IDENTIFYING BARRIERS HINDERING THE AQUAPONICS AS AN EMERGING VALUE-CONSCIOUS SOCIO-TECHNICAL SYSTEM IN THE NETHERLANDS

Marianna Piptová

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3rd and 4th Urban Crops demonstration PFAL[online] Available at: https://www.hortidaily.com/article/24546/Belgium-Urban-Crops-opens-largest-automated-plant-factory-in-Europe/ [Accessed 4 Apr. 2018].

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Author: Marianna Piptová

Student nr. Technische Universiteit Delft 4326199

Student nr. Universiteit Leiden s1440101

Thesis committee

1st Supervisor: Dr. Linda Kamp

Faculteit Techniek, Bestuur & Management - Engineering Systems and Services, Technische Universiteit Delft

2nd Supervisor: Dr. Udo Pesch

Faculteit Techniek, Bestuur & Management - Values, Technology and Innovation, Technische Universiteit Delft

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"No, no! The adventures first, explanations take such a dreadful time."

— Lewis Carroll, Alice's Adventures in Wonderland & Through the Looking-Glass

PREFACE

"You cannot legally call it organic but it is very organic" said Erik Moesker in the interview (2020) about the barriers hindering the Aquaponics development in the Netherlands. To date, a considerable amount of literature has been published on Aquaponics, but no previous study has provided information on identifying theoretical framework that can be used to determine the barriers to the Aquaponics emerging as a value-conscious socio-technical system in the Netherlands

This thesis is a part of MSc. Industrial Ecology and it aims to research which theoretical framework can be used to systematically analyse what is hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. The proposed final theoretical framework Piptová 2.0 (2020) considers various processes and phenomena representing barriers hindering the Aquaponics in institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions based on stakeholders' values. Apart from an anthropocentric orientation, it includes ecocentric research interests in non-human well-being. The Aquaponics, as a part of technological disruption in the Netherlands, is subject to adaptation and transformation. It reshapes and attunes according to emerging obstacles and requirements from actors and changing socio-technical landscape in the process of development.

These barriers exist on several levels of the socio-technical systems and within the technological niche itself. They are set in an institutional context. In order to face the current challenges of environmental degradation, uncertainty, as well as social and economic inequality, it is crucial to examine the various nested contexts of new technologies and identify bottlenecks hindering their spread. Moreover, it is crucial to assess how they are interrelated from the system dynamics perspective and to come up with new out-of-box ideas about how to tackle them. The developed final theoretical framework Piptová 2.0 (2020) helps to identify these barriers from the system perspective; hence, Aquaponics can become the new 21st century efficient, value-conscious, fair and resilient food production system incorporating diverse values of stakeholders.

EXECUTIVE SUMMARY

In the current times when "facts [are] uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz & Ravetz 1990) humanity reaches for new ways of improving our life through resilient technology enhancements embedded in a socio-technical landscape. This thesis presents an effort to develop a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. The barriers are identified in institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions. In the research, the initial barrier criteria theoretical framework was established based on combining Functions of innovation system, Circular economy theoretical models in the Verhulst (2017) theoretical framework with ethical barriers based on Value Sensitive and Value Conscious Design approach. This primary theoretical framework Piptová 1 (2018) was applied to the current Aquaponics case in the process of desk research and in-depth interviews with stakeholders. This resulted in a list and description of barriers. The high initial investment costs, scalability issues due to the niche character of the market for Aquaponics products, cold climate in the Netherlands, current non profitability due to incumbent infrastructure of cheap vegetables supplied by elaborate Dutch horticulturalists from their greenhouses and cost-effectively imported fish, biophysical limitations as well as several ethical barriers in the form of value tensions and values not represented by a value advocate in the Aquaponics discourse were identified as the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. Based on the list and description of barriers, the primary theoretical framework was revised and adapted by adding and removing indicators. The final theoretical framework Piptová 2.0 (2020) was established. It reflects on the malfunctions, ethics and risks of new technologies but also democratisation in the design process and science in general through an ecocentric prism due to the fact that it contains a consideration for all directly and indirectly affected stakeholders, whether presented or not by an actor, including the non-human ones. Via employing the fundamental capabilities of the created framework and adapting it in order to be able to detect a wider horizon of developmental bottlenecks from the systemic Industrial ecology perspective, a novel generally applicable theoretical framework was also created. Producers, consumers, scholars, practitioners, policy makers and other actors might utilise this framework with improved generalizability when executing improvements on targeted hotspots in the transition towards a 'responsible society' via a variety of 'fair' innovations emerging as value-conscious socio-technical systems. These are the advancements that not only 'look good on paper' but truly are more innovative in a 'responsible and responsive' manner due to the fact that they challenge the status quo of problem shifting; the one which Beck (1998) in his sociological understanding defined as the 'organized irresponsibility'.

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LIST OF ABBREVIATIONS AND ACRONYMS

A Aquaponics

CE Circular Economy

FIS Functions of Innovation System

IS Innovation System

RAS Recirculation Aquaculture system

RI Responsible Innovation

R&D Research and Development

SSI Sectoral System of Innovation

STP Science and Technology Push

TIS Technological Innovation System

TSIS Technology Specific Innovation System

VSD Value Sensitive Design

VCD Value Conscious Design

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1. GENERAL INTRODUCTION

1.1. Global Food System Challenges and Aquaponics

Aquaculture is globally the fastest growing sector of agricultural industry while trying to meet sustainable bio economic demands (Kloas et al. 2015). Aquaponics is a rapidly emerging closed-loop food production technology, which can be very low-tech. It integrates aquaculture (fish farming) with hydroponics (growing plants using water rather than soil) in a symbiotic system. The precursors of aquaponics were systems where aquaculture and agriculture were integrated without the recirculation of water nor hydroponics. Aquaponics started to appear in the scientific literature in the 90ties.

By 2050, Earth is projected to have a population of 9.8 billion people (UN 2017:12). The Dutch population is expected to increase from 16,3 million in 2018 to 17,6 million people in 2050 (UN 2017:24). The climate change and the impact of humans on the environment and other non-human beings is becoming increasingly recognised as a problem of the here and now instead of as a problem of future generations. Rising temperatures cause huge local and global die-offs raising fears for the wellbeing of broader nested ecosystems (Cagle 2019).

How to feed 10 billion people and how to sustain our megacities of the future? Aquaponics might be one of the technically, economically, socially viable and environmentally sound solutions. In this thesis, the barriers hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands are addressed. These exist in various degrees on multi-levels of socio-technical systems and established socio-technical regimes nested in the web of life (Capra 1997). Aquaponics is a radical innovation trying to replace an incumbent unsustainable agro technology on the path of technological transition towards sustainability and a 'just society'; a term used by Shue (1999) to describe a more fair society.

Assuring food quantity and quality within planetary boundaries while acknowledging the complexity arising from sustainability in the future requires innovative agricultural techniques which provide food in a sustainable and fair manner (Leach et al. 2012). Aquaponics as a Recirculation aquaculture system (further RAS) with closed matter and energy cycles can provide a solution to two main challenges of sustainable development: firstly, the growing global demand for animal proteins by providing a low ecological impact fish supply; and secondly, farmed fish production lowers overfishing of diminishing marine fish stocks (Kloas et al. 2015, Tschirner and Kloas 2017). High-tech Aquaponics could be a new future agro-ecological intensified food production system offering city farming with lowered maintenance and maximized yield (Al-Kodmany 2018) on limited farmland, such as vacant industrial areas.

In Figure 1.1 the Aquaponics functioning is explained. Fish are fed and their ammonia rich discharge gets converted into nitrites and then nitrates by established bacteria colonies. These serve as nutrients for growing plants. Water in the systems is filtered with the help of plant roots and grow beds medium. Air pumps pump the oxygen into the system. The result is a synergistic interaction between fish, microorganisms and plants.

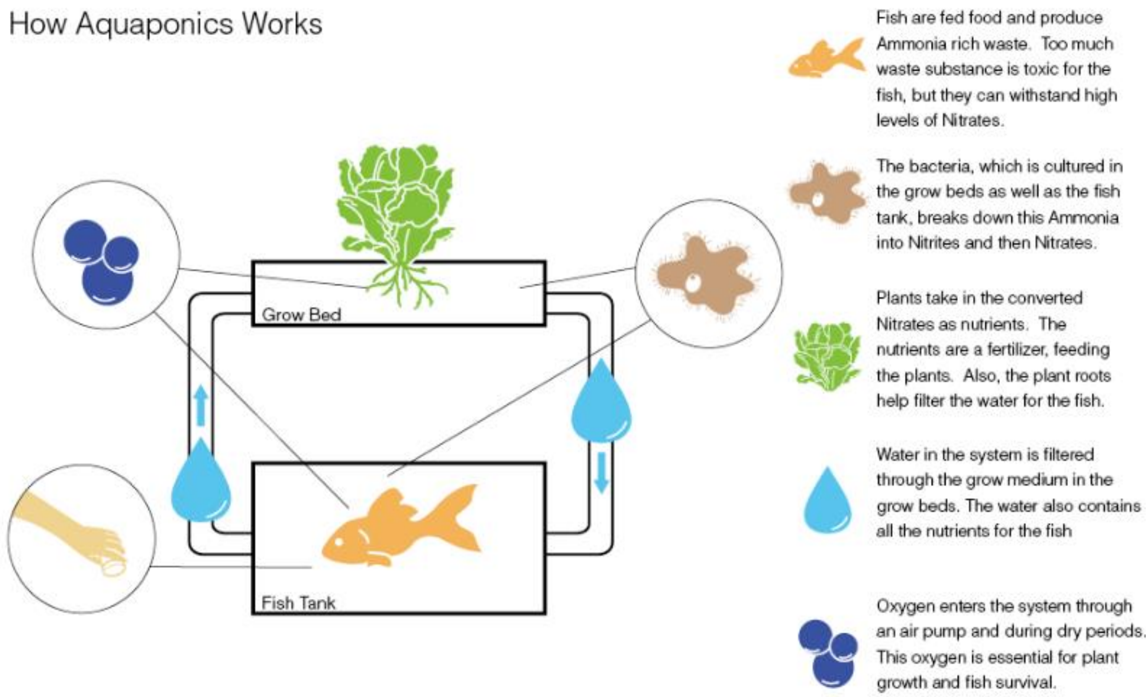


Figure 1.1 Aquaponic System explained ("Why Aquaponics? | Leafy gills" 2018). Fish are fed and their discharge gets converted into nutrients by the bacteria colonies for the growing plants. Water in the systems is filtered and air pumps pump the oxygen into the synergistic system of fish, microorganisms and plants

This technological niche emerged as a form of urban agriculture, which tries to "bring food back into the city". It is spreading around as one of the sustainable closed loop solutions towards the climate change crisis, promising to solve problems connected to food quality and quantity. Aquaponics practitioners are also a sort of a social movement. The urban farmers and activists perceive Aquaponics as an opportunity to save resources, increase consumer awareness, improve aesthetics of abandoned buildings and educate and create experimental spaces based on novel business models (Specht, Siebert, Thomaier 2016).

In an Aquaponic system, water with nutrients recirculates between plants, bacteria and fish (Rakocy 1988). Excretions from the fish being raised are by-products which are processed by bacteria and then utilized by the plants as nutrients for their growth (Graber and Junge 2009). In Aquaponics, there is no need to use chemical nutrients for the plants and there is no fish waste build-up in the system that causes the water to become toxic due to nitrites (Turkmen and Gunner 2010).

Aquaponics represents one of the Circular economy approaches and its development is influenced by Responsible innovation, currently trending in socio-technical sphere. This soil-less closed loop system can be used anywhere. In certain conditions, it could have a significantly lower requirements on energy, materials and resources compared to traditional forms of agriculture (Al-Hafedh, Alam and Beltagi 2008; Hancock 2012; Love, Uhl and Genello 2015). Sometimes referred to as one of the ZFarming techniques, meaning Zero-acreage Farming, it does not require farmland or open space. It is rather practised in 'extraordinary' places, indoors in unused spaces, such as unoccupied buildings, old warehouses, abandoned plants, rooftops, gardens and vertically in the form of edible walls (Specht et al. 2016). Cradle-to-cradle design used in Aquaponics offers eco-efficiency aiming towards lower emissions and provides added value services and products that are concerned with social, economic and environmental well-being (McDonough and Braungart 2002; Kumar and Putnam 2008).

The idea of growing food in the city started in the 90' as a result of a food crisis connected with population rise, overwhelming urbanization and radical biodiversity loss. Environmental decay, experts have been telling us, goes hand in hand with human inequality and also interspecies inequality (Cooper and Palmer 2005). By the end of the 20th century, in response to a growing environmental crisis, more scholars started to address the issues of interrelation between inequality and environmental sustainability (Dietz, Rosa and York 2009). It motivated peer-reviewed publications (Schneider, Kallis, Martinez-Alier 2010). Social justice and sustainability towards and for humans is being extended to include other species and ecosystem entities. Reducing inequalities between humans and other species, next to environmental damage, is becoming the new sustainable development challenge. This can be seen in the gradual shift from a reductionist and incremental anthropocentric perspective towards a more holistic system-oriented ecocentric paradigm (Burdon 2011, De Lucia 2014a, De Lucia 2014b, Kopnina 2012, Shastri 2013). Scholars and practitioners of Industrial ecology are also influenced by this trend penetrating Socio-technical landscape. More attention is paid to the non-human wellbeing and non-humans quality of life. There is a realisation that technology is valued-laden, embedded in social context and antagonistic value tensions between value sets occur. In the process of technological innovation, these values of interacting direct and indirect stakeholders need to be taken into consideration. That is crucial not only during the process of technological artifact creation, but also within institutional context redesign (Correljé, Cuppen, Dignum, Pesch & Taebi 2015).

1.2. Responsible Innovation through Stakeholder Engagement

Nowadays food security issues within the sustainability corridor ask for technological innovations beyond traditional paradigms, addressing the wicked character of sustainability challenges (Pretty et al. 2010). Moreover, moral and ethical intelligence is finding its way into the science of technology, business and technology itself (Manders-Huits & Zimmer 2009).

Aquaponics could change the way food is produced and consumed (König et al. 2018). It could change our perspective on how we as a public perceive sustainable food systems. Aquaponics and its design, like other technologies, has value implications due to the fact that technologies determine our beliefs and practices, by creating or weakening certain values (Van de Poel 2009, Manders-Huits 2017). We as a public have 'a stake' or our interest in technological development which we are directly or indirectly a part of (Van de Poel & Royakkers 2011).

Responsible innovation is characterised by stakeholder engagement and longitudinal participation throughout the innovation process. Proponents of Responsible innovation approach emphasise the urgency of taking stakeholders' opinions, values, beliefs, expectations and needs into consideration when proceeding with innovation. According to ethical justification, if technology has influence on stakeholders, causing them harm or benefit, then these stakeholders should be involved in its design and further implementation (Pols 2017). This reasoning 'taking values into account' is in line with the Value sensitive design approach. We are obliged to 'listen' to the stakeholders.

Morality and ethics call for inclusion of stakeholders' interests, even when these stakeholders might be powerless (Van de Poel & Royakkers 2011). This is one of the requirements of 'fairness and equality' in ethics of technology (Manders-Huits 2017). Values of stakeholder have a dynamic character, they emerge and evolve; therefore Value sensitive design approach does not have an ambition to be a blueprint but rather to serve as a tool which is context dependent and flexible (Correljé et al. 2015). Responsible innovation is to be sensitive to specific cultural, political and economic factors. In order to deal with the benefits and harms of technology and science in general, Van der Velden (2008) suggests also cultivating Cognitive justice, meaning respecting the diversity of human knowledge as an indicator of a democratisation of science.

