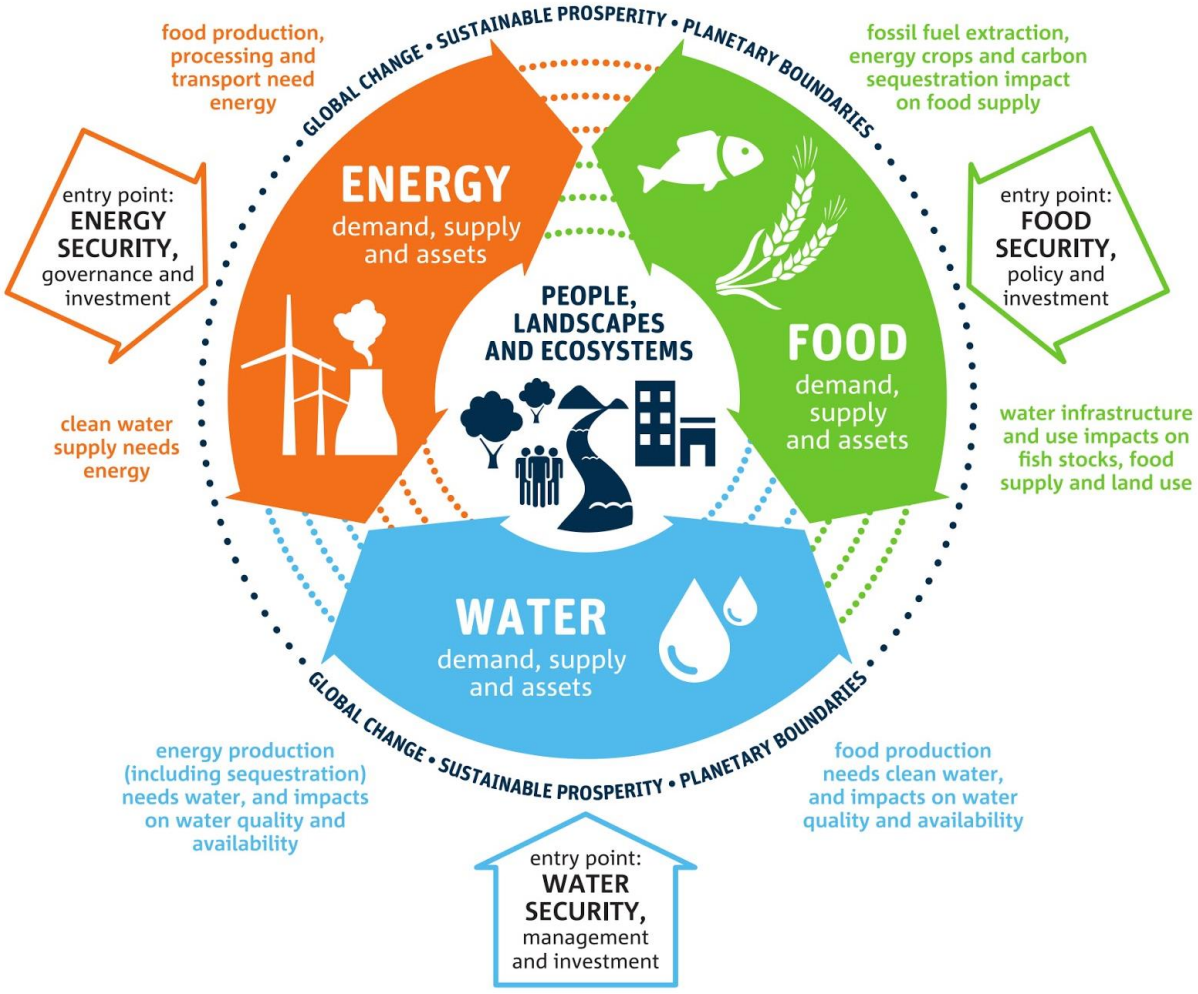

Figure A1: The intersection of water, energy and food in the Environmental Nexus. Source: CSIRO, 2015.

Sustainable Progress in The Environmental Nexus

When observing the implementations of sustainable technologies and developments from the Environmental Nexus perspective, it can be argued that the energy sector receives the bulk of attention and has progressed tremendously over the last decades. Some researchers, stressing the *exponential trends of technologies*, argue that the dramatic price reductions of solar and wind energy are continuing, making (renewable) *energy free and abundant* before mid-century (Diamandis, 2012; Finette, 2016a; Naam, 2017a; 2017b; Rifkin, 2011; 2014; 2018). Thus, one could argue that the energy element of the Environmental Nexus is accounted for. It also raises the question: what to do with free and abundant energy? Water desalination is a possibility, as the energy requirements to desalinate water has halved three times, or dropped nearly factor 10, from 1970 to 2010 (Elimelech & Phillip, 2011). Consequently, an abundant amount of fresh (drinking) water can be generated with affordable energy, thereby realizing water security and the second Climate Nexus element. The trends of exponentially decreasing prices for renewable energy and water desalination in the last decades is in stark contract with the cost of food,

which only has increased (FAO, 2018). Having both renewable energy and fresh water produced sustainably, and for neglectable marginal costs, more sustainable and affordable food production can also become a reality, creating balance in the Environmental Nexus. Next sections will explore these briefly described trends in more detail.