Manders-Huits (2017) claims further that from the point of view of ethics of technology, taking stakeholders' values into account is insufficient. From an ethically justified prism, there is a normative ethical component missing in Value sensitive design approach. Technology inevitably forms stakeholders' values. Manders-Huits (2017) argues that the purpose of technological innovations is not only to be 'sensitive' to stakeholders' values, only taking them into account. The technological innovation should in the first place be consciously and deliberately conceptualised, designed, and developed while pre-emptively implementing ethical value concerns, before the introduction of technology into society. This 'value conscious' approach then includes normative reasoning by creating a technology based on moral values from the start. Value conscious design offers a more proactive approach to ethics of technology compared to retroactive application of Value sensitive design (Manders-Huits and Zimmer 2009. This 'frontloading of ethics' (Van Den Hoven 2005) prefers a proactive normative outlook; which can be challenging (Manders-Huits and Zimmer 2009) due to the fact that the outcomes of our value choices are unknown, complex and as Funtowicz and Ravetz (1995) call it, "uncertain, contested and irreducible". An important element in line with the frontloading of ethics reasoning is the establishment of the role of values advocates in the design process who present all value choices together with essential normative justification. Value advocates can be seen as actors acting on behalf of stakeholders that steer the direction of technological development. Stakeholders not represented by actors or some sort of 'value advocates', 'value defenders or promoters' still have an interest ('a stake') in the technological development, however, they cannot necessarily influence its trajectory and therefore their views might not be taken into consideration (Van de Poel & Royakkers 2011). However, morality and ethics demand that any stakeholders with values in technological development, no matter how weak or insignificant according to certain justifications, will be taken into consideration.

There are various types of direct and indirect, external or internal, stakeholders involved in the development of socio-technical systems who through their perspective and their value system influence the technology development. On the other hand, these stakeholders and their values are also influenced by technology development. There are values for each stakeholder in the emerging socio-technical system. When these values of various stakeholders are in conflict with each other or are not being vocalised through a representing actor who can and is acting on their behalf, then this might hinder the innovation and represent barriers or bottlenecks which need to be dealt with in order for technological innovation to flourish and further develop. In the food systems, there are values connected to quality of life and well-being of human and non-human beings.

Developers and producers, regulators and other actors influence technological development and its further ecological, ethical, social, health, political and economic consequences. They have a responsibility of steering the technology in a desired and beneficial direction. They do not decide about technological development in isolation. Technology and criteria for its evaluation are not value neutral (Roeser 2012, Jafari et al. 2015) and should be morally laudable (Manders-Huits and Zimmer 2009). Van de Poel and Royakkers (2011) presume that there are three ideals of engineers, which we could extrapolate to the ideals of technology developers in general: technological enthusiasm, effectiveness and efficiency and human welfare enhancement. The enhancement of non-human welfare is missing in this presumption.

According to Friedman et al. (2002) in Value sensitive design, the starting point is a technology, its use or a value. Next, the direct and indirect groups of stakeholders and harms and benefits for each group are determined. These are linked to corresponding values which are later conceptualized. This way the potential value frictions between human values implicated in technological development become visible and can be identified (Friedman, Kahn & Borning 2008).

1.3. Bottlenecks Hindering Innovation

What theoretical framework can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands from the inter- trans- multi-disciplinary view of Industrial ecology? What blocks Aquaponics from being the urban food production of the future? What are the barriers hindering Aquaponics as an emerging value-conscious socio-technical system in order to grow, spread and develop in line with nowadays efforts, such as Circular economy, more ethical thinking approach, values incorporating and stakeholder engaging Responsible innovation and also Value sensitive and Value conscious design trends? What are the socio-technical barriers hindering Aquaponics development? What are the ethical barriers? How does the conflict between values of various stakeholders in Aquaponics hinder its development? What values of stakeholders are not represented by actors or value advocates in the Aquaponics discourse and therefore decelerate this innovation? How do these interconnected, sometimes latent, phenomena and processes interplay hindering emerging value-conscious socio-technical systems?

The phenomena and processes that hinder the development of Aquaponics in the Netherlands exist on multi-levels of socio-technical systems and within the technological niche itself. These are all set in an institutional context. A plethora of anthropocentric and also ecocentric lenses from the system dynamics perspective can be employed in order to identify the barriers nested in various socio-technical contexts.

The development of a theoretical framework that can be used to analyse the barriers hindering the Aquaponics has two connotations. Firstly, it refers to the particular significance of different types of institutional (based on hard and soft values and norms), technical, economic (financial), infrastructural, knowledge, socio-cultural and ethical arrangements in the process of the Aquaponics development. The main focus is given to the influence of barriers that exist as certain patterns at multi-levels of socio-technical systems. Secondly, it refers to the fact that the above mentioned arrangements with its sets of values and norms are not static, but - on the contrary – dynamic and constantly in development themselves.

By bringing these two connotations together, the study of 'a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands' not only refers to the dynamics of Aquaculture development in the Netherlands but attempts to relate these to processes and phenomena of socio-technical change, such as transition towards sustainability, social justice, proactive responsibility in innovation, democratic technology and ecocentric perspective. Moreover, it bridges social sciences and engineering, closing the illusional gap between them.

1.4. Research Aim and Approach

In this chapter the research aim, problem definition, research questions, research approach and relevance are described.

1.4.1. Problem Definition and Aim

The current environmental crisis connected to food production and consumption in the city areas requires transdisciplinary knowledge in order to battle its negative effect. Aquaponics combining horticulture and aquaculture within a closed-loop ecologically sound system presents one of the emerging solutions to this problem. Aquaponics and activities connected with it are embedded in socio-technical context. Several aspects of infrastructure and socio-technical landscape, however, might hinder its development, spread and growth. Various kinds of barriers exist on institutional, technical, financial, infrastructural, knowledge related, socio-cultural and ethical levels. It is crucial to identify these processes and phenomena that hinder Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The aim of this thesis is to develop a theoretical framework that can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands from the inter- trans- multi-disciplinary view of Industrial ecology.

Research on the Dutch Aquaponics is still in an early phase and requires further research due to the fact that there is only a small number of publications available on this subject. These publications consider mostly the profitability of Aquaponics in the Netherlands (Godek 2017).

Missing research on the barriers hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands comprises the gaps in knowledge. Several studies have addressed some challenging aspects of Aquaponics separately. There are several publications available which focus on Aquaponics challenges and opportunities in the Netherlands and globally.

Bosma et al. (2017) based on grey literature review and a post-hoc cost-benefit analysis intended for Aquaponics in the Philippines identified the challenges for Aquaponics as the price of high-value niche vegetables, high financial investment into a small fish production compartment of Aquaponics, specific know-how in order to fine-tune the whole biotic system and creating a niche market for high-value fish.

There has not yet been developed a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. König et al. (2018) have analysed Aquaponics as an emerging technological innovation system in Germany using TIS as a basis for further analysis. Their framework consisted of assessing the System core; Factors shaping the system characteristics, such as Actors, Networks, Knowledge, Human capital; Institutional system including Legislation and Future development and Influence of incumbent regime actors. Their research has identified that the main challenges for Aquaponics existing between the well-established TIS of vegetable production and aquaculture are not united visions about the future of Aquaponics by various stakeholders, missing long-term ideas about how to develop Aquaponics in the complex landscape of new and incumbent technologies and institutions and also how to modify the institutions in order to shift from regime lock-in mechanisms towards a more resilient sustainable food system paradigm (König et al. 2018). Moreover, they conclude that Aquaponics in Germany is currently in the early era of formation according to Bergek et al. (2008a) TIS developmental phases chart and is characterised by high entrepreneurial insecurity, low economic activity and a fact that Aquaponics technology legitimisation building is crucial. Another important observation is that there is an issue about an unclear communication of benefits of Aquaponics towards future sustainability from the side of Aquaponics producers which might cause a loss of their legitimacy.

Godek (2017: 22- 36) focuses on the global challenges that Sustainable and Commercial Aquaponics faces in the technological, socio-ecological, economic and educational dimensions while showing a lack of training in systems thinking from holistic and interdisciplinary prism. From a technological perspective, the following challenges are mentioned: pH stabilization, nutrient balance, phosphorus amount, pest and disease management, regulation of the nitrate level. As socio-ecological challenges, mineral recycling, water and energy use, overfishing, urban farming and short supply chains are mentioned. At the time of research, mainly challenges connected to the technical aspects of Aquaponics were researched; financial aspects were not known due to not being shared publicly or due to the difficulty of comparing available parameters, outputs and figures for various systems (Godek 2017).

There is a study done on the financial profitability of Aquaponics in the Netherlands by Bosma (2017). The results show that in the current market situation, sustainable farming with Aquaponics is not profitable in the Netherlands for various reasons. Aquaponic fish and vegetables are an expensive commodity to sell. Aquaponics only makes sense if the entrepreneur succeeds in finding a good niche market for a combination of an expensive fish and relatively expensive vegetables. This is difficult in the Netherlands due to the established cheap greenhouse production (Bosma 2017).

Turnsek et al. (2020) note the following challenges for the commercialisation of the Aquaponics in the European context in their research: due to the Aquaponics complexity, calibrating the system via trial and error is a risky endeavour; it is labour intensive; lacks large-scale demonstration projects to show its potential; has high investment costs that caused bankruptcies of several Aquaponics enterprises; there is a lack of Aquaponics specific regulation; a lack of 'organic' labelling and issues with the marketing of the Aquaponics to the public in order to increase the awareness. That is due to the fact that according to Miličić et al. (2017) half of questioned respondents have never heard of the Aquaponics.

There is no research done on barriers hindering the Aquaponics in the Netherlands from the institutional, infrastructural, knowledge, socio-cultural and ethical perspective. Given these gaps, complexity and co-evolving nature of interlinked infrastructures, multi-dimensionality of wicked issues connected to sustainability (Mayumi and Giampietro 2006), it can be stated that there is a need to investigate a theoretical framework that can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The aim of this research is to develop a theoretical framework which would help to systematically identify these barriers acting as bottlenecks in the Aquaponics development in the Netherlands by combining various theoretical perspectives.

To summarize, the research goal is to develop a theoretical framework that can be used to identify the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands in three areas:

1. Identify socio-technical barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands in the process of Technology assessment. These barriers are recognized as poorly performing functions of the innovation system (further FIS) elaborated in the Verhulst (2017) theoretical framework.
2. Identify additional types of barriers - the ethical ones, missing in the Verhulst (2017) theoretical framework and considered crucial by Value Sensitive Design (further VSD) and Value Conscious Design (further VCD) approach as:
    a. Tensions between Values of various stakeholders involved in the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Values of various stakeholders in the Aquaponics development are connected to the harm and benefit of the Aquaponics development for the stakeholders.
    b. Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.
3. Identify additional types of barriers or dimensions.

The final developed universal methodological framework can be used to systematically assess the barriers hindering the development of a technological niche or innovation as an emerging value-conscious socio-technical system in the Netherlands.

1.4.2. Research Questions

The research questions are shown in Figure 1.2. The main research question is:

Which theoretical framework can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

The research sub-questions are:

- What initial theoretical framework and approaches can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
- How to include the ethical barriers into an initial theoretical framework and amend it so that it can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
- How can this methodological framework be applied to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

- What has to be adapted, added to or removed from the theoretical framework in order to make it suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

Figure 1.2 The research sub-questions and the main research question.

1.4.3. Research Approach

In this chapter, the scope, boundaries and data sources are described. The phases of research and the detailed methodological steps are described in chapter 2 Methodological overview.

1.4.3.1. Scope and Boundaries

For the purpose of this research, the Aquaponics installations currently existing in years 2018, 2019 and 2020 with implemented technology solutions and main stakeholders involved in the Aquaponics development in the Netherlands are taken into account. The focus of this thesis is to develop a theoretical framework that can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands from the inter- trans- multi- disciplinary view of Industrial ecology. It takes on a systemic perspective by considering the current complex interlinked trends influencing the Aquaponics development in the socio-cultural, technological, economic, environmental, political, legal and ethical dimensions. The amended Verhulst (2017) theoretical framework is used and applied to this case. It is extended by Ethical dimension based on Value sensitive design and Value conscious design approach towards Responsible innovation.

1.4.3.2. Data Sources

The data for determining a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands were collected, first, from the scientific literature and grey literature in the desk research, and second, through in-depth interviews with selected stakeholders. During the initial desk research, Google search was performed as described in chapter 2 Methodology Overview. Various sources, such as scientific journals, newspapers, books, reports, organizations' websites were used.

Crucial data sources were the websites of found Aquaponics installation projects and involved organizations with references to the next ones and searches in other phases of research in order to find answers to research questions in an iterative manner.

1.4.4. Research Relevance

In this chapter, the scientific, Industrial ecology and practical relevance of the research are described.

1.4.4.1. Scientific

There is a gap in scientific literature, which identifies a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands Moreover, there is no literature mapping the current Aquaponics situation in the Netherlands and the barriers to its further diffusion, as explained in chapter 1.4.1. Problem Definition and Aim. There is much to be learned about the barriers of Aquaponics as an emerging socio-technological innovation in environmental, operational, and socio-economic, cultural, infrastructural, institutional, political and ethical context. This thesis aims through research and data acquisition from available literature and in-depth interviews to fill this gap. It also strives to provide an overview of barriers which hinder the Aquaponics development in a pioneering manner through adding the prism of ethical aspects.

The Verhulst (2017) theoretical framework adapted for this case is combined with a novel ethical element. It enables analysis of both the niche development domain and also the mechanisms existing in the further socio-technical system. This theoretical framework consists of combined: firstly, Functions of innovation System criteria and indicators in order to identify hindering factors in the Aquaponics development niche and secondly, criteria and indicators of possible barriers extracted from Circular economy concepts. The additional ethical element is sourced from Value sensitive and Value conscious design principles which view tensions between values of stakeholders and the fact that some values of certain stakeholders are not represented by actors or value advocates as barriers to further technology diffusion.

The theoretical framework adapted and further developed in this thesis can serve other interdisciplinary scholars examining various perceived risks to the technology development globally. It can be implemented to other cases, in order to explore technology development hindrances. I hope this scientific knowledge can contribute to the disruption or slower transformation of the current dysfunctional economic system, which requires a profound system change on all levels of our consciousness, institutions, sectors, industries, regions, cognate fields and a discursive traction in order to better benefit the people, planet and other non-human beings.

1.4.4.2. Industrial Ecology

This thesis provides a novel approach in Industrial ecology due to combining anthropocentric FIS approach and extending the VSD and VCD towards a more ecocentric approach, which could be seen as a progressive part of Responsible innovation.

Until now, there have not been trials to merge these two theoretical frameworks and apply them to a case by implementing the circularity principles of Industrial ecology. This thesis aims, according to system thinking from Industrial ecology perspective, to take into consideration human and non-human wellbeing by including into the research also groups representing the stakes that non-human entities have in the Aquaponics development. The focus is more holistic, in line with Industrial ecology, performing the research through social, economic, environmental and ethical prism, paying attention to nested interdependencies between various elements. The newly developed theoretical framework can be applied to other cases in the area of niche management or the development of industrial symbiosis projects.

1.4.4.3. Practical

It is important to develop a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands if we want Aquaponics to become the next form of urban farming combating the soil salinization and nitrogen crisis caused by jam-packed livestock. The current food security crisis requires research focusing on systematic identification of barriers hindering the technology implementation. It can enable the future generations to better steer the development of new regional, national and transnational food systems in order to mitigate possible environmental, social, economic and health risks.

This research provides an insight for various scholars, practitioners, consumers and producers into what theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands and what needs to be overcome in order to make it more successful.

1.5. Thesis Outline

This thesis consists of eleven parts in the following order: chapter 1 General Introduction, chapter 2 Methodology Overview, chapter 3 Initial Theoretical Overview, chapter 4 Primary Theoretical Framework Piptová 1 (2018) Overview, chapter 5 Current Aquaponics Situation in the Netherlands, chapter 6 Barrier Analysis for Aquaponics in the Netherlands, chapter 7 Adaptation of Primary Theoretical Framework Piptová 1 (2018), chapter 8 Final Theoretical Framework Piptová 2.0 (2020) Overview, chapter 9 Conclusion, Reflection and Recommendations, chapter 10 References and chapter 11 Appendices.

2. METHODOLOGY OVERVIEW

To investigate the theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, a qualitative research involving desk research and in-depth interviews was performed.

In order to understand how the research was performed, the five phases of research are shortly described here and shown in Figure 2.1. The more detailed methodological steps are listed further In the first phase, a theoretical literature desk research and a review of scientific and grey literature on theoretical framework assessing the barriers was performed. An initial Verhulst (2017) theoretical framework was explored. Second, the ethical barriers theory was integrated into the initial framework, the Verhulst (2017) theoretical framework was updated and the primary theoretical framework Piptová 1 (2018) was developed. Third, the primary theoretical framework Piptová 1 (2018) was applied to the case of the Aquaponics in the Netherlands and a list and description of barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands was obtained. Fourth, a systematic revision of the primary theoretical framework Piptová 1 (2018) based on desk research and interviews was performed. Lastly, the final theoretical framework Piptová 2.0 (2020) was developed.

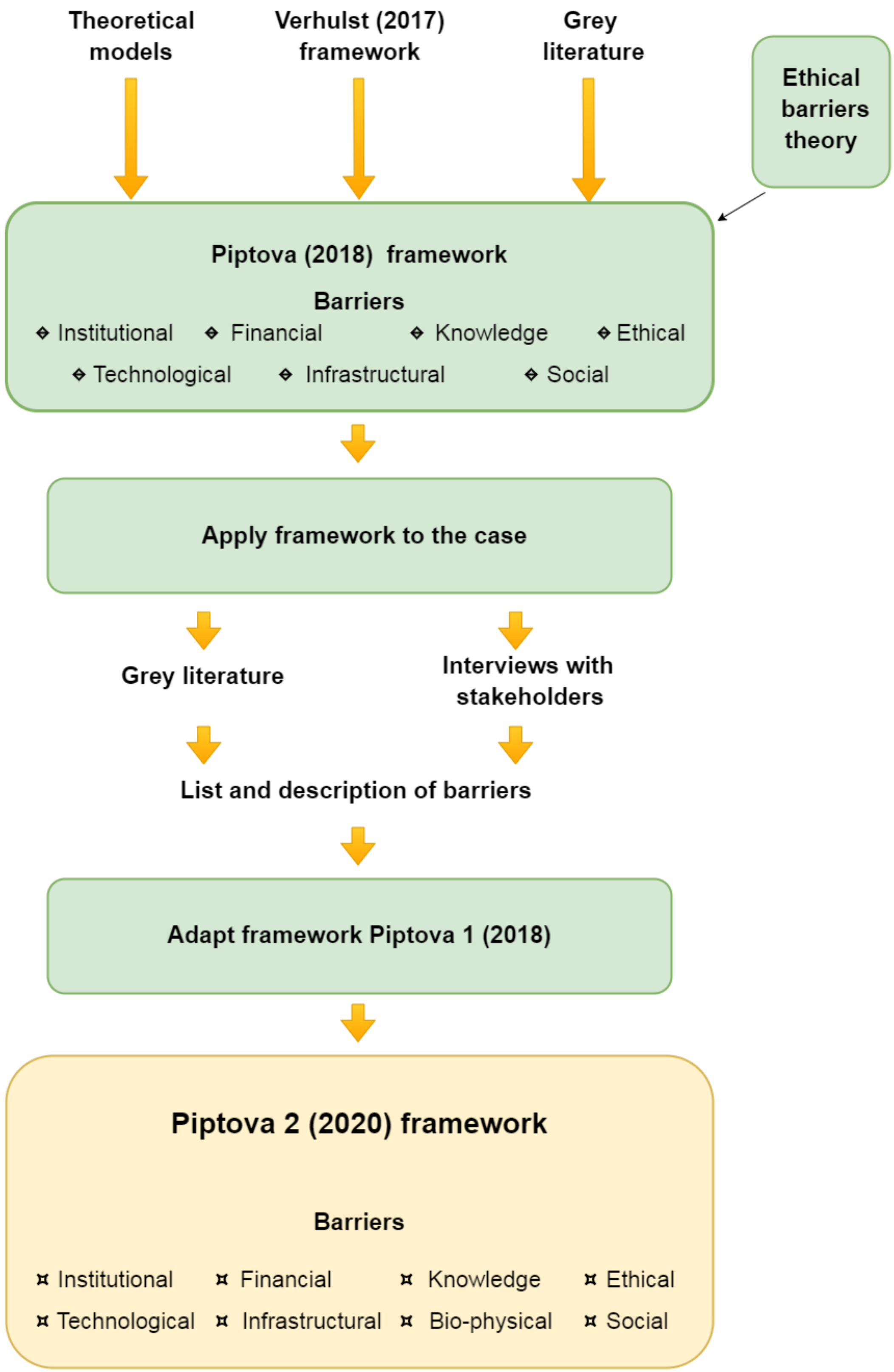


Figure 2.1 The main phases of research: first, a review of the scientific and grey literature on barriers and the Verhulst (2017) theoretical framework. Second, the ethical barriers theory

integration and development of a primary theoretical framework Piptová 1 (2018). Third, an application of the theoretical framework to the case. Fourth, a systematic revision and adaptation of the primary theoretical framework. Fifth, the development of a final theoretical framework Piptová 2.0 (2020).

In Figure 2.2 and in the text further, the iterative steps in order to answer each of the sub-questions and finally the main research question and the results are presented. The result of answering the sub-question 1 is the Theoretical overview of FIS and CE approach and the Verhulst (2017) theoretical framework. The result of answering the sub-question 2 is the Theoretical overview of VSD and VCD approach, integration of ethical barriers and primary theoretical framework Piptová 1 (2018). The result of answering the sub-question 3 is a List and description of barriers achieved by performing the scientific and grey literature review and interviews with stakeholders. The result of answering the sub-question 4 is the adaptation of primary theoretical framework Piptová 1 (2018). The result of answering the Main research question is the revised final theoretical framework Piptová 2.0 (2020).

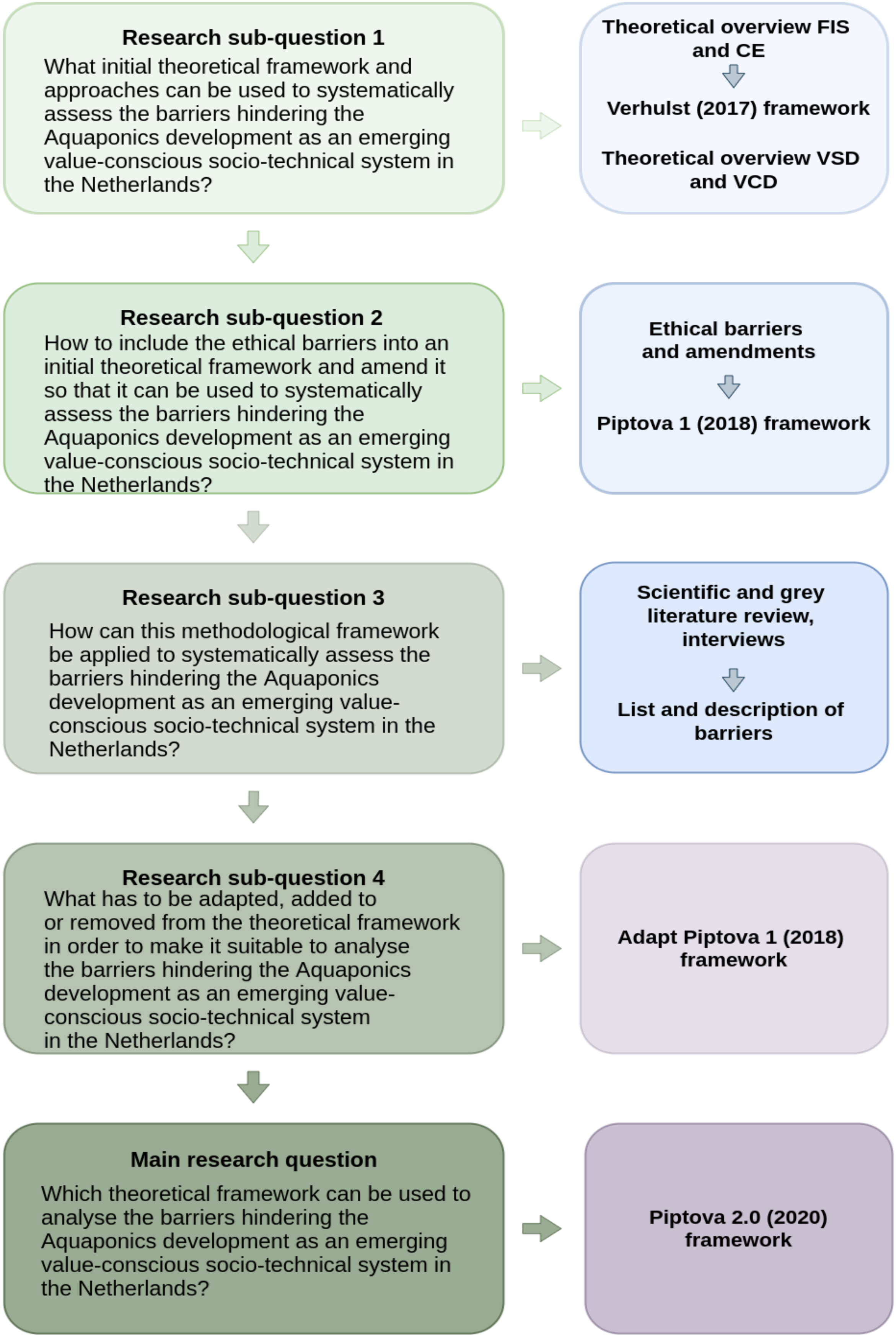

Research sub-question 1
What initial theoretical framework and approaches can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
Theoretical overview FIS and CE
Verhulst (2017) framework
Theoretical overview VSD and VCD
Research sub-question 2
How to include the ethical barriers into an initial theoretical framework and amend it so that it can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
Ethical barriers and amendments
Piptova 1 (2018) framework
Research sub-question 3
How can this methodological framework be applied to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
Scientific and grey literature review, interviews
List and description of barriers
Research sub-question 4
What has to be adapted, added to or removed from the theoretical framework in order to make it suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
Adapt Piptova 1 (2018) framework
Main research question
Which theoretical framework can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?
Piptova 2.0 (2020) framework

Figure 2.2 Presentation of each sub-question, the main research question and the results. The result of answering the sub-question 1 is the Theoretical overview of FIS and CE approach and the Verhulst (2017) framework. The result of answering the sub-question 2 is the Theoretical overview of VSD and VCD approach, integration of ethical barriers and Piptová 1 (2018) framework. The result of answering the sub-question 3 is a List and description of barriers achieved by performing the scientific and grey literature review and interviews with stakeholders. The result of answering the sub-question 4 is the adaptation of Piptová 1 (2018) framework. The result of answering the main research question is the revised final Piptová 2.0 (2020) framework.

In the text below, the detailed description of each step leading to the answer to each research sub-question and finally the main research question is provided.

1. **Sub-question 1: What initial theoretical framework and approaches can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?**

In this sub-question, the selection criteria for theories, the Verhulst (2017) theoretical framework, Value sensitive and Value conscious design approach were explored. In the Verhulst (2017) theoretical framework, barriers are recognized as poorly performing functions of the innovation system (further FIS) and barriers hindering CE efforts elaborated as a part of the Technology assessment as shown in Figure 3.1. The list of potential socio-technical barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands taken from CE theory was revised and updated. Further in this sub-question, it was also concluded that there are ethical barriers missing in the Verhulst (2017) theoretical framework. Therefore, Responsible innovation via Value sensitive and Value conscious design approaches were introduced and potential ethical barriers based on these theories were described in chapter 3.5. Value Sensitive and Value Conscious Design towards Responsible Innovation. The results of answering the sub-question 1 is chapter 3 Initial Theoretical Overview.

2. **Sub-question 2: How to include the ethical barriers into an initial theoretical framework and amend it so it can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?**

In this sub-question, it was explored how Value sensitive and Value conscious design approach can complement Technology assessment perspective based on Functions of innovation system and a Circular economy concept in order to develop a holistic theoretical framework to examine the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The aim was achieved by linking the Verhulst (2017) methodological framework and Value sensitive and Value conscious design approach techniques as shown in chapter 4 Primary Theoretical Framework Piptová 1 (2018) Overview.

The Verhulst (2017) theoretical framework was adopted and amended as explained in chapter 4.1 Construction of Piptová 1 (2018). The additional Ethical dimension barriers were identified, as shown in chapter 3.5. Value Sensitive and Value Conscious Design towards Responsible Innovation. according to the Value sensitive and Value conscious design conceptual and empirical approach (Friedman 2002) in the two forms:

- Tensions between Values of various stakeholders.

- Values of stakeholders which are not covered by actors or value advocates.

Later, the theoretical framework was amended further as a result of desk research and interviews with stakeholders. Interviews with selected stakeholders were the main source of information about Ethical barriers. Interview is a more appropriate method for values identification than desk research (Correljé et al. 2015).

3. Sub-question 3: How can this methodological framework be applied to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

In this sub-question, the socio-technical barriers and ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands are explored.

First, the core desk research of grey literature was performed in order to map the current situation of the Aquaponics development in the Netherlands and explore the following:

1. Socio-technical description including a brief history of Aquaponics to be found in chapter 5 Current Aquaponics Situation in the Netherlands and an overview of the technological aspects of Aquaponics to be found in chapter 11.2. Technological Aspects of an Aquaponic System.

2. Brief STEEPLE analysis to be found in Appendices in chapter 11.1. STEEPLE Analysis presenting the trends influencing the Aquaponics development in the Socio-cultural, Technological, Economic, Environmental, Political, Legal and Ethical dimension.

3. Description of the stakeholders involved in the Aquaponics Development in the Netherlands illustrated in the form of Stakeholder map showing the stakeholders and the Current aquaponics producers' connections presented in Figure 5.1. in chapter 5.2 Stakeholder description. A stakeholder is a person or group who has a positive or negative interest or values in an enterprise, the technology development or a project and whose support is required in order for an enterprise, the technology development or a project to be successful or not.