Sustainable Energy

It can be argued that the public and political perception of 'sustainability' emphasises renewable energy and electric transport. Consequently, the 2010's has seen an increasing adoption of sustainable energy and subsequent transport innovations, such as electric vehicles. The efforts of entrepreneur Elon Musk, CEO of Tesla and Solarcity, who is skilled at media and hype generation, and has a visionary perspective for the coming decades, have arguably significantly contributed to the sustainable energy transition (Urban, 2016; Vance, 2016). Another factor in this diffusion can be contributed to the exponentially decreasing costs and increasing adoption for these sustainable energy technologies, as can be observed in solar and wind production (Diamandis, 2012; Earth Policy Institute, in Richard, 2015; Finette, 2016a; Landberg & Eckhouse, 2018; Rifkin, 2014; 2018).

The exponential observations in solar technology are generally formulated in relation to *Swanson's Law*, which stipulates that with even doubling of installed solar panels, the price drops by 20% (Finette, 2016a; Partain et al., 2016). It is similar to Moore's Law, which states that every two years, the number of transistors on a computer chip are doubled, which has proven accurate for over 50 years (Moore, 2006). In practical terms, Swanson's Law explains the relationship of rapidly decreasing prices for solar, resulting in increasing adoption (Richard, 2015). Figure A2 illustrates the exponential price/adoption of solar technology. From another perspective, the cost for solar energy in 1977 was approximately $76/kWh, ten years later it has dropped by 8x to about $10/kWh. In 2015, solar energy reached grid-parity with coal at $0.30/kWh in California, and a year later, Dubai provides *unsubsidized solar energy for $0.03/kWh* (Finette, 2016a). Rifkin (2018), involved in implementing his Third Industrial Revolution model in Europe and China, states that European and American utility companies are also making long-term, 20-year contracts for solar and wind for around $0.03/kWh. The relationship between the cost-decrease and adoption-increase of *wind energy technology* is also observable. The cost per kilowatt hour of wind energy has decreased 30x from 1980 to 2016, which is reflected in the adoption of wind technology, which grew 6.5x in just a decade, from 2006 to 2016. As a result of these trends, renewable energy from wind is increasingly becoming the cheapest form of energy, especially in coastal areas (Naam, 2017b). Additionally, wind and solar are quite complementary; the wind blows more in winter and nights, while solar produces more during the summer and daytime (Naam, 2017b). Due to the exponential decreasing prices, unsubsidized solar and wind energy is now cheaper than energy from coal, oil and gas, indicating a tipping point in the sustainable energy transition.

Not only solar and wind technologies, coupled with batteries are disrupting the energy industry, additional innovations in smart grids, hydrogen fuel, and new forms of nuclear are progressing rapidly too (Naam, 2017b). Due to these *complementary developments*, Rifkin (2011; 2014; 2018), envisions an *Energy Internet*, via which renewable, decentralized energy production, storage, consumption and trading can become a reality. If the observed exponential trends for sustainable energy will continue in the coming decades, green energy will likely become nearly free and abundant (Diamandis, 2012; Finette, 2016a; Naam, 2017a; 2017b; Rifkin, 2011; 2014; 2018). With a future of free and abundant energy, one element of the Environmental Nexus has been fulfilled.

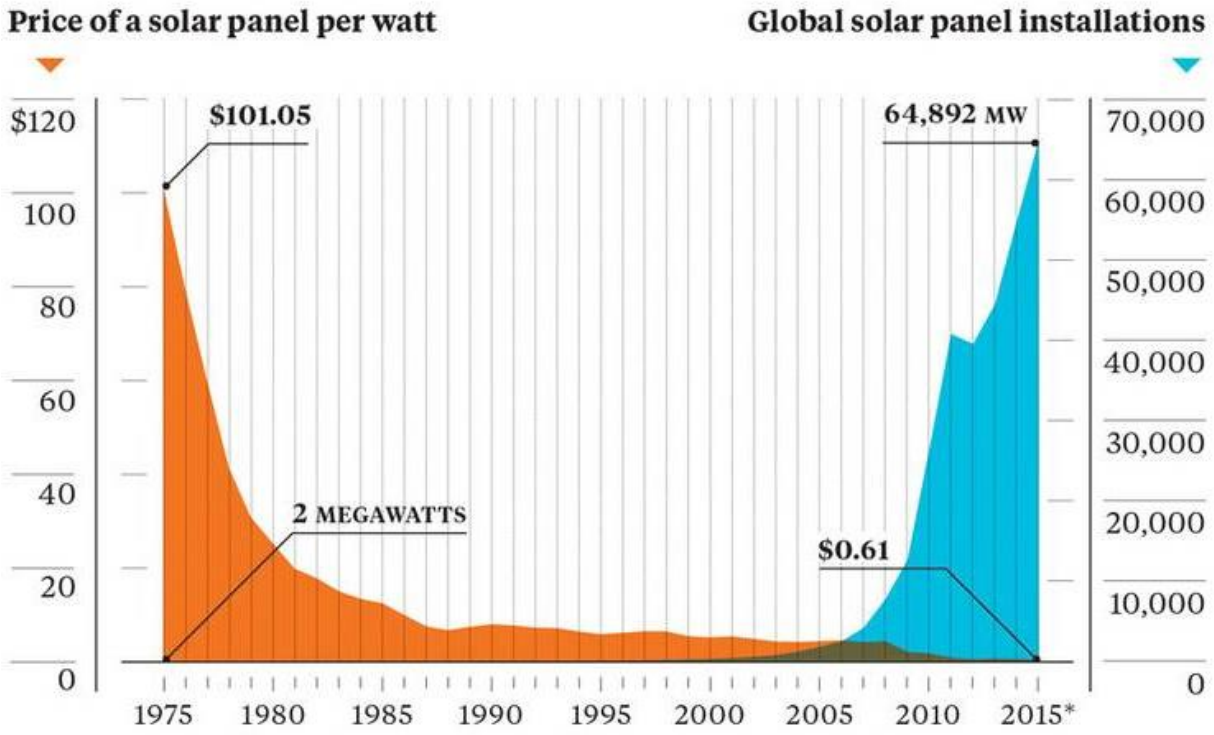

Figure A2: The exponential price reduction and adoption of solar panel technology. Source: Earth Policy Institute, in Richard, 2015.