The initial search for the stakeholders and mapping the current situation of aquaponics was performed by using the Boolean operators AND and OR for Google search in combinations of the following terms in Dutch, translated into English for the purpose of this thesis:

- Aquaponics in the Netherlands
- Aquaponics development in the Netherlands
- Aquaponic farm in the Netherlands
- Aqua farming in the Netherlands
- Zero-acreage farming in the Netherlands
- ZFarming techniques in the Netherlands
- Urban farming in the Netherlands
- Warehouse farming in the Netherlands

- Aquaponics stakeholders in the Netherlands
- Aquaponics actors or stakeholders in the Netherlands
- Aquaponics research in the Netherlands
- Aquaponics innovation in the Netherlands
- Aquaponics technology in the Netherlands
- Responsible Aquaponics
- Aquaponic food in the Netherlands
- Aquaponics growth in the Netherlands
- Aquaponics spread in the Netherlands
- Aquaponics development in the Netherlands
- Stakeholders in Aquaponics development in the Netherlands
- Barriers of aquaponics in the Netherlands

In the next phase, the primary theoretical framework Piptová 1 (2018) shown in chapter 4.2. Primary Theoretical Framework Piptová 1 (2018) was applied to the current case of the Aquaponics. A desk research of available literature on barriers in the established dimensions according to selected indicators from the analytical theoretical framework was performed. The search aimed at identifying the socio-technical barriers was performed by using the Boolean operators AND and OR in the Google search with the following terms in Dutch, translated into English for the purpose of this thesis:

- Aquaponics barriers in the Netherlands
- Aquaponics problems in the Netherlands
- Aquaponics challenges in the Netherlands
- Aquaponics opportunities in the Netherlands
- Aquaponics difficulties in the Netherlands
- Aquaponics advantages in the Netherlands
- Aquaponics disadvantages in the Netherlands

The next search aimed at identifying the ethical barriers was performed by using the Boolean operators AND and OR in the Google search with the following terms in Dutch, translated into English for the purpose of this thesis:

- Aquaponics values in the Netherlands
- Aquaponics ethical OR moral barriers in the Netherlands
- Aquaponics ethical OR moral in the Netherlands

- Aquaponics ethical OR moral challenges in the Netherlands
- Aquaponics ethical OR moral difficulties in the Netherlands
- Aquaponics ethical OR moral advantages in the Netherlands
- Aquaponics ethical OR moral disadvantages in the Netherlands
- Aquaponics space OR odour in the Netherlands
- Aquaponics safety in the Netherlands
- Aquaponics health in the Netherlands
- Aquaponics trust in the Netherlands
- Aquaponics esthetical issues in the Netherlands
- Aquaponics and taste of fish and plant OR food in the Netherlands
- Aquaponics values in the Netherlands
- Aquaponics conflict OR tensions in the Netherlands

Detailed further data sources are listed in chapter 1.4.3.2. Data Sources.

The result of this step was a list and description of socio-technical and ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. These need to be overcome in order for Aquaponics to flourish.

In this thesis, in order to identify ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, the procedure recommended by Friedman et al. (2002) about how to apply Value sensitive design approach was used. The procedure begins with one of the three core aspects: a technology, its use embedded in a context or a value. In this case, technology was used as a starting point. As suggested by Friedman et al. (2008), in the second phase, direct and indirect groups of stakeholders and missing actor representation are identified, harms and benefits for various stakeholder groups are determined, corresponding values are attached to harms and benefits; a conceptual investigation of discovered key values is performed and finally potential value conflicts are recognized. The result of this step are the Ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, as shown in the results in chapter 6 Barrier Analysis for Aquaponics in the Netherlands and they manifest themselves in two forms:

- Tensions between Values of various stakeholders involved in Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Values of various stakeholders in Aquaponics development are connected to the harm and benefit of Aquaponics development for the stakeholders.
- Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The last part of the ethical barriers to Aquaponics development in the Netherlands are the Values of stakeholders which are not covered by acting actors. There are Values in technological innovation and set in social

context independent of human evaluation as useful or important. The stakeholders have Values in Aquaponics development and are positively or negatively affected by it. These Values not covered by actors also might hinder Aquaponics development. The stakeholders might be also non-human entities that have a stake in the case in a certain way.

Values are understood as "values at risk, in question, at issue, to be won or lost" (Anon 2018). Values are based on stories and narratives of each stakeholder (JafariNaimi et al. 2015). In the current research, the Values and tensions are identified by using two types of intermediate identification frameworks. First one is shown in Table 2.1 Values identification and the second represents the final linking the conflicting values in the phase of Identification of Tensions between Values of various stakeholders.

Following the VSD recommended techniques (Friedman et al. 2002 and 2008), the following intermediate and final outcomes used in this research were:

- Identification of direct and indirect stakeholders and if their values are represented by an actor or not shown in chapter 6.1 Direct, Indirect Stakeholders and Missing Actor Representation.

Distinction of Direct and Indirect Stakeholders (and their respective values) in the conceptual investigation of the values is crucial due to the fact that they are both influenced by display of technology or its development (Friedman & Kahn 2007). A stakeholder is distinguished from an actor (Okoro 2016). Actors (of the case) are directly involved in the process and responsible for its outputs. They are those who act. The stakeholders are positively or negatively affected by change or a decision. Stakeholders are entities that have a stake in the case in some way. Sometimes their values are not covered by actors. If the interests or needs of a stakeholder are not presented and acted on by an actor or a value advocate in the form of a person or organization in Aquaponics discourse, the actor representation is missing. This might cause issues in the further technology development (Van de Poel & Royakkers 2011). It is also against the principles of Responsible innovation. Value-sensitive design is about being responsive to ways that Direct and Indirect Stakeholders perceive the new technology (Friedman et al. 2008).

- Identification of Harms and Benefits for various stakeholder groups as shown in template Table 2.1 and later in the results in chapter 6 Barrier Analysis for Aquaponics in the Netherlands.
- Extracting corresponding Values for various stakeholder groups attached to Harms and benefits analysis as shown in template Table 2.1 and later in the results in chapter 6 Barrier Analysis for Aquaponics in the Netherlands .
- Identification and conceptualization of discovered Values for various stakeholder groups as shown in the results in chapter 6 Barrier Analysis for Aquaponics in the Netherlands .
- Identification of tensions between Values for various stakeholders as later shown in the results in chapter 6 Barrier Analysis for Aquaponics in the Netherlands .

Stakeholder	Benefits (connected to interests and expectations)	Harms (connected to interests and expectations)	Values (In Aquaponics development in NL)
Stakeholder 1	Benefit 1 Benefit 2 Benefit 3...	Harm 1 Harm 2 Harm 3...	Value 1 Value 2 Value 3...
Stakeholder 2	Benefit 1 Benefit 2 Benefit 3...	Harm 1 Harm 2 Harm 3...	Value 1 Value 2 Value 3...

Table 2.1 Values identification which identifies Values in technological development of various stakeholders through the process of identifying The Harms and Benefits for stakeholder (connected to interests and expectations) according to Friedman et al. (2002 and 2008) VSD application procedure.

After the desk research phase mapping the grey literature, in-depth interviews were performed. The purpose of the interview was to:

- Validate findings
- Address gaps
- Find additional information

In-depth Interviews with selected stakeholders providing their answers anonymously were recorded, transcribed, analysed and interpreted via Issue Focused and Thematic Analysis through manual annotation and highlighting of the attitudinal data as recommended by Braun et al. (2019) which involved:

- Coding
- Sorting according to emerging themes
- Integration and conceptualization

By acknowledging the values of all the ones using the technology and its products and all the ones impacted by the technology and its products - direct and indirect stakeholders and by identifying, respecting and not ignoring these values in the early stage of the technology development process, these ethical barriers might be overcome and potential problems once the technologies have been deployed might be thereby diminished or fully eliminated (Flanagan, Howe & Nissenbaum 2005). To address the Ethical barriers in the development of a technological niche is hence crucial.

Le Dantec et al. (2009) argue that the first contact with values in research is to be empirical, happening in the local context rather than based on researcher's anticipation and discursive analysis. Values are to be discovered in their context and in a local vocabulary according to two-step: identify/apply logic (Le Dantec et al. 2009). Therefore, the main source of data about ethical barriers were the interviews with stakeholders. Interview is focused on, especially, determining the tensions between values and values not covered by actors as ethical barriers. Interview as a method is more suitable for this purpose than desk research. Due to the dynamic and emergent character of values, their ex ante evaluation is difficult (Correljé et al. 2015).

To supplement the literature review, in the months of February and March 2020 all organizations and individuals listed in chapter 5.2. Stakeholder Description were contacted via email, phone or in person in order to participate in the interviews. All communication with stakeholders is listed in chapter 10. References in section Interviews, email/personal/phone communication, excursions and tours.

In-depth interviews were performed at a location or by telephone and recorded for the purpose of analysing the interviews later. In order to elicit further information, heuristics for Interviewing stakeholders by Friedman et al. (2002) was used in the form of probing stakeholders with questions, such as Why? Can you give me an example? What did you do when you encountered this situation? The interview protocol can be found in Appendices in chapter 11.5. Interview Protocol. In the first part of an interview a question 'What prevents Aquaponics from being successful in the Netherlands?' was asked. In the second part of the interview, additional questions about each of the specific institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions were asked in case the interviewee did not mention them. Open question was asked: "Would you like to add something or are you aware of any other barriers which we have not mentioned yet?" in order to explore barriers which were not mentioned in the literature or in the primary theoretical Piptová 1 (2018) framework.

The following participants agreed to participate in the interviews over the phone or at a location face to face: Jos Hakkennes the founder of Duurzame kost face to face, Andrei Radu Beca the Aquaponics Manager in Metabolic face to face, Erik Moesker the founder of NoordOogst Aquaponics over the phone, Bouke Kappers the CEO of TGS Business & Development Initiatives over the phone, Roel Bosma who used to work for Wageningen University & Research over the phone and Geert Wilms representing the Non-profit organization partners from De Stuurgroep Landbouw Innovatie Noord – Brabant face to face. In total, there were interviewed the Current Aquaponic producers (n=4), a scientist from the Research and knowledge group (n=1), Non-profit organization partners stakeholder (n=1) and a short email conversation was exchanged with a Anja Goossens – Nillesen from 't Genot Vierlingsbeek (n=1) representing the stakeholder group For profit firms and partners - demand side - Shops and restaurants who until 2020 used the Aquaponics installation as an eye-catcher for the terrace until it became too expensive. The answers of the interviews are provided further anonymously in chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

The author of this thesis also participated in the Aquaponics installation tour in Duurzame kost in Eindhoven, Metabolic and Mediamatic in Amsterdam. Written notes were made from Aquaponics installation tour in Duurzame kost in Eindhoven and in Mediamatic in Amsterdam. The NoordOogst Aquaponics has currently only a marine system which was hibernating at the time of interview, therefore, no tour was possible.

The rest of the organizations and individuals not mentioned above, whose more detailed descriptions are listed in Appendices in chapter 11.3. Stakeholders Contact Data and who were all also contacted and asked to provide more information in an interview, have decided not to participate in the research for various reasons. These are provided together with contact persons details representing certain stakeholders in chapter 11.4. Contacted stakeholders not participating in the interviews. Many contacted stakeholders said that they knew nothing about Aquaponics and recommended speaking directly to a certain Current Aquaponic producer. Metabolic based in Amsterdam was the only Current Aquaponic producer who did not show interest in participation in the interview. The Incumbent farmers stakeholders were also contacted and provided their answer via phone conversation (n=3). They were found by search in google for the following term in Dutch language: farmer AND nl AND direct. Website https://www.hofweb.nl/groenteboer was found and farmers in the category Salad, tomatoes, herbs; growing and selling vegetables similar to the ones grown in Aquaponics; were selected. None of the Incumbent farmers (n=3) and none of the personally contacted Product users/public stakeholders (n=3) knew Aquaponics.

After the interviews, the results from the in-depth Interviews and literature desk research were merged. The information was updated in an iterative manner. The result of the research for the sub-question nr 3 was an updated list and a description of ethical barriers hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands shown in Figure 3.1 and chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

4. Sub-question 4: What has to be adapted, added to or removed from the theoretical framework in order to make it suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

In this phase, a revised theoretical framework Piptová 2.0 (2020) shown in chapter 8. Final Theoretical Framework Piptová 2.0 (2020) Overview was established. Based on the results of applying primary theoretical framework Piptová 1 (2018), obsolete or unsuitable barriers were deleted and extra barriers were added. In chapter 7. Adaptation of Primary Theoretical Framework Piptová 1 (2018) the changes were provided. The barriers additionally identified in the research were listed in italics. Updated primary theoretical framework serves as a general tool for identification of barriers hindering technological development as an emerging value-conscious socio-technical system in the Netherlands

5. Main question: Which theoretical framework can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

Framework Piptová 2.0 (2020) shown in chapter 8. Final Theoretical Framework Piptová 2.0 (2020) Overview was established in order to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.

3. INITIAL THEORETICAL OVERVIEW

In this section, selected particular theoretical models are briefly discussed based on how they relate to the study subject of this thesis.

3.1. Selection Criteria for Theories

The theoretical models described in this chapter were chosen due to the fact that they take a system approach to innovation, they promote stakeholder engagement or take into consideration ethical values. They recognize the fact that innovation is not the result of the work of individuals, nor single organization, but of a network of various parties, such as human agents, institutions and technological artefacts. These elements are involved iteratively through participating directly and indirectly in various events embedded in institutional socio-technical context and they represent a socio-technical system (Kroes 2006). Ethical lens is crucial in the current trends of Responsible innovation which strives to be responsive to values of direct and indirect stakeholders.

These theoretical models are used to identify the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. They are later combined in the primary theoretical framework Piptová 1 (2018) in order to grasp the properties of the emerging socio-technical system and its value-conscious aspect when identifying bottlenecks hindering its development.

The following theories have been selected and described according to their approach to identifying barriers hindering the Aquaponics: Functions of Innovation System (FIS), Circular Economy (CE), Responsible Innovation (RI), Value Sensitive Design (VSD) and Value Conscious Design (VCD). The Verhulst (2017) theoretical framework described as the first was used as an initial theoretical framework in the process of identifying a theoretical framework that can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.

3.2. Initial Theoretical Framework Verhulst (2017)

For the purpose of this research, it is important to illustrate the steps how the Verhulst (2017) developed her theoretical framework used in the primary theoretical framework Piptová 1 (2018). The Verhulst (2017) theoretical framework was developed by Renske Verhulst in her MSc thesis about barriers to phosphorus recycling in the Netherlands (2017). The Verhulst (2017) theoretical framework for identifying barriers to growth is a result of combining Technology oriented barriers using Functions of innovation systems approach (FIS) (Hekkert, Suurs, Negro, Kuhlmann and Smits 2007) and further based on Circular economy (CE) requirements perspective as shown in Figure 3.1.

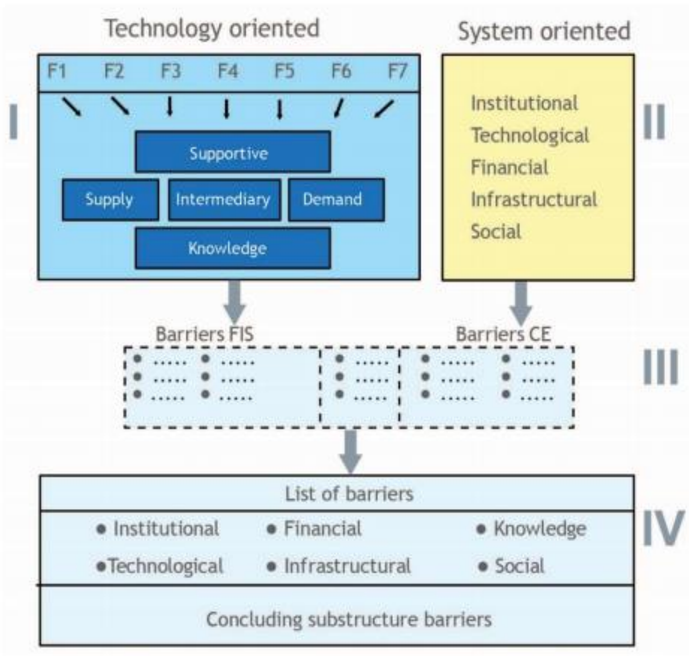


Figure 3.1 Theoretical framework for barrier analysis (Verhulst 2017) combining barriers found within the niche through Technology assessment using Functions of innovation systems approach (FIS) (Hekkert et al. 2007) and Circular economy (CE) requirements perspective (adapted from Verhulst 2017).