Sustainable Water

With increasing water scarcity and consumption trends, access to freshwater has been stated as a possible cause for the next global conflict (Ericson, 2017), even though the availability of near free and abundant, renewable energy can lead to an abundance of clean freshwater (Diamandis, 2012). About 70% of Earth's surface is covered in water, with the vast majority located in the planet's oceans (USGS, 2016). This salty seawater can be desalinated to create freshwater. However, this process used to be highly energy intensive, making it an expensive and inefficient method to produce clean water usable for drinking, hygiene or agriculture. However, the energy requirements, and thus price, of water desalination has exponentially decreased over the last decades. From 16 kWh/m^3

of water in 1970, to under 2 kWh/m³ of water in the 2010, almost a 10x improvement or three halfations in 40 years (Elimelech & Phillip, 2011). With the increasing availability of cheap, clean energy and the decreasing energy requirement to desalinate water, it can be argued that an abundance in freshwater can be obtained in the coming decades (Diamandis, 2012). Water security via energy efficient desalination processes and available cheap and green energy can contribute to achieving sustainable water, the second element in the Environmental Nexus.

Sustainable Food

Two of the three elements in the Environmental Nexus, energy and water, have arguably promising sustainable futures. Sustainable food, however, is the next piece of the puzzle. Realizing food security is a major challenge considering a growing (urban) population (UN DESA, 2015, Wagner, 2008), an industry built on fossil fuels, increasing changing climate and weather patterns, and dwindling resources such as arable, nutrient-rich land (Johnson, 2015; Pollan, 2009; Satterthaite et al., 2010; Sedghi, 2013; van Staalduinen, 2014). Widely available and affordable sustainable energy and freshwater should help to mitigate this issue. However, even though desalinated water and renewable energy are exponentially becoming more cost effective, the price of food has only increased in the last decade (FAO, 2018), as illustrated in figure A3.

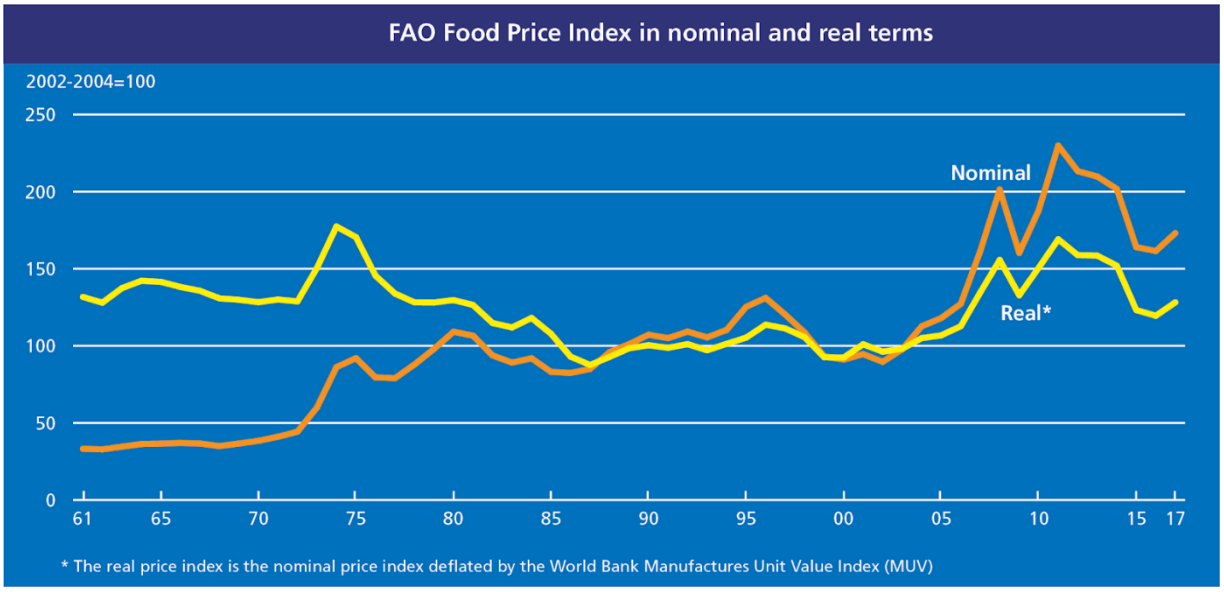

Figure A3: Global food prices have increased in the last decade. Source: FAO, 2018.

It can be stated, however, that the sustainable and healthy food movement has seen tremendous growth in recent years. Reflected in the increasing organic food sales, the demand for sustainable food is clearly observable (Organic Trade Association, 2017). Kimbel Musk, the brother of Elon Musk, coined the term *real food*, referring to food that can be *trusted to nourish the consumer, the community including the farmer, and the planet* (2017). "It is food that is driven by information" (Musk, 2016 [2:18]). Information about the

food and supply chain of products found in supermarkets is currently difficult to come by. There are many actors in the journey from farm to the stores, all using varying systems to track and quality control the goods. In the words of Yiannas (2017), vice-president of Walmart, "most actually do it on paper or on systems that do not speak to each other, so you can never have a full view of what is happening in the food system" (1:20). Even though there is a growing demand for sustainable food, the current traceability and information, as well as production and quality of food is inefficient.

A possible solution is found in the European Commission's funded project the *Internet of Food and Farm 2020* (IoF2020, 2018), exploring the potential of Internet-of-Things (IoT) technologies for the European food and farming industry. Essentially, the aim is to digitize and automate aspects of the food industry, using complementary exponential technologies such as robotics, artificial intelligence (AI), sensors, big data analysis, and biotech to realize a more efficient and sustainable food system. Not only governmental organizations are working towards an interconnected food system, also enterprises see business opportunities. For instance, IBM's private blockchain solution is being implemented by Walmart to increase efficiency, traceability and food safety in their supply chain (Yiannas, 2017). Additionally, Amazon acquired biological food retailer Whole Foods in 2017, and has since aggressively dropped prices and made thousands of Whole Food items available via its e-commerce platform *with two-hour drone delivery*, attracting more customers and growing the sustainable food market (Taylor, 2018). The digitization of these agri-food processes can have can disrupting effects on the incumbent food industry, as Finette (2016b) states:

> *"Once a technology becomes digitized, it moves on an exponential curve. The biggest business opportunity you can find in life, is if you find something which is analogue, and you can turn it into a digital good, because you move it from linear growth to exponential growth. Massive opportunities. This is the reason why everybody is so incredibly bullish about agricultural technology, because it's a whole business which is analog to a large extend. If you turn that into digital, it turns into a goldmine"* (15:22).

Moreover, Musk has stated that "food is the new internet" (2015), arguing that the internet opened a world for new entrepreneurs, similar to the entrepreneurial opportunities in sustainable food in the coming decade. Musk (2017) believes that 100 acres of 'real food' produce, could become more profitable than 10.000 acres farming industrial food, which is an exponential 100x increase:

> *"What I believe will happen with real food is, more and more people are getting on board to innovate and create real food at prices that are affordable. We are facing a five trillion-dollar industry, where a young entrepreneur can come in and be a small-scale farmer and make more money in a hundred acres in Colorado, than they would make if they had ten thousand acres growing industrial corn and soybeans"* (12:18).

There are arguably many business opportunities to disrupt the incumbent food regime with sustainable food production and agricultural technology. It can thus be stated that even though the current sustainable progress of the food element in the Environmental Nexus is still very minimal, there is a growing customer demand and entrepreneurial mindset, as well as numerous interdependent exponential technologies and tools being developed to achieve an *Internet of Sustainable Food*. The next section provides more details about complementary developments in agricultural automation, plant data-science, as well as biotechnological and genetic innovation for sustainable food, and presents the role of urban agriculture and ZFarming initiatives.

Sustainable Food: Agricultural Innovations and Food Technologies

As Finette (2016b) and Musk (2015; 2016; 2017) argue, the food industry is ready for disruption by entrepreneurs leveraging complementary technologies that can transform analogue, linear, and inefficient industrial farming processes into digital, exponential, decentralized and sustainable agriculture. Von Maltzahn (2017) views agriculture as a technology to produce food:

> *"You can think of it [agriculture] as a solar manufacturing process that produces us [humanity]. On a atom by atom basis, we are made up of atoms that plants on farms around the world are gathering from their atmosphere and pulling from their soil, and delivering to us as carbon nitrogen and micronutrient atoms in the medium of food"* (2:38).

Since the dominant agricultural practises are unsustainable, it threatens the medium of food that mankind relies on. Therefore, following section presents a range of agricultural innovations and food technologies, as well as novel farming locations and business models, which can be utilized by entrepreneurs as tools to contribute to the sustainable food transition.

The Internet of Food: Smart Farming via IoT, Data, Sensors, Robotics and AI

The Internet of Food is the idea to leverage sensors, data, and automation technologies for agri-food processes (IoF2020, 2018). Precision farming is an early form of this trend, collecting data via sensors and IoT-enabled farming tools, to be more efficient and sustainable regarding managing herbicide, pesticide and water usage processes (McBratney et al., 2005). The next step is to develop and use a digitized and transparent supply chain management system, to be used by every actor in the chain. This digital

supply chain platform can be built on several blockchain-based infrastructures, as envisioned in figure A4.