The resulting Verhulst (2017) theoretical framework looks at barriers hindering the development and implementation of industrial ecology related technologies from the institutional, technological, financial, infrastructural, social and knowledge perspectives:

- Institutional perspective including policies, legislation, guidelines, officially described rules. There is a world interconnected with the existing 'technological regime' such as shared networks of institutions, organizations, infrastructures, supply chains, consumer and producers patterns and other technologies with their own set of norms, beliefs, roles and rules (Rip and Kemp 1998). These are also directing the technological trajectory of technology innovation of Aquaponics and its further development (Raven 2005). Scott (1995) in his broad regime model explains that 'retention' of technology is the result of cognition abilities of knowledge community obeying three dimensions of rules existing within society:
  -Regulative, such as law, legislative and other explicit formal rules.
  -Normative, such as societal values, norms and role descriptions.
  -Cognitive, such as people's abilities, priorities and aims.
- Technological perspective including technology, installations and technical requirements.
- Financial perspective including prices, demand or market characteristics.
- Infrastructural perspective including the technology, its retention and its position to the mainstream 'technological regime' and broader 'socio-technical landscape' within the currently available supply chain.

- Knowledge perspective including the knowledge capital on various topics.
- Social perspective including social acceptance, public opinions and satisfaction and informal institutions and norms (Suurs 2009).

In the next sections, the two main theoretical concepts FIS and CE used by the Verhulst (2017) in her theoretical framework will be explained.

3.3. Functions of Technological Innovation Systems

The barriers in this research are based on the seven functions of Technological Innovation Systems and their indicators as shown in Table 3.1 (Bergek at al. 2008a, Vasseur at al. 2013). For innovation to be successful and maturing, these functions need to perform well and be continuously stimulated internally and externally. Failure in any of these functions presents a threat for the further development of an innovation system.

TIS approach enables the study of the dynamics of innovation systems' parts in order to understand technological change. Carlsson & Stanckiewicz (1991:94) define TIS as: "a network or networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilise technology."

Innovation is an ongoing collective effort embedded within the context of a wider institutional environment coined 'technological innovation system'. A TIS is a collective of actors and rules that together define the velocity and direction of technological change trajectory in a specific technological dimension crossing geographic as well as sectoral boundaries (Bergek et al. 2008a, Hekkert et al. 2007). It consists of three structural parts: actors, networks and institutions (Bergek et al. 2008a):

- The actors are firms, including competitors, along the whole supply and value chain, academic institutions with researchers, industry organisations, intermediary organisations, non-governmental and government agencies. Each actor has a specific knowledge (Bergek et al 2008a). The more firms and other organisations supporting TIS, the better.
- The networks can be 'learning' or 'political' in the form of advocacy coalitions. In these networks the actors share their expectations, influence and belief systems in order to steer the political agenda (Vasseur at al. 2013). Formation of networks is crucial for establishing the new technology.
- Institutions are quintessential for the legitimation of new technologies. Institutional alignment aiming for steering the institutional context offers new access to the resources needed for TIS survival within the marketplace and the political and social institutional environment (Van de Ven & Garud 1989).

The success of TIS formation depends on the above described structural processes and phenomena (Bergek et al. 2008a:82).

An emerging innovation system has less actors, networks and institutions than an already embedded innovation system. Only a few of them are cooperative and corresponding in favour of new technological innovation (Hekker & Negro 2009). Therefore, TIS approach with the relatively small number of elements enables better research of technological innovation dynamics. For technology to develop well; meaning generate, diffuse, and utilise (Carlsson & Stanckiewicz 1991); the functioning of TIS and its parts is crucial.

In order to decide if a TIS functions well, a number of studies which apply system functions approach was developed. System functions are mapped through the key events in innovation systems, as shown in Table 2.1. There are 7 proposed functions of TIS mapping the key processes in technological innovation system dynamics (Hekker & Negro 2009, Alkemade et al 2007; Bergek et al 2008; Bergek et al 2015):

Function 1: Entrepreneurial Activities

The number of entrepreneurs promoting the new technology is crucial. The more activities, experiments and exchange of information between them, the better for the spread of new technology. The entrepreneurs spread knowledge, connect markets and networks in order to promote the new technology.

Function 2: Knowledge Development (learning)

'Learning by searching' and 'learning by doing' encompassing activities done through R&D projects, feasibility studies, patents and pilot projects are crucial. The depth and breadth of knowledge and its development is crucial in the contemporary economy.

Function 3: Knowledge Diffusion through Networks

In order to learn, knowledge needs to diffuse in the society on an academic level and also firm cooperation level through imitation, learning by doing and learning by using. Knowledge gets combined through various learning networks.

Function 4: Guidance of the Search

Government has a huge influence on the new technology development, it gives it some sort of a direct and indirect guidance through legislative incentives, regulations, policy and changes in the landscape due to public debates and expectations on the future societal development. Actors also shape the technology development through their interpretations of the opportunities considering technical bottlenecks in order for their ideas to strive.

Function 5: Market Formation

There are no markets for emerging technologies, it goes slow, there is no demand, technology might be crude and inefficient due to price/performance at the beginning. Protecting nursing and bridging niche markets with their protected learning spaces are quintessential for the new technology to develop further.

Function 6: Resource Mobilisation

Resources, such as financial and human capital and also complementary assets, are the base of each technology.

Function 7: Creation of legitimacy / counteract resistance to change

Process of legitimation or advocacy coalition is a prerequisite for the formation of new markets, technology establishments and industry sectors. It influences expectations of actors and their relations to various institutions in order to make the new technology successful. It is not given, but it is formed as "liability of newness" (Zimmerman and Zeitz 2002). It includes lobbying.

Function	Indicator
Function 1: entrepreneurial activities	Organisations or companies entering/leaving the market Size of companies *Export activities*
Function 2: knowledge development	Research and technological projects Demonstration and pilot projects Learning by doing and learning by using
Function 3: knowledge exchange	National knowledge exchange between organisations (e.g. via workshops, conferences, joint projects) *International knowledge exchange (e.g. in joint research projects, international conferences or seminars)*
Function 4: guidance of the search	Targets set by the government of industry Expectations and opinion of experts (positive/negative)
Function 5: market formation	Financial market incentives (regulation/stimulation programmes) Regulations/tax regimes Market size *Import share*
Function 6: resource mobilisation	Financial resources (e.g. subsidies for and investments in the technology) Human resources Physical resources *Foreign direct investment*
Function 7: creation of legitimacy	Extent to which the technology is promoted by organisations, government (awards, brochures, competitions) Lobby activities for/against the technology

Table 3.1 The theoretical framework with seven System Functions and their indicators representing key processes that need to be performed and stimulated in order for a TIS to function well (Vasseur et al. 2013).

Suurs (2009) uses a slightly different distinction between actors including their interacting and collaborating in the form of networking, institutions and technological aspects. According to his theory, technological traits are crucial in influencing the actions of the involved actors in various ways. Technological factors are technological artefacts and infrastructure. According to Suurs (2009) TIS is influenced by the following elements: Actors, Institutions, Technology factors, Relationships and Networks. There are five substructures: government structure as a part of supportive infrastructure, supply-side, demand-side, knowledge and intermediary structure. An analogy to flows and stocks when discussing the functions and structures is used. These are interlinked and influence each other. Functions are flows and substructures are stocks. Events that happen enable a particular function and therefore can change the structure of the system. The event types serve as a guide to identify any relevant information about the system functioning.

TIS has a structure consisting of various components. There are many distinctions, such as suggested by Van Alpen et al. (2008), Alkemade et al. (2007) and Suurs (2009) found in the literature. When a certain Function of Technological Innovation System does not function properly, the further development and implementation of the technology is hindered. Based on above, in the

Verhulst theoretical framework (2017) for each Function of Technological Innovation System several potential barriers are provided (Alkemade et al. 2007; Bergek et al. 2008; Bergek et al. 2015):

Function 1: Entrepreneurial Activities

Low number of entrepreneurs promoting the new technology. Without them the technology cannot exist.

Function 2: Knowledge Development (learning)

Low number of 'Learning by searching' and 'learning by doing' encompassing activities done through R&D projects, feasibility studies, patents and pilot projects. Knowledge and its development is crucial in the contemporary economy. Insufficient funds for research.

Function 3: Knowledge Diffusion through Networks

Low number of activities crucial for the exchange of information and networking, such as various platforms, conferences and collaborations between entrepreneurs and other actors of the market, educational knowledge diffusing activities where R&D faces government, competitors, consultants and market. Low number of activities enabling 'learning by interacting'.

Function 4: Guidance of the Search

Low number of events considering the government and regulation changes in favour of the new technology towards a more sustainable, circular and renewable approach in the future. Low demand for the technology or insufficient articulation of the demand. Unclear visions and not unified or non-existent expectations on a specific topic necessary to move the new technology forward from the back of the incumbent technology and its prevailing infrastructure. Occasions of government not positively affecting the visibility of the new technology causes the lack of legitimacy of the new technology. This demobilises resources for technological development and creates negative landscape conditions uninviting the new technology development.

Function 5: Market Formation

Low number of temporary niche markets or temporary competitive advantage creations done by the government through: favourable tax systems, subsidies, consumption quotas which enable a reasonable price/performance ratio. In order for the new technology to compete with the incumbent technologies, especially the sustainable ones, this is crucial and gives advantage to the new technology. Insufficient protected spaces for new technology through temporary niche markets manifest through insufficient size of scale of supply, narrow product application, insufficient number of customers, uncooperative and unstimulated incumbent technology entrepreneurs.

Function 6: Resource Mobilisation

Low amount of supportive financial and human capital resources. Low amount of supportive infrastructure surrounding the implementation of new technology. Insufficient mobilisation of humans through education in order to stimulate the development of this technology.

Function 7: Creation of legitimacy / counteract resistance to change

Low amount of advocacy coalitions, lobbies, incumbent technology overthrowing activities in order to counteract the actors with vested interests who oppose the change and hinder the flourishment of the newly created technology and new infrastructure. Low amount of activities catalysing the creation of legitimacy for the new technology showing through low level of public acceptance, unclear risks related to the technology and its product's use, disinterest into technology and legislation incompatibility.

3.4. Circular Economy

Circular economy discourse has been led by key players, such as the European Union institutions, consultancies, third sector, academics and multinationals (Webster 2017), therefore it has a large influence on the Aquaponics development. Aquaponics itself is based on circularity and closed-loop principle. It incorporates Cradle-to-cradle and biomimicry principles aiming to create a zero-waste economic model (Braungart, McDonough, Bollinger 2007). There are multiple needs to turn away from business-as-usual business models or linear economy and continue transition towards a circular economy. It is necessary to make the eco and socio-technical systems more resilient, decouple economic growth from the use of scarce materials, lower demands on material consumption by people worldwide and increase product lifespan. Aquaponics could be perceived as a positive impact circular economy approach to feeding our megacities (Beckers 2019).

The Aquaponics development in the Netherlands is also a part of a circular economy persevering. The Netherlands has become an international circular economy hotspot in progress, where stakeholders from various segments bring together their business ideas, initiatives, knowledge and skills with the goal to boost circular economy opportunities and collaboration globally (NLCH 2016). The Netherlands has been deploying environmental policies since the 1970s, has been a contributor to the recent European Green Deal aiming for Europe to be the first carbon-neutral continent and has joined both the objectives of United Nations Sustainable Development Goals and the Paris Agreement.

Beyond speaking, the Dutch renewable energy target share of 14% by the end of 2020 has not been reached yet. Currently, the Dutch circularity stands at 24.5%. That means that only less than a quarter of all the materials used to satisfy the necessary societal needs has a non-virgin background and comes from secondary reused sources (The Circularity Gap Report The Netherlands 2020). The ambition is to become 50% circular by 2030 and completely circular by 2050 as reported by the Dutch government in A Circular Economy in the Netherlands by 2050 (The Netherlands Circular in 2050 2016). Globally the circularity is 8.6% (The Circularity Gap Report Global 2020, 2020).

Some scholars see the Circular economy movement as a next 'fetishizing narrative within a capitalist order' (Valenzuela and Böhm 2017: 25 and 26) or just another kind of wasteful strategy, which tries to place waste production and consumption together with the material services in the position of a valuable commodity, instead of limiting the growth and vainglorious wasting of restrained Earth resources (Valenzuela and Böhm 2017). The socio-environmental spoilage in the circular economy strategy gets fetishized as a 'sustainable commodity' (Böhm and Batta 2010, Böhm, Misoczky and Moog 2012).

In contrast to a linear economy, a circular economy aims to continue to generate an economic value without causing environmental harm. Instead of an unbounded 'take-make-discard' paradigm, it focuses on the prevention of environmental damage in an innovative way following the 'Rs'

(Rethink, Redesign, Reuse, Repair, Remanufacturing, Recycling, Recover) of a product or a material as shown in Figure 3.2. This is done as efficiently as possible, in an optimal way and for as long as possible through various systems changes and transitions. This approach is crucial in the times of increasing prosperity, consumption and population levels globally and brings new market opportunities. The new collaborations and investments, however, face challenges in the form of a resistance from the incumbent infrastructure and established linear-thinking companies which hinders the transition towards a circular model (Circular-economy-related opportunities 2020).

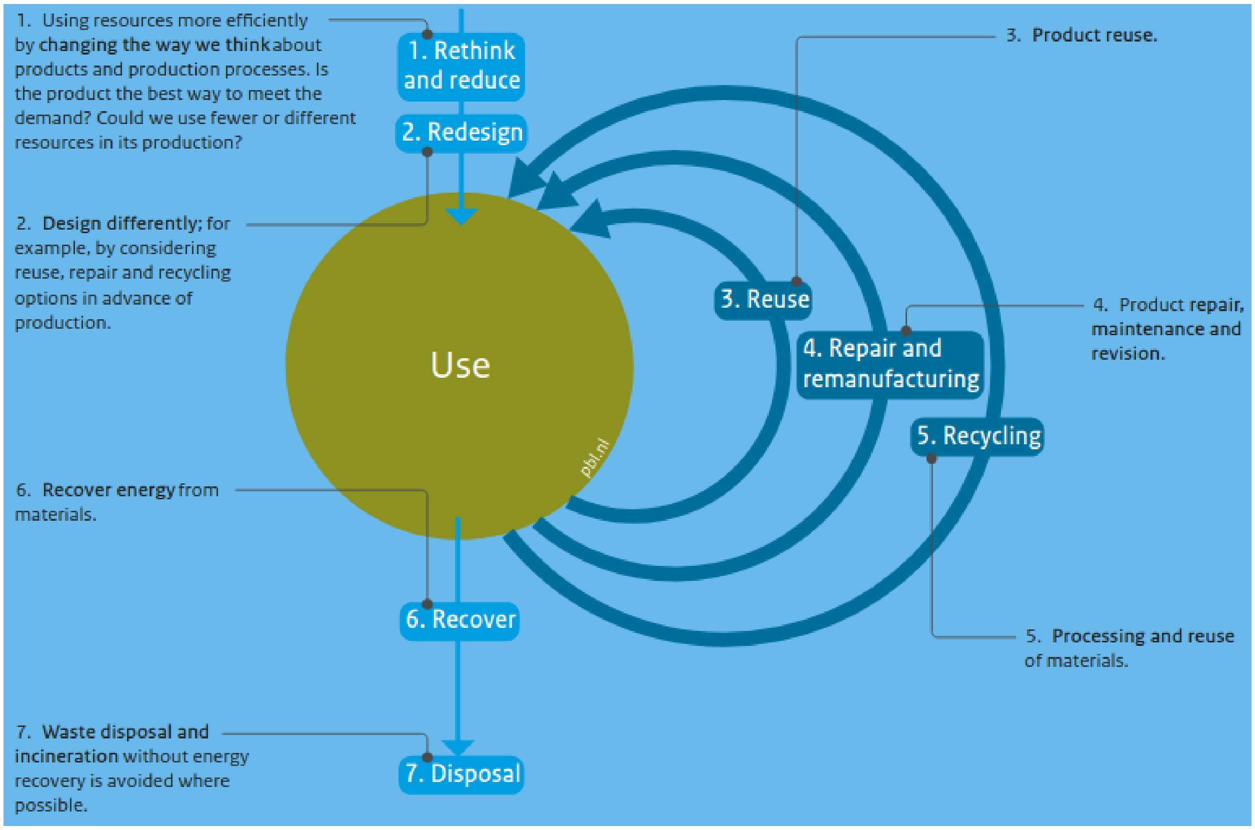


Figure 3.2 A circular economy model based on preventing wasting the energy and resources by following the 'Rs': Rethink, Redesign, Reuse, Repair, Remanufacturing, Recycling and Recover (Circular-economy-related opportunities 2020).