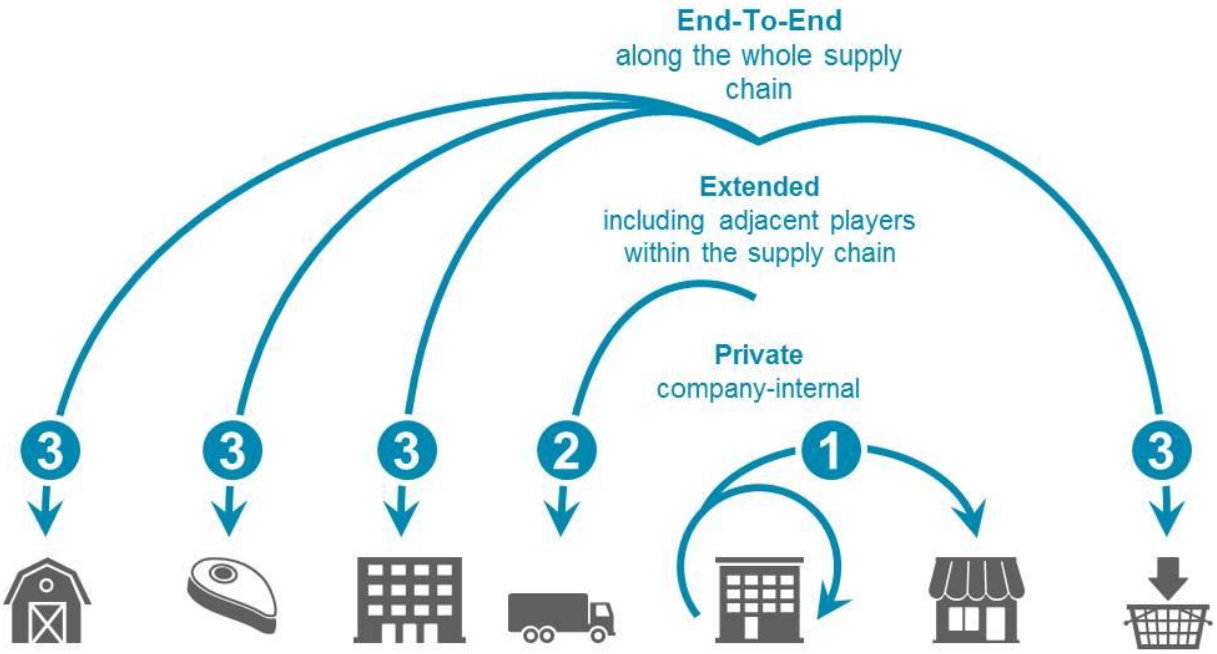

Figure A4: Various blockchains can be integrated into the digital supply chain. Source: Lierow et al., 2017.

The hardware infrastructure for the Internet-of-Food is slowly arriving on the market, for instance by IBM's 1mm by 1mm blockchain-ready chips. These mini-computers have the power of a 1990s CPU and cost a mere $0.10 (Jones & Wagner, 2018). The rise of near-free computing power indicates the start of the Internet-of-Things; as the cost of ICT technology becomes neglectable, it will be increasingly integrated into things (Finette, 2016a; 2016b). IBM's innovation also indicates the era of *disposable computing*, in which these chips are for instance assembled into simple packaging to trace the food and meant to be thrown out after usage (Jones & Wagner, 2018, Yiannas, 2017). Additionally, the development of 5G mobile data networks is a game changing technology for farmers (Gagliordi, 2018). By exponentially increasing the data throughput and speed on the 5G network by 10x-20x compared to 4G connectivity, more data can be collected, transferred, and leveraged by precision agriculture technologies such as drones, as well as autonomous farming robots and machinery. The increased connectivity does not only benefit industrial agriculture incumbents, but also rural small-scale farmers in lower-income countries; improved data-driven feedback and decision-making contributes to realizing a 'Smart Farming Industry' and the Internet of Sustainable Food.

Moreover, new data-driven farming methods, collecting several dozen data-points per individual plant in real-time, are being pioneered by MIT's Open Agriculture Initiative (Harper, 2016). The aim is to measure and control various metrics regarding an individual plant's vitals and nutritional value, as well as growing climate conditions and *phenome*

data. Every individual plant is connected to the internet, so it can be managed from anywhere. This transforms agricultural and plant science processes into a digital and AI-supported environment, with real-time data, automated *climate recipes*, and nutrient control mechanisms for customized plant growth. These open-source farming systems are available in varying types: desktop size (food computer), container size (food server), or warehouse size (food datacentre). Furthermore, this innovation allows further understanding of the intimate biochemical relationships between plants that grow together (Harper, 2016). The work of MIT's OpenAg team delivers major agricultural innovations by digitizing many farming processes into data-driven, automated food systems that can significantly disrupt the incumbent food industry.

Food Technology: Genetics, Biotech, Nanotech, and Synthetic Biology

The digitization and innovation of complementary agri-food processes does not only include information and communications technologies to realize a Food Internet, also in the field of *digital biology* and food technology, progress is made exponentially. Cultured meat, taking stem cells from livestock and biologically multiplying them in a petri dish to create sustainable *in-vitro food*, was first pioneered by Maastricht University in the Netherlands. In 2013, the first cultured beef burger was presented, costing $330,000 for the patty. Just two years later, in 2015, the price had dropped to about $44, not for just one burger but for a pound of cultured meat. The cost for regular retail ground beef in the USA is approximately $4/lbs, so still much cheaper. However, the price for lab grown meat in 2017 had already dropped to $11/lbs, making it only 3 times more expensive than traditional ground beef (Wang, 2017). Due to the rapid declining costs, producers of cultured meat have stated that the first lab-grown meat products can be bought in stores by the end of 2018, and it is estimated that the early 2020s will likely see more widespread adoption (Pasha-Robinson, 2018).

The exponential price reduction of cultured meat technology, 30.000x in just 4 years, is similar to that of DNA sequencing technology. The sequencing cost of the first human genome was about $3 billion in 2001, a technology only accessible for governments. However, just six years later, in 2007, human DNA sequencing was offered as a commercial service for $350.000. The infamous price of 'the $1000 genome' was reached in 2014, making DNA sequencing widely available (Finette, 2016b). In 13 years, DNA sequencing has experienced a price-reduction of 3.000.000x. In the words of Welser (2015), vice-president of IBM Research, *genomic data is the next frontier*:

> *"IBM has been looking at lots of different ways of attacking different types of data. Obviously, we spend a lot of time a lot of time in the database world with structured data, but increasingly we are looking at unstructured data, both text, audio, [and] video. And genomic data is sort of the next frontier. We start looking at metagenomics, start looking at the microbiome. That is a whole nother level of data"* (1:30).