A circular economy transition demands changes in various areas set in a social context. It requires, as shown in Figure 3.3, the following amendments: renewable energy use instead of using up non-renewable fossils, natural capital protection through non-toxic production and consumption patterns without depleting the nature, new business models supporting services instead of ownership, design through the use of the 'Rs' (Rethink, Redesign, Reuse, Repair, Remanufacturing, Recycling and Recover), supply chain alliances of the incumbent and newly establishing companies and high-value product maintenance with prolonged life-span of materials and products.

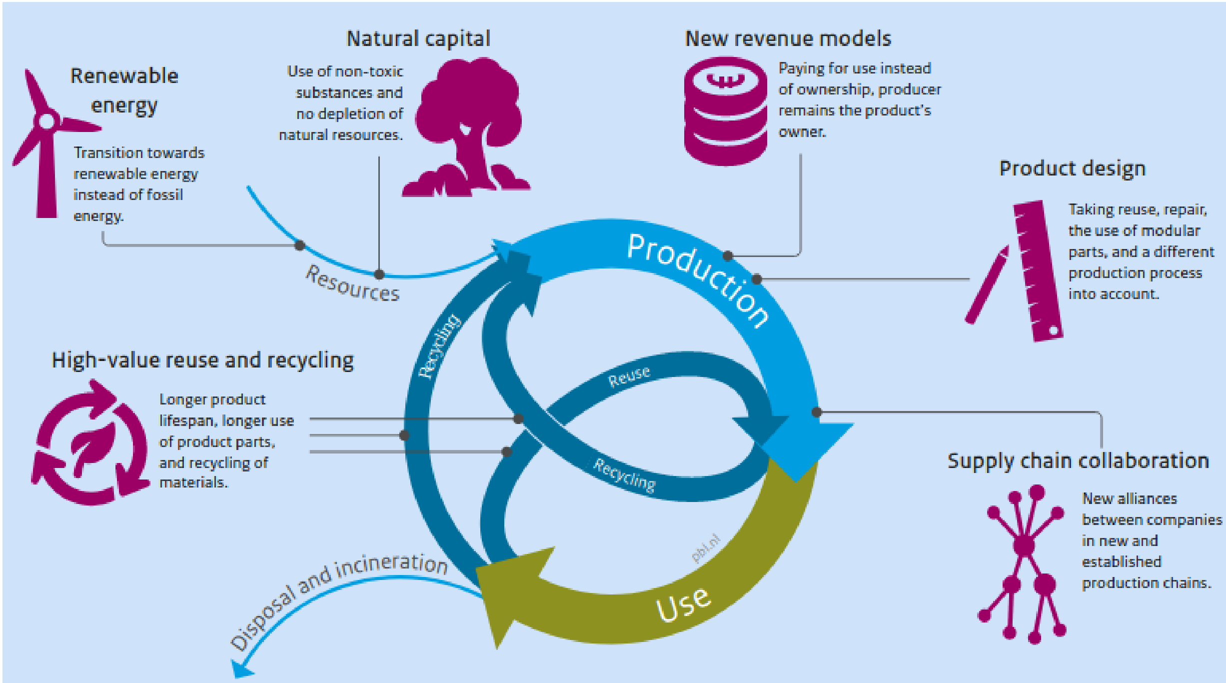


Figure 3.3 Elements of a circular economy: Renewable energy, Natural capital, New business models, Design through the use of the 'Rs', Supply chain alliances, High-value product maintenance with prolonged life-span which support the transition towards a circular business model stressing the following aspects: Renewable energy use instead of using up non-renewable fossils. Natural capital protection through non-toxic production and consumption patterns without depleting the nature, New business models supporting services instead of ownership, Design through the use of the 'Rs' (Rethink, Redesign, Reuse, Repair, Remanufacturing, Recycling and Recover), Supply chain alliances of the incumbent and newly establishing companies and High-value product maintenance with prolonged life-span of materials and products (Circular-economy-related opportunities 2020).

The technological development heading towards a circular economy paradigm faces various challenges. These challenges can be subdivided into the institutional, technological, financial, infrastructural and societal dimension. Verhulst constructed the theoretical framework Verhulst (2017) with a list of barriers to a circular economy (CE) based on a division taken from the report of Kok et al. (2013). The following list of challenges has been revised as well as supported by references from the more recent scientific literature.

Institutional

- The government does not provide support in the form of new legislation, advances and subsidies for technologies towards the transition to CE and therefore the innovation towards the new CE model is hindered. When entering the market with a CE product, various obstacles are encountered (Rizos et al. 2015). There are policies that support a change towards a circular economy lacking and some laws and regulations are even obstructive (Kirchherr et al. 2018).
- Standardization to measure the performance of offered services and products towards fulfilling the CE standards is missing. The CE standards are also very vague and mostly descriptive (Wallace and Raingold 2012). Standardization and data about the impact of CE

efforts are lacking (Kirchherr et al. 2018). There need to be metrics and a measurement framework developed in order to enable CE goal-setting, evaluations, peer review and on the other hand benchmark setting and progress tracking (The Circularity Gap Report 2019 2019).

- Linear economy thinking is still present in the new legislation supporting the incumbent regime through financial advantages (Kok et al. 2013, Pheifer 2017). In spite of ongoing CE debate, there is a persistent lack of regulatory pressures to include circularity into innovation. This implies a low demand for new CE services, products, new circular technological developments including supply and demand sides connected to it (Kok et al. 2013). Circular procurement is insufficient (Kirchherr et al. 2017). A tax shift from labour to taxing the use of virgin materials has not yet been achieved (Kok et al. 2013, What policies are still necessary? - Kennis Kaarten - het Groene Brein 2020). Virgin materials are cheap (Mont et al. 2017)

- In spite of the verbal efforts to encourage collaborations between businesses, there is no actual action plan present in the governmental organizations' initiatives. Competition and "battles in sustainability" are more prominent than cooperation (Kok et al. 2013). There are obstructing regulations that disable companies' cooperation (Pheifer 2017). The European and national competition policy focused on protecting consumer interests forbids intensive cooperation in the form of the cartels formulations according to the EEC/EU prohibition principles incorporated by the Netherlands fully in 1998 and known as Article 6 of the Competition Act (Jaspers 2019).

- The responsibility and ownership in the new circular business models is not clear (Kok et al. 2013). The shift from ownership of assets to services providing focused on accessibility and performance rather than ownership still needs to be figured out (Jesus & Mendonça 2018). The extended producer responsibility and the role of end users in novel systems are yet to be clearly determined (Mativenga et al. 2017)

- Recycling is considered only in the quantitative sense, focusing on the rates. This thinking can slow down the advancement of high quality waste products to be upcycled in various ways (Kok et al. 2013). Recycling might also have a negative reputation (Rood and Kishna 2019).

- Waste management is preoccupied mostly with the image, esthetics of recycling and its presentation to the public. These are only the end-of-pipe solutions. This is inefficient in order to make the current society function on circular principles (Het Groene Brein 2015). Making benefit only from the end phase of the product life cycle through recycling prevents retaining a higher value from the service loop (Pheifer 2017).

- There are barriers at EU level too. There is insufficient support for CE in the form of tax advances on certain materials, nor application of the waste hierarchy Waste Framework Directive (Directive 2008/98/EC) in the practice. Changes on EU level take a long time (Het Groene Brein 2015). The current legislation serves linearity preventing cascading and re-looping of materials and products (Pheifer 2017).

Technological

- The benefits of using CE principles in production and consumption through Life cycle impact and LCA studies should be utilised more to show the advantages of CE strategies (Ghisellini et al. 2016).
- There is a prevailing socio-technical system and it is difficult for new small companies to break through and compete with skilled big players (Markard et al., 2012, Rizos et al. 2015).
- Products are designed in a linear manner and not for a longevity connected to the circular use (Kok et al. 2013, Mont et al. 2017, Pheifer 2017).
- Recycled materials are not available in sufficient quality and quantity, more research on better ways of recycling is necessary (Kok et al. 2013). The quality of remanufactured products might be doubtful (Kirchherr et al. 2018).

Financial

- Small and medium-sized enterprises face big challenges when trying to implement CE principles. The initial costs are huge, the payback periods long, and financial incentives low. These changes also require time and a long-term whole system transformation (Kok et al. 2013; Rizos et al. 2015, Mont et al. 2017, Ritzén & Sandström 2017). The circular procurement is limited by the cost of procured goods and services Kirchherr et al. 2018). EU governments should enforce a mandatory circular procurement (Pheifer 2017).
- Banks are not willing to offer investments and loans to the small companies adopting CE practices. Grants are also more accessible to the big companies (Rizos et al. 2015).
- In the current system, the new linear products made from virgin materials are cheaper than CE ones or recycled ones (Kok et al. 2013, Kirchherr et al. 2018).
- There are several system lock-ins in place which present a form of a technological and economic path dependency. These hinder the societal and economic transition towards a more CE functioning system (Wallace and Raingold 2012). Incumbent systems show signs of inertia and economic lock-ins (Markard et al. 2012). Significant initial costs hinder new investment efforts (Sanyé-Mengual et al. 2014). More than one life-cycle of a product or a service should be considered (Wallace and Raingold 2012). The future profits are uncertain and therefore investments are perceived as risky (Jesus & Mendonça 2018).
- Short-term prysma among business and government is more prevalent than long term CE perspective (Robèrt et al. 2002, Kok et al. 2013, Ellen MacArthur Foundation 2015).
- Product stewardship initiatives are still not fully implemented and the price of the products and services do not fully represent the “true cost” of a product or a service. Environmental and social costs of a product or a service are still accounted for as externalities in economics and are not calculated in the final price of the considered product or the service (Wallace and Raingold 2012, Kok et al. 2013, Pheifer 2017, Raad 2016, Vollebergh et al. 2017, Raad 2016). Extended Producer Responsibility (EPR) should be introduced as obligatory for all companies (Pheifer 2017).

Infrastructural

- The guidelines on the labour definition, demands and the establishment of the roles of 'Scavenger' companies in the waste management sector are not transparent (Ghisellini et al. 2016).
- Usually, there are external consultants hired to implement CE visions which can hinder trust (Kok et al. 2013). Collaboration and trust are essential for successful implementation of CE principles (Kok et al. 2013, Pheifer 2017).
- There is a need for transnational cooperation. There can be trust issues between foreign companies forming partnerships due to cultural differences, unfamiliarity and other factors (Kok et al. 2013, Het Groene Brein 2015, Rood and Kishna 2019).
- There is still insufficient data on allocation of materials in the production and consumption process (Wallace and Raingold 2012, Pheifer 2017).

Societal

- Developers and society are still not fully aware of nor interested in facing the negative consequences of our linear business model (Mont et al. 2017). More information needs to be provided through more channels (Ghisellini et al. 2016). The company culture does not widely embrace CE in their practices (Kirchherr et al. 2018). Supply and demand networks' interest in CE is lacking as shown via the rigid practices in business and consumer behaviour (Jesus & Mendonça 2018).
- Consumers and producers' awareness is low (Rizos et al. 2015). The awareness is necessary for the transition towards CE (Circular economy from wish to practice 2015). Ghisellini et al. (2016) insist that consumers' responsibility needs to be enhanced which can lead to a wider adoption of CE oriented behaviours. CE requires more support and engagement of citizens (Rood and Kishna 2019).
- There is an idea that there is still time to implement CE principles and no need to rush (Kok et al. 2013, Pheifer 2017).
- The GDP should not be considered as a main indicator of wellbeing (Kok et al. 2013, Jones & Klenow 2016). The negative consequences of economic growth on society are ignored when focusing solely on GDP as a measure of welfare. New wide-angle view metrics that go beyond the income and material wealth refined to include more environmentally and socially oriented indicators are inevitable (Giannetti et al 2015).
- Service business according to CE principles can be in place when the consumers are discouraged or disabled to own things and instead share them (Wallace and Raingold 2012). Collaborative models promoting sharing, lending, renting or exchanging shift the business-as-usual towards the loss of ownership which is a base of CE oriented efforts (Ghisellini et al. 2016). Fine consumers' experience and convenience enhances the satisfaction with services models (Kirchherr et al. 2018).
- The incumbent system operates in a linear manner and is resistant to transformation towards CE (Wallace and Raingold 2012, Kok et al. 2013, Kirchherr et al. 2018).

3.5. Value Sensitive and Value Conscious Design towards Responsible Innovation

These approaches were not included in the Verhulst (2017) theoretical framework and as mentioned earlier the Verhulst (2017) theoretical framework misses ethical barriers. Ethical barriers hindering technological development can be explained by VSD and VCD perspectives as a part of RI efforts. RI is connected to forward-looking accountability instead of retrospective backward-looking one (Dekker 2014). It combines constructive technological assessment strategies, stakeholder engagement and fore sighting under ethical reflection (Grunwald 2014). It strives to deal with unpredictability and growing complexity of socio-technical systems in a way that produces maximum positive effects and minimum negative impacts (Grinbaum and Groves 2013). Developers and other stakeholders are expected to be mutually responsive in an environmental, societal, ethical and democratic way (Schomberg 2012: 63, Schomberg 2013).

Stakeholders are stakeholders in technology development because they have something at stake, something to win or something to lose - their values are at stake. The technology can benefit them and harm them in a certain way. Various stakeholders have various values. Values are "values at risk, in question, at issue, to be won or lost" (Anon 2018). They have an emergent nature, and in this research, they are more closely addressed via in-depth interviews with stakeholders. These values are not to be taken for granted and cannot be explored ex ante due to the fact that innovations are nested in dynamic institutional context and stakeholder interactions (Taebi et al. 2014). When innovation is being developed, these values emerge and change (Correljé et al. 2015). Some of the values of certain stakeholders can be conflicting with values of other stakeholders causing value frictions or value tension. This can constitute barriers hindering the development of an emerging technological innovation along with other barriers in various dimensions of socio- eco-technological reality (Friedman 2010).

Technology has ethical implications and is value laden. New technologies challenge the ethics or does the ethics challenge the new technologies? This phenomena represents the new challenge of the 21st century (Manders-Huits 2011). Bottlenecks hindering innovation are interconnected with the values of stakeholders and also with the values of the technology developers who according to the approach of Value conscious design are able to steer the technology development and also the values of the stakeholders by creating new ones or suppressing undesired ones (Zimmer 2010). The tensions between values between developers and users and also among other stakeholders hinder the innovation. The difference between VSD and VCD is the recognition of VCD that technology developers have an ethical responsibility connected to the creation of new technologies.

During the design phase of technology development and beyond, the technology is being developed according to certain values of particular stakeholders. Technology is shaped by values and vice versa. Designers and developers, sometimes not being aware of their impact, influence the direction of technological innovation based on their own beliefs and values (Van de Poel & Royakkers 2011). Term 'Value Conscious Design' introduced by Manders-Huits and Zimmer (2009) represents an idea that the choices engineers and designers shape socio-technical systems through steering them by their own understandings of various human and moral values at play and their significance.

‘Value Conscious Design’ is about increasing awareness within the research and technical environment about the ethical and value implications of technologies. Moreover, it offers conceptual tools to foster critical dialogue on the hidden agendas, ideas, reasoning and values underlying the technology design and development decisions. In VSD, the position of Value advocate is used in order to promote certain values of particular stakeholders. This gives the stakeholders their voice, an actor who can represent and vocalise their concerns and beliefs which are the base of their values in technological innovation. When there are no Value advocates, nor other actors vocalising the values of certain stakeholders, the values stay latent. As a result, these values are not considered in technological innovation, the value consciousness is eroded, no trade-offs can be made and there is no win-win situation. This can cause future issues due to unforeseen imbalance in the socio-technical system and conflicts in the values of various stakeholders who are conscious and aware of these unaccounted or ignored values of other stakeholders and consider them significant. Therefore, the fact that there are certain values of certain stakeholders underrepresented by actors constitutes an ethical barrier to an emerging technological innovation.

There is an increasing attention paid to ethics in the Industrial ecology, engineering and science in general curricula. Scholars and practitioners are becoming more aware of the broader ethical and social implications of science and there is an increasing demand to reflect on these (Van de Poel & Royakkers 2011). This comes with ethical responsibility which is crucial to understand the impact of scientific solutions embedded in global socio-technical context. Therefore, researching the ethical nature of barriers of Aquaponics as an emerging technological innovation in the Netherlands is quintessential.

Values are essential to ethics, representing the ends towards which stakeholders aim and they reflect what is important in a certain context. They denote the degree of importance of some act or thing. Technological innovations are interlinked with human values (Friedman & Kahn 2007) and put these values into stake. Values are hidden in stories and narratives of stakeholders (JafariNaimi et al. 2015).

Friedman et al. recommends a procedure about how to apply Value sensitive design approach: begin with any of the three core aspects: a technology, its use embedded in a context or a certain value, recognize direct and indirect groups of stakeholders, determine harms and benefits for various stakeholder groups; match harms and benefits to corresponding values; perform a conceptual investigation into key values and finally recognize the plethora of potential value tensions between human values implicated in the technological development (Friedman, Kahn & Borning 2008).

The distinction between direct and indirect stakeholders shows the depth of their interactions with technological development: direct stakeholders are those that interact straightforward with the technological development and indirect stakeholders are those that are affected by the technological display in a less direct way. This distinction between stakeholders should be done in the Conceptual Investigation phase of value sensitive design approach. Technology should be to be responsive and address the perceptions, beliefs and values about certain technological development of both direct and indirect stakeholders (Friedman, Kahn & Borning 2008).

These values as facts to be considered are identified by using a Value sensitive design approach, which claims that for innovation to be successful, it needs to create and represent a ‘shared solution’(Correljé et al. 2015). That involves the dynamic process of recognizing and acknowledging values of various stakeholders. Value sensitive design follows iterative tripartite methodology, consisting of conceptual, empirical, and technical part (Friedman et al. 2002). It aims to identify tensions between Values for various stakeholders and take these values into consideration in the creation of technological processes, artifacts and also in the creation of institutional context, in which the innovation is embedded. These are emerging processes, with constant interaction of stakeholders, who change their attitudes, expectations, value-laden resistance or cooperation mind-set and interests in time.

There are Values of certain stakeholders in a technological innovation set in a social context which are independent from human evaluation or if they are deemed as useful or important by human stakeholders The stakeholders that have a stake in a case in a certain way might be also non-human entities, however VSD and VCD do not account for these values.

Dynamics of the processes and phenomena hindering an innovation should be explicitly taken into consideration at each stage. These barriers and controversies exist beyond technology. They are nested in the social context in a form of various inconveniences. In order to prevent an imminent threat to technological development, they need to be systematically recognised and addressed (Correljé et al. 2015). VSD approach, as a part of Responsible innovation, guarantees more success for the innovation. It represents a more ethical approach. Higher transparency, stakeholder involvement, recognition of their values and free access to available information to all stakeholders represent equality and fairness. Such conditions accompanied by the necessary trade-offs brings a win-win situation for both types of stakeholders - the developers and the affected public (Correljé et al. 2015).

An explicit list of potential ethical barriers cannot be provided due to the fact that Values have a dynamic and emergent character and their ex ante evaluation is problematic (Correljé et al. 2015). The ethical barriers were identified after the desk research and the interviews were accomplished by following the methodological steps described in chapter 3 Methodological overview. The identified list of ethical barriers is presented in chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

In this research, the ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands manifest themselves in two forms as shown in the section 7 of chapter 4.2. Primary Theoretical Framework Piptová 1 (2018):

- Tensions between Values of various stakeholders involved in Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Values of various stakeholders in Aquaponics development are connected to the harm and benefit of Aquaponics development for the stakeholders.
- Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. There are Values in technological innovation, set in social context, however, independent of human evaluation as useful or important. The stakeholders have Values at stake in Aquaponics development and are positively or negatively affected by it. These Values, if not covered by actors, also might hinder Aquaponics development. The stakeholders might be also non-human entities that have a stake in the case in a certain way.

In the next chapter, the primary theoretical framework Piptová 1 (2018) and its construction are described.

4. PRIMARY THEORETICAL FRAMEWORK PIPTOVÁ 1 (2018) OVERVIEW

In this chapter, the primary theoretical framework Piptová 1 (2018) used to identify the barriers of Aquaponics as an emerging socio-technological innovation in the Netherlands and its construction by adding the ethical aspects and changing other elements in the initial theoretical framework Verhulst (2017) are presented.

4.1. Construction of Piptová 1 (2018)

Piptová 1 (2018) is based on an amended Verhulst (2017) initial theoretical framework enriched by an additional ethical dimension as shown in Figure 4.1. It contains barriers in institutional, technical, economic (financial), infrastructural, knowledge, socio-cultural dimension (Verhulst 2017) and added ethical dimension (Correljé, Cuppen, Dignum, Pesch & Taebi 2015; Van der Poel 2014) as explained in chapter 2 Methodology Overview and chapter 3 Initial Theoretical Overview. In Figure 4.2, the barriers extracted from various theoretical approaches used in primary theoretical framework Piptová 1 (2018) are illustrated. Technology oriented barriers using FIS approach and system oriented barriers based on CE optic were combined with value oriented barriers based on VSD and VCD prisms.

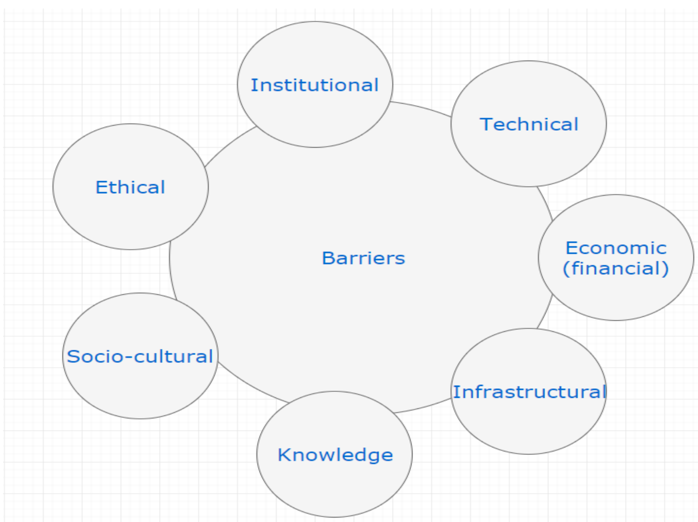


Figure 4.1 Barriers of Aquaponics as an emerging socio-technological innovation in the Netherlands with expanded dimensions based on the Verhulst (2017) theoretical framework and added ethical barriers according to Value sensitive design approach (Correljé et al. 2015, Van der Poel 2014).

For the purpose of this research, the initial Verhulst (2017) theoretical framework was adopted and amended in four ways. First, the ethical barriers based on VSD and VCD towards RI were added to the initial Verhulst (2017) theoretical framework and the primary theoretical framework Piptová 1 (2018) described in the next chapter was constructed. Ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands manifest themselves in two forms as shown in the section 7 of chapter 4.2. Primary Theoretical Framework Piptová 1 (2018): Tensions between Values of various stakeholders and Values of stakeholders which are not covered by actors or value advocates.

Second, the distinction of Technology related Product related barriers was introduced. The Verhulst (2017) theoretical framework was focused on two perspectives: the first perspective of the Technology user and producer (recovery) and the second perspective of the Product user (reuse) in phosphorus recycling. In other words, the first perspective considers the processes that deal with use of the recovery technology and the production of a product- recovered phosphorus, and the second perspective considers the processes that deal with the actual product of the technology meaning reuse of the recovered phosphorus. To summarize, there is a distinction between barriers hindering the installation and use of the phosphorus recovering technology and barriers related to the use of the product meaning recycled phosphorus use in the Verhulst (2017) theoretical framework. In the current research of barriers hindering the Aquaponics, this distinction would consider barriers hindering the Aquaponic technology and barriers preventing the use of fish and vegetables. In order to make the distinction more clear for the current Aquaponics case, this distinction was renamed to the Technology related Product related barriers due to the fact that the Technology related barriers consider the use and production of the Aquaponic technology used in Aquaponic installations as explained in chapter 11.2. Technological Aspects of an Aquaponic System and the Product related barriers consider the fish and plants as the final products of an Aquaponic production. This distinction gives an opportunity to describe the barriers based on the perspectives of many various types of stakeholders when considering the technology and products of it.

The third way in which the initial Verhulst (2017) theoretical framework was revised was that it was checked if it does not contain the Verhulst (2017) research specific words, such as Phosphate recovery and reuse specific technologies and products.

In the last step, the concluding of the poor functioning of the substructures of an innovation system according to Suurs (2009) in the initial theoretical framework of Verhulst (2017) was not taken into consideration in the current research. This is due to the fact that the current research focuses exclusively on identification of barriers differentiated according to the various dimensions including an ethical one as described in chapter 4 Primary theoretical framework Piptová 1 (2018).

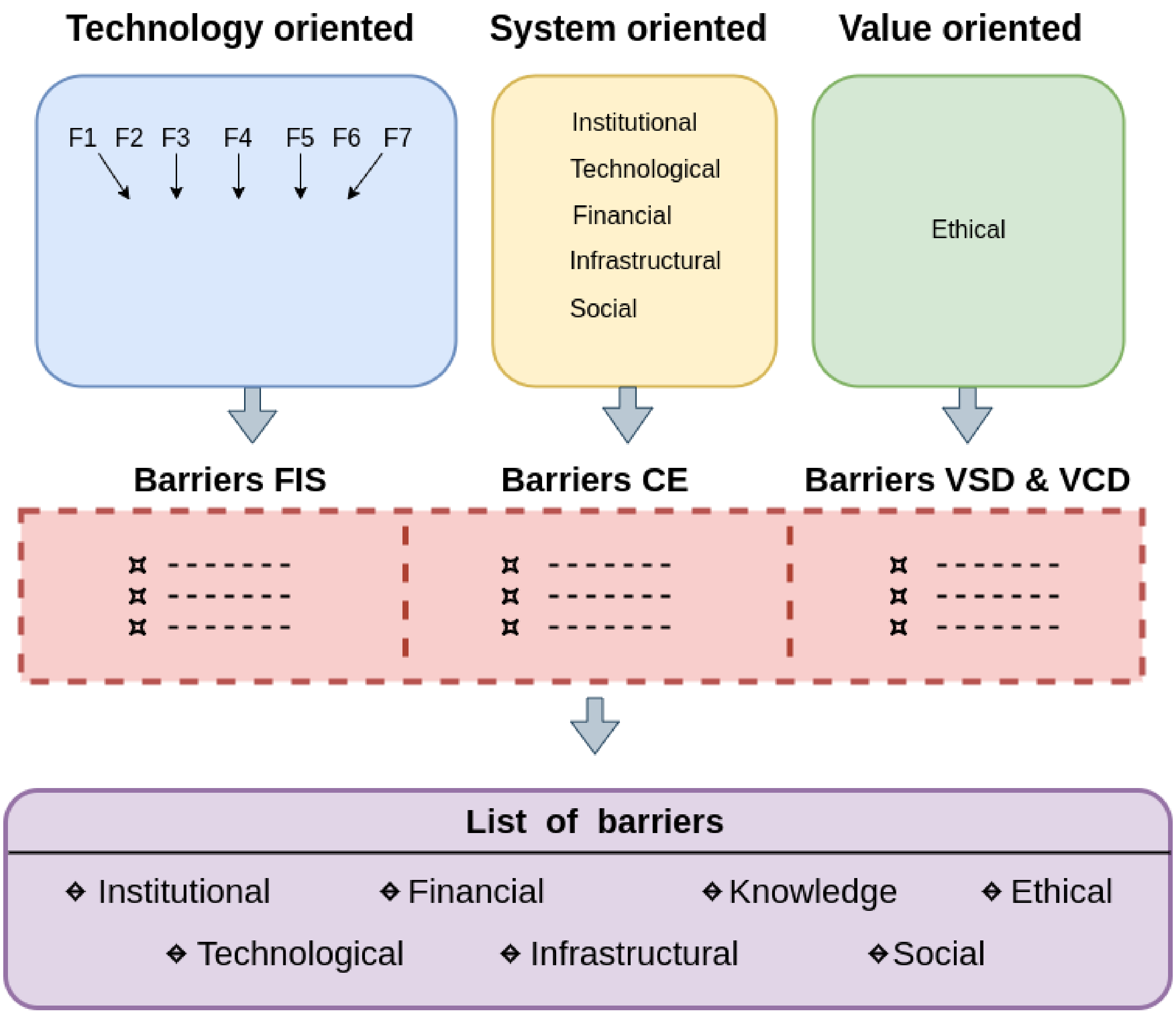


Figure 4.2 Construction of the primary theoretical Piptová 1 (2018). The potential technology oriented barriers using FIS approach and system oriented barriers based on CE optic were combined with value oriented barriers based on VSD and VCD prisms. Primary theoretical framework Piptová 1 (2018) contains institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions.

4.2. Primary Theoretical Framework Piptová 1 (2018)

In this chapter, the Primary Theoretical Framework Piptová 1 (2018) containing the potential institutional, technical, economic (financial), infrastructural, knowledge, socio-cultural based on the amended Verhulst (2017) theoretical framework and added ethical barriers according to Value sensitive design approach (Correljé, Cuppen, Dignum, Pesch & Taebi 2015) and Value conscious design approach (Manders-Huits & Zimmer 2009) is presented. It is shown in Table 4.1. There are potential barriers in two categories: Technology related Product related based on the perspectives of various types of stakeholders when considering the technology and products of it. Each potential barrier will be assessed from the perspective of all distinguished groups of stakeholders as provided in chapter 5.3 Stakeholder Map based on their roles in Aquaponics in the Netherlands.

The proposed primary theoretical Framework Piptová 1 (2018) serves as a tool for the barriers analysis of the case of Aquaponics in the Netherlands. Below in italics, for each potential barrier it is provided if it is extracted from Functions of innovation systems (FIS) theoretical approach as explained at the end of chapter 3.3. Functions of Technological Innovation Systems or Circular economy (CE) theoretical approach as explained at the end of chapter 3.4. Circular Economy or Value Sensitive Design and Value Conscious Design (VSD and VCD) theoretical approach as explained at the end of chapter 3.5. Value Sensitive and Value Conscious Design towards Responsible Innovation.