Microbiomes are communities of microbes that live inside tissue of humans, animals and plants. Approximately half of the cells in a human body are microbial. In other words, half of a person's genetic material consists of DNA from microbiomes. Also, in plants, the microbiome influences many characteristics, both biotic and abiotic (Von Maltzahn, 2017). Agricultural start-ups such as Indigo Ag have noticed the business opportunities regarding microbiome data and are offering custom microbiomes (software) for crops and plants (hardware). According to Von Maltzahn (2017), the microbial seed treatments for corn, cotton, rice, soybeans, and wheat can reportedly lead up to 10% increases in yields, a 10x improvement over yields from GMO seeds for similar climate salient treatments. Due to the falling cost of DNA sequencing and data analysis, understanding and manipulating new types of data, such as human, animal and plant microbiomes, has resulted in novel treatments and opportunities for sustainable food.

Finette (2016b) and McCauley (2017) extrapolate the cost-dropping trend of DNA reading, arguing that the cost of *a human genome will become nearly free* in the next decade. Some businesses are seizing the genetic related business opportunities by building 'smart-toilets', giving personalized health and dietary reports based on the genetic material in human waste, indicating the era of preventive medicine (Finette, 2016b). These developments also pave the way for *personalized nutrition*, food based on an individual's genetics and health metrics gained via quantified-self technologies, pioneered by startups like Habit (Koenderink, 2016; Van Noort, 2018). Additionally, it is increasingly easier and cheaper to program, modify, and hack genetic material, using tools such as CRISPR (Hessel, 2017; McCauley, 2017; Smulders, 2017). According to Hessel (2017), these programmed, digital DNA sequences can then transform into synthetic organisms or biological structures:

> *"Today we have companies like Twist [...] they print DNA. Essentially, they have a 3D printer for the DNA molecule. So, if you can design the genetic code, you can just print it, and then install it into a living organism"* (21:16).

DNA is essentially an information and data medium, using ATCG instead of 0/1 in computer science. As technologies that allows reading, writing and hacking of the programming language of life become widely available, plant growth and food production can become more efficient and sustainable (McCauley, 2017). Producing plants and food with specific nutritional value or genetic material in a personalized manner can result in healthier diets and reduced medical treatments. Additionally, several food startups in Silicon Valley, such as Soylent, NotCo, Perfect Day and Impossible Foods, are creating plant-based, bio-engineered, and sustainable alternatives for protein, dairy, and meat products via a software engineering approach (Bajarin, 2015; Ismail, 2017; Van Noort, 2018). Other novel types of foods, made from algae, seaweed, fungus, and insects are also heavily researched for commercialization. The advances in complementary food

technologies, powered by biotechnology and genetics, are exponentially decreasing in price and disrupting the industrial food system with digitized biological processes.

Agricultural Innovations and User-generated Innovation

In addition to advances in the Internet of Food, as well as biotechnology and genetic-engineering, other agricultural innovations and trends are also contributing to sustainable food economies. One of these innovations is the emerging resource-efficient non-soil-based farming methods, such as aeroponics, hydroponics and aquaponics, saving up to 95%+ of water consumption compared to traditional soil-based field farming (Kozai et al., 2015). Moreover, analysing farmable land not in terms of surface area but in terms of volume creates *agricultural opportunities in 3D space*, such as horizontal stacked layers of plant beds and vertical wall farming approaches (Despommier, 2010). Due to these developments, new (indoor and urban) agricultural locations are becoming viable for business opportunities, such as: backyard gardens, rooftops, walls, vacant buildings, shipping containers, underground spaces, or directly in supermarkets (Specht et al., 2015). These novel agricultural growing methods and locations lead to more sustainable use of resources such as land, water, pesticides, herbicides and fertilizer, allowing farmers to *grow more real food closer to the consumer with less resources in sustainable, decentralized and local food economies* (Groesbeek, 2009; De Schutter, 2010; Kozai et al., 2015; McIntyre et al., 2009). Hence, projects are emerging to realize short food supply chains via:

- urban farming and building integrated agriculture;
- vertical farming and indoor food production;
- community supported agriculture (CSA) and city gardening;
- permaculture, regenerative agriculture and agroecology;
- in-store agriculture and farming-as-a-service;
- local food-box subscriptions and food-as-a-service.

Most of these new forms of agriculture are only recently viable as a farming business opportunity and are likely becoming more cost-effective in the future due to advances in aforementioned trends.

Additionally, user-generated food innovation is occurring via physical and digital collaboration, places where people come together to learn from each other, share knowledge, verify information, and cooperate to push the sustainable food transition forward. An increasing network of food innovation hubs, farming incubators and agricultural accelerators, as well as community-based agriculture and food education programs is emerging. In these physical places, consumers, entrepreneurs and public administration can come together and collaborate to realize local sustainable food projects. Additionally, digital platforms are being built, allowing for sharing information about farming and food via crowd-sourced and open-source Wikipedia-like applications. MIT's Open Phenome Project is a noteworthy example, as it is attempting to realize a database of phenome data, essentially a digital encyclopaedia for plant specific climate

recipes (Harper, 2016). Due to new forms and locations of agriculture, as well as physical and digital collaboration places for user-generated innovation, developments in sustainable food can be achieved.

A final trend in sustainable food is the aim to implement circular economy principles to farming, realizing *circular agriculture*. Not only by utilizing permaculture, regenerative agriculture and agroecology techniques, but also by using waste streams of one sector as resource inputs for another, resource loops in food economies can become more sustainable. An example can be found in the growing number of mushroom farms leveraging used coffee grounds. Circular economy hubs, such as BlueCity in Rotterdam, can include complementary food start-ups to close resource loops within the business ecosystem. Myers (2016) envisions an integrated urban farming system, in which several common waste streams in urban environments can be used for sustainable and circular agri-food ventures, as illustrated in figure A5.

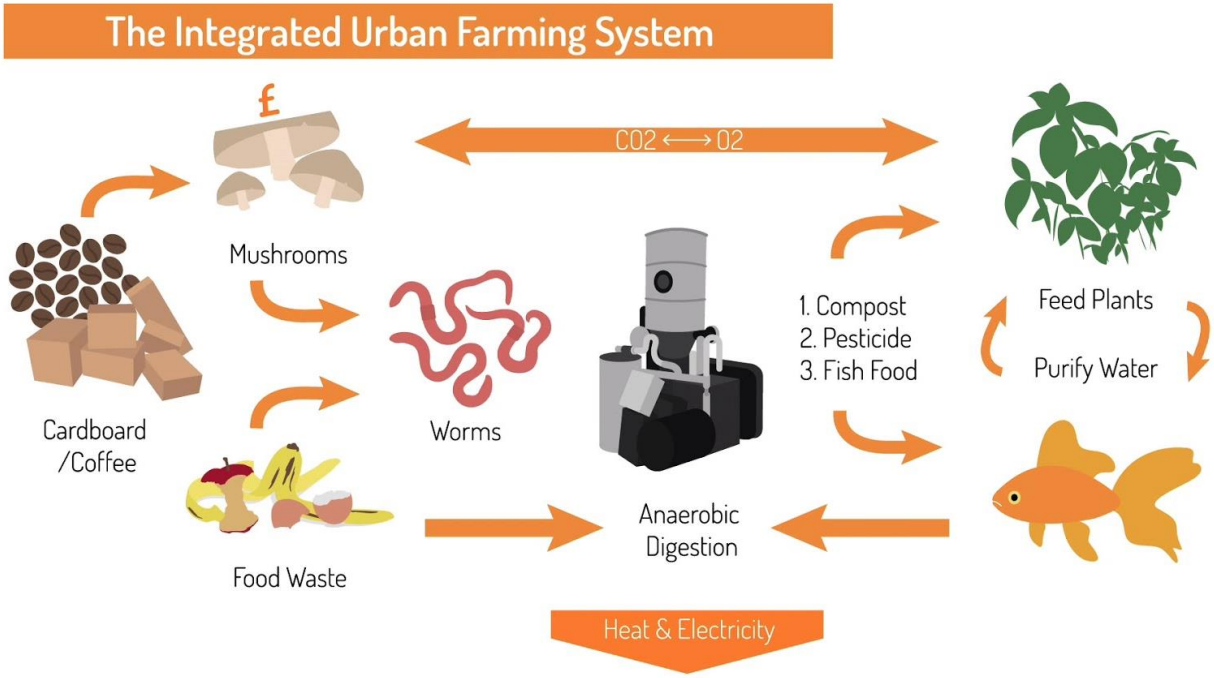

Figure A5: A conceptual schematic for an integrated urban farming system. Source: Myers, 2016.

An Overview of Tools, Technologies and Trends for Sustainable Food

Aforementioned business opportunities, agricultural innovations, food technologies, and exponential advances in ICT, robotics, genetics, biotechnology are all complementary in contributing to the sustainable food transition, and the last element for sustainability in the Environmental Nexus. Figure A6 presents a visual overview of these emerging business opportunities for sustainable food in five categories. First, the technologies that are impacting the agrifood industries, such as the trend towards more nature inspired and biological based approaches on the one side, and the push towards automated

agriculture and climate controlled indoor growing environments. A second category views the food industry from a life science perspective that is increasingly digitized. Due to the exponential drop in cost for DNA sequencing, from 2.5 billion per human genome in 2003 to 100 dollars in 2018, not only has humanity gotten a better understanding of the human code, also animals, plants and another food producing organisms are biologically researched. This leads to innovations in biotech and food engineering, such as cultured meat, new types of food or genetic manipulation. Additionally, the innovations regarding the so-called internet-of-food are listed. Smart connectivity between farming and processing machinery, coupled to processes in the transportation and retail phases of the products can lead to more openness and transparency in the food chain. The data collected from these processes are additive to the data collected from biological processes, as biotech sensors are measuring and tracking not only the nutritional value of the produce, but also genomic, phenomic and microbial data. Next, novel farming locations, such as on rooftops, inside buildings, underground, and floating systems on water are becoming more recognized and used for agricultural purposes. Hence, a potential future of a global ecosystem of local food distribution networks can be envisioned. Lastly, business model innovation plays a major role in the food transition to city regions achieving a circular metabolism. Many business opportunities can be identified in the agrifood industry and the emergence of open innovation, knowledge sharing, and collaboration enables a rapid growth of urban farming networks. Many organizations are working in wildly varying disciplines to achieve a more sustainable agri-food system. These *agricultural innovations are complementary* and feeding off each other, thus are likely going to be combined to radically change the industrial agri-food industry. Gaining a better understanding about these trends is important because these technologies and innovations can be combined and applied in ZFarming operations, expanding the innovation ecosystem with more network actors.