1 Institutional barriers

Technology related

1.1.a Low alignment with current legislation (FIS)

1.2.a Low level of lobbying (FIS)

1.3.a Absence of regulatory pressures (FIS)

1.4.a Lack of clarity on how to use waste hierarchy (CE)

1.5.a Recycling rates focus on quality, not quantity (CE)

1.6.a Cartel formulation legislation hinders collaboration between companies (CE)

1.7.a No CE standards for products (CE)

1.8.a CE is not integrated in innovation policies of the government (CE)

1.9.a No clarity on ownership, liability and responsibility in new business models (CE)

1.10.a Regulations change slowly (CE)

Product related

1.1.b Low alignment with current legislation (FIS)

1.2.b Absence of regulatory pressures (FIS)

2 Technical barriers

Technology related

2.1.a Uncertainties or risks related with the technology (FIS)

2.2.a Lack of LCA to prove the effect of CE principles (CE)

2.3.a Products are not designed for end-of-life (CE)

Product related

2.1.b Risks are associated with product (FIS)

2.2.b Quality of product is limited (FIS)

3 Financial (Economic) barriers

Technology related

3.1.a Low amount of competitors and new companies in the field (FIS)

3.2.a Low investments in research (FIS)

3.3.a Negative landscape developments (FIS)

3.4.a Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product) (CE)

3.5.a Not enough financial resources available (FIS)

3.6.a Investment calculations are based on one lifecycle instead of more cycles (CE)

3.7.a Labour is taxed instead of materials (CE)

3.8.a High amount of investment costs (CE)

3.9.a Long payback period (CE)

Product related

3.1.b Application is too narrow (FIS)

3.2.b Price/performance is bad (FIS)

3.3.b Financial resources for consumer are lacking (FIS)

3.4.b Price of raw material is lower than recycled products (CE)

3.5.b Externalities are not reflected in price (CE)

4 Infrastructural barriers

Technology related

4.1.a Complementary services & products are lacking (FIS)

4.2.a Scale of supply is too small (FIS)

4.3.a Low alignment with incumbent infrastructure (FIS)

4.4.a Incomplete production chain for technology or products (FIS)

4.5.a Companies are relying on external providers to adopt CE principles (CE)

Product related

4.1.b Complementary services & products are lacking (FIS)

4.2.b Scale of supply is too small (FIS)

5 Knowledge related barriers

Technology related

5.1.a Lack of knowledge dissemination (FIS)

5.2.a Low amount of R&D and pilot projects (FIS)

5.3.a Lack of human capital (FIS)

5.4.a Gap between research and practical needed information (FIS)

5.5.a Low cooperation between firms (FIS)

5.6.a Lack of awareness between intermediaries on developments (CE)

5.7.a Lack of knowledge required to develop, produce and control technology (FIS)

5.8.a Lack of skills or knowledge to apply/deal with technology (CE)

5.9.a Lack of data on material flows (CE)

5.10.a Lack of knowledge on roles of companies in circular economy (CE)

Product related

5.1.b Lack of knowledge or awareness on CE by producers and consumers (CE)

5.2.b Lack of skills or knowledge to apply or deal with product (CE)

6 Socio-Cultural barriers

Technology related

6.1.a No belief in potential technology (FIS)

6.2.a No belief in the potential of product (FIS)

6.3.a No clear vision (FIS)

6.4.a Negative landscape developments (FIS)

6.5.a Sense of urgency is missing (CE)

6.6.a Shareholders have short-term thinking (with focus on benefits) (CE)

6.7.a Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling (CE)

6.8.a Incumbent industry is not willing to cooperate and resists changing status quo (CE)

6.9.a GDP is not a good measure of welfare (CE)

6.10.a Lack of trust between companies (CE)

6.11.a Acceptance of service products instead of ownership of products (CE)

6.12.a Consumers interest in sustainability is not reflected in buying behaviour (FIS)

Product related

6.1.b Acceptance of service products instead of ownership of products (CE)

6.2.b Sense of urgency is missing (CE)

6.3.b Consumers interest in sustainability is not reflected in buying behaviour (FIS)

7 Ethical barriers

Technology related

7.1.a There are value tensions between values of certain stakeholder versus values of another stakeholder which hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands (VSD and VCD)

7.2.a There are values of stakeholders which are not covered by actors or value advocates, therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. These hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands (VSD and VCD)

Product related

7.1.b There are value tensions between values of certain stakeholder versus values of another stakeholder which hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands (VSD and VCD)

7.2.b There are values of stakeholders which are not covered by actors or value advocates, therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. These hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands (VSD and VCD)

Barriers	Technology related	Product related
	1.1.a Low alignment with current legislation 1.2.a Low level of lobbying 1.3.a Absence of regulatory pressures 1.4.a Lack of clarity on how to use	1.1.b Low alignment with current legislation 1.2.b Absence of regulatory pressures

	waste hierarchy 1.5.a Recycling rates focus on quality, not quantity 1.6.a Cartel formulation legislation hinders collaboration between companies 1.7.a No CE standards for products 1.8.a CE is not integrated in innovation policies of the government 1.9.a No clarity on ownership, liability and responsibility in new business models 1.10.a Regulations change slowly	
	2.1.a Uncertainties or risks related with the technology 2.2.a Lack of LCA to prove the effect of CE principles 2.3.a Products are not designed for end-of-life	2.1.b Risks are associated with product 2.2.b Quality of product is limited
	3.1.a Low amount of competitors and new companies in the field 3.2.a Low investments in research 3.3.a Negative landscape developments 3.4.a Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product) 3.5.a Not enough financial resources available 3.6.a Investment calculations are based on one lifecycle instead of more cycles 3.7.a Labour is taxed instead of materials 3.8.a High amount of investment costs	3.1.b Application is too narrow 3.2.b Price/performance is bad 3.3.b Financial resources for consumer are lacking 3.4.b Price of raw material is lower than recycled products 3.5.b Externalities are not reflected in price

	3.9.a Long payback period	
	4.1.a Complementary services & products are lacking 4.2.a Scale of supply is too small 4.3.a Low alignment with incumbent infrastructure 4.4.a Incomplete production chain for technology or products 4.5.a Companies are relying on external providers to adopt CE principles	4.1.b Complementary services & products are lacking 4.2.b Scale of supply is too small
	5.1.a Lack of knowledge dissemination 5.2.a Low amount of R&D and pilot projects 5.3.a Lack of human capital 5.4.a Gap between research and practical needed information 5.5.a Low cooperation between firms 5.6.a Lack of awareness between intermediaries on developments 5.7.a Lack of knowledge required to develop, produce and control technology 5.8.a Lack of skills or knowledge to apply/deal with technology 5.9.a Lack of data on material flows 5.10.a Lack of knowledge on roles of companies in circular economy	5.1.b Lack of knowledge or awareness on CE by producers and consumers 5.2.b Lack of skills or knowledge to apply or deal with product
	6.1.a No belief in potential technology 6.2.a No belief in the potential of product 6.3.a No clear vision	6.1.b Acceptance of service products instead of ownership of products 6.2.b Sense of urgency is missing 6.3.b Consumers interest in sustainability is not reflected in buying

	6.4.a Negative landscape developments 6.5.a Sense of urgency is missing 6.6.a Shareholders have short-term thinking (with focus on benefits) 6.7.a Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling 6.8.a Incumbent industry is not willing to cooperate and resists changing status quo 6.9.a GDP is not a good measure of welfare 6.10.a Lack of trust between companies 6.11.a Acceptance of service products instead of ownership of products 6.12.a Consumers interest in sustainability is not reflected in buying behaviour	behaviour
	7.1.a There are value tensions between values of certain stakeholder versus values of another stakeholder which hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands 7.2.a There are values of stakeholders which are not covered by actors or value advocates, therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. These hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands	7.1.b There are value tensions between values of certain stakeholder versus values of another stakeholder which hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands 7.2.b There are values of stakeholders which are not covered by actors or value advocates, therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. These hinder Aquaponics as an emerging value-conscious socio-technical system in the Netherlands

Table 4.1 The barriers in the primary theoretical framework Piptová 1 (2018) in the institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions (Icons' attribution text: Institution by Mike Wirth from the Noun Project, Technology by Icongeek26 from the Noun Project, Finance by Aneeque Ahmed from the Noun Project, Infrastructure urban by

Eucalypt from the Noun Project, Knowledge by Alena from the Noun Project, Social by Park ji sun from the Noun Project, Ethical by Priyanka from the Noun Project.

5. CURRENT AQUAPONICS SITUATION IN THE NETHERLANDS

In this chapter, a brief history of Aquaponics and stakeholder overview are presented. STEEPLE analysis, description of the Technological aspects of Aquaponics system and detailed stakeholders' description are to be found in chapter 11 Appendices.

5.1. Brief History of Aquaponics

Aquaponics is a rapidly emerging closed-loop food production technology which can be very low-tech. The precursors of aquaponics were systems where aquaculture and agriculture were integrated without the recirculation of water. The first examples of Aquaponics can be the Chinampas "floating gardens" in the lakes in central America by Aztecs 1150–1350 BC (Godek 2017). Aquaponics started to appear in the scientific literature in the 1990s. In the Netherlands, there have been two kinds of installations: domestic/small-scale aquaponics and semi-commercial and commercial aquaponics, used also for education.

Scientific research into Aquaponics and trial installations has gradually taken place at various universities in Europe in Berlin, Zurich and Wageningen. The EU has started a multi-year project to establish a European platform for Aquaponics (Hoevenaars et al. 2018).

So far, in the Netherlands, there have been small-scale farming initiatives for R&D purposes, education, demonstration and decoration inside buildings but also few commercial urban systems.

Mediamatic from Amsterdam started Aquaponics as an art project in 2012 (Broekaert 2012). City farm Uit Je Eigen Stad in Rotterdam, supervised by Wageningen University, grew tilapia, catfish and leafy vegetables in their Aquaponic system from 2014 till their bankruptcy in 2016. In 2016 Swiss Urban Farmers AG in Den Haag installed a commercial Aquaponic system on the rooftop of the empty former Philips office block building "De Schilde". It went bankrupt in July 2018. In 2015 Jos Hakennes started Blue Acres Aquaponics installation in abandoned outdoor swimming pool Veldzicht in Genderen and later also came up with Aquaponics Webshop (Blueacres.nl 2018). In 2015 he also started Duurzame Kost in Vortum Mullem (Landvancuijk.nl 2015) which later moved to Eindhoven. In 2015 TGS Business & Development Initiatives founded an Aquaponics installation with TGS R&D and Wageningen University (Tgsbusiness.com 2018a). Currently, there are less projects than in 2016 (Seijdel 2018a) and their detailed descriptions can be found in the next chapter 11.4. Stakeholder description.

Urban Farmers AG in Den Haag was till their bankruptcy the second largest Aquaponic producer in Europe. Europe's Largest City Aquaponics Farm is currently in Brussels, Belgium. "Ferme Abattoir" opened in May 2018 and it is built on the rooftop of Foodmet Arable in Anderlecht. It was partially funded by BIGH's equity financing which raised €4.3m, and partly in a debt facility from BNP Paribas Fortis bank (Burwood-Taylor 2018).

5.2. Stakeholder Description

The stakeholders are described and subdivided into 11 groups according to their role in Aquaponics development; more detailed description and stakeholder contact details can be found in chapter 11 Appendices:

Current Aquaponic producers

Name of stakeholder: Duurzame Kost
Type of stakeholder: Current Aquaponic producers
Description: Foundation Duurzame Kost and Duurzame Kost City Farm work together with Futuris Zorg & Werk employing autistic youngsters.

Name of stakeholder: Metabolic Lab @ De Ceuvel
Type of stakeholder: Current Aquaponic producers
Description: Urban regeneration project and a "circular" community,
Partner with a variety of organizations : Metabolic, Urgenda , WaterNet, Gemeente Amsterdam, Advantage Metropolitan Solutions, Space & Matter, Amsterdam university and Stichting Doen.

Name of stakeholder: Mediamatic Fabriek
Type of stakeholder: Current Aquaponic producers.
Description: Aquaponics greenhouse, offering tours, workshops, and consultancy, as well as internship opportunities.

Name of stakeholder: TGS Business & Development Initiatives
Type of stakeholder: Current Aquaponic producers
Description: Aquaponics model farm researching cultivation processes in Driel in cooperation with students and researchers from Wageningen University.

Name of stakeholder: NoordOogst Aquaponics
Type of stakeholder: Aquaponic producers
Description: Aquaponic producing focusing on Marine aquaponics and the development of salt water systems with an interest in social sustainability.

Name of stakeholder: Blue Acre
Type of stakeholder: Aquaponic producers
Description: Founder Jos Hakennes is behind Blue Acres, Duurzame kost and Agrofoodpluim. Blueacres joined CrossRoads2 stimulation program from EU, they also used to sell Aquaponics material in Aquaponics Webshop.

Former Aquaponic producers

Name of Stakeholder: Uit je eigen stad
Type of stakeholder: Former Aquaponic producers, urban farmer, and cafe/restaurants
Description: Faced financial difficulties in 2016 (Mulders 2017).

Name of stakeholder: Urban Farmers Den Haag
Type of stakeholder: Former Aquaponic producers
Description: It used to be the largest city farm in Europe. Declared bankruptcy in July 2018 (Ketelaar 2018), they are now searching for new investors.

National and transnational governmental organizations

Name of stakeholder: Municipality Amsterdam
Type of stakeholder: National and transnational governmental organizations
Description: Partner with Metabolic @ De Ceuvel

Name of stakeholder: The EU Aquaponics Association (EUAA)
Type of stakeholder: National and transnational governmental organizations

Description: It continues the work of the EU Aquaponics Hub in order to foster the dialogue about Aquaponics, consumer education, food safety and used technology in the EU and globally (Milliken 2018). Cooperates with COST Horizon 2020.

Name of stakeholder: The EU Aquaponics Hub
Type of stakeholder: Former National and transnational governmental organizations

Name of stakeholder: Municipality Aalburg
Type of stakeholder: National and transnational governmental organizations
Description: Connected with Blue Acres.

Research and knowledge groups

Name of stakeholder: Wageningen University & Research
Type of stakeholder: Research and Knowledge groups
Description: Valuable information has been provided by Dr.ir. RH (Roel) Bosma who used to work for Wageningen University & Research and was a part of a research group Aquaculture and Fisheries at Wageningen University & Research (Leerstoelgroep Aquacultuur en Visserij van Wageningen Universiteit) (Bosma et al. 2017, Sikkema 2017). Opportunities and Challenges of Multi-Loop Aquaponic Systems. PH.D. (Godek 2017) were also published at Wageningen University. Wageningen University & Research has cooperated also with TGS Business & development initiatives focusing on the integration of innovative technologies to save water, energy and nutrients.

Name of stakeholder: Amsterdam university
Type of stakeholder: Research and Knowledge groups
Description: Partner of Metabolic Lab @ De Ceuvel.

Name of stakeholder: HAS Hogeschool Den Bosch
Type of stakeholder: Research and Knowledge groups
Description: School cooperating with Duurzame kost focusing on education and projects connected to city food, technology and regenerative agriculture. Partner with Metabolic @ De Ceuvel

Name of stakeholder: Hanze Institute of Technology in Assen
Type of stakeholder: Research and Knowledge groups
Description: Institute focusing on Energy, entrepreneurship and healthy ageing, partnered with NoordOogst Aquaponics