Tools, Technologies and Trends for Sustainable Food

The food industry is ready for disruption by entrepreneurs leveraging complementary technologies and trends that can transform *analog, linear, inefficient and industrial farming processes* into **digital, exponential, decentralized and sustainable agriculture**

AgriFood Tech

sustainable growing processes

ECOLOGICAL AGRICULTURE
- aquaponic food production
- hydroponic / aeroponic food
- organic & biodynamic farms
- holistic farm management
- regenerative agriculture
- permaculture & agroecology
- worm & food waste compost
- circular economy farming

AUTOMATED AGRICULTURE
- climate control systems
- genome control systems
- phenome control systems
- microbial control systems
- artificial lighting (LED)
- app-based plant growing
- smart farmbots & drones
- 3D printing components
- modular farming systems
- greenhouse technologies

Digital Life Sciences

read, write & hack DNA and life

BIOTECH & NANOTECH
- genetic engineering (GMO)
- CRISPR-CAS9
- 3D printing DNA
- plant programming
- synthetic & digital biology
- prebiotics & probiotics
- micro-organism treatments
- personalized nutrition

FOOD ENGINEERING
- insects & worms farming
- seaweed & duckweed farms
- algae & rapeseed farming
- fungi / mycelium food
- cultured / in-vitro food
- plant-based dairy & meat
- 3D printing living food

Internet of Food

connected & decentralized data

SMART CONNECTIVITY
- internet of things
- blockchain-ready hardware
- disposable electronics
- cloud computing
- sensors, robotics, AI
- precision farming
- traceability & food safety
- digital supply chains
- 5G mobile networks

DATA-DRIVEN AGRIFOOD
- blockchain data systems
- genetic data
- phenome data
- microbiome data
- metagenomics data
- quantified-self data
- health & vital signs data
- nutritional value data
- big data analysis algorithms

Farming Locations

urban, vertical & indoor farms

LOCAL FOOD PRODUCTION
- zero-acreage farming
- rooftop & underground
- vertical stacked plant beds
- vertical growing towers
- edible facades & walls
- building integrated (BIA)
- in-office agriculture
- shipping container farming
- fridge-sized farm systems
- household agriculture
- community-based farming
- balcony / window farming
- urban integrated agriculture

LOCAL FOOD DISTRIBUTION
- food-box subscriptions
- online food markets
- autonomous drone delivery
- bicycle delivery networks
- grow-it-yourself kits
- local farmer markets
- food festivals & food trucks
- pop-up restaurants & shops

Business Models

local food economies & SFSCs

BUSINESS OPPORTUNITIES
- community agriculture (CSA)
- in-house food production
- farming-as-a-service
- food waste & vermicompost
- circular resources manager
- farming & food education
- tours, events and workshops
- food community building
- data & knowledge brokering
- data aggregation & security
- local cryptocurrencies
- ICOs & crowdfunding
- blockchain transactions

OPEN INNOVATION
- collaborative learning
- agrifood innovation hubs
- user-generated innovation
- openAg / phenome project
- open source ecology
- biohack labs & maker spaces
- digital sharing platforms
- crowdsourcing communities
- information & media hubs

Figure A6: An overview of emerging innovations, technologies and trends for sustainable food.

Appendix B) Interview Questions

What is your organization's role in the urban farming network?
(mission and vision, activities, etc)

What is in your opinion typical to the ecosystem in Denmark?
(cultural traits, collaboration mechanisms)

What are some of your most important partners and how did they come to be?
(eg funding, testing of knowledge and ideas, logistics & distribution)

What do you find important in a partnership?

To what extend can the organization be classified in the following roles?
(Ask questions related to the activities described in the integrated framework and rate the answers on a scale from 1-5; 1 = not at all, 5 = daily focus).

- Leadership roles
- Planning & construction
- Sales & distribution
- User
- Expert
- Champion
- Entrepreneur
- Sponsor
- Regulator

What does the interviewee think about niche protection mechanisms?

- Shielding (processes that protect the emerging niche against multidimensional selection pressures, such as dominant industry structures, political power, and cultural significance)
- Nurturing (ask about: network formation, shared vision, learning experiences)
- Empowerment (Processes that make niche innovations competitive within unchanged selection environments "fit-and-conform". Or change mainstream selection environments favourable to the path-breaking innovation "stretch-and-transform)

Appendix C) Full Scoring Results

Tables C1 and C2 provide a full overview of the scoring results, based on the quantitative data collected from the interviews.

Network Role	DK1	DK2	DK3	DK4	DK5	DK6	DK7	DK8	DK9	DK10					Max	Total	Percentage
Leadership roles	3	2	4	3	5	4	4	5	2	5					50	37	74%
Planning & constr.	5	3	5	2	4	5	2	2	5	1					50	34	68%
Sales & distribution	2	1	4	5	4	2	5	2	2	1					50	28	56%
Expert	4	5	4	4	2	4	4	2	5	2					50	36	72%
Champion	2	4	3	2	3	2	2	4	2	4					50	28	56%
Entrepreneur	3	2	5	5	5	4	5	2	5	1					50	37	74%
Sponsor	1	2	1	1	1	1	1	5	2	3					50	18	36%
Regulator	1	3	2	1	1	1	1	1	3	5					50	19	38%

Table C1: An overview of the scoring result of the Danish ecosystem roles.

Network Role	NL01	NL02	NL03	NL04	NL05	NL06	NL07	NL08	NL09	NL10	NL11	NL12	NL13	NL14	Max	Total	Percentage
Leadership roles	1	2	2	3	4	5	5	5	3	2	5	2	4	4	70	47	67%
Planning & constr.	3	5	5	2	2	2	2	5	5	2	1	3	4	1	70	42	60%
Sales & distribution	2	2	2	1	2	1	5	1	2	5	1	5	5	1	70	35	50%
Expert	2	3	5	5	5	3	4	4	5	3	2	3	4	2	70	50	71%
Champion	1	2	2	4	5	3	4	4	2	3	5	3	2	5	70	45	64%
Entrepreneur	5	5	5	1	2	1	3	2	5	5	2	5	5	1	70	47	67%
Sponsor	1	1	1	2	5	4	2	3	4	1	5	1	1	2	70	33	47%
Regulator	2	1	3	1	4	5	5	4	2	2	2	2	3	3	70	39	56%

Table C2: An overview of the scoring result of the Dutch ecosystem roles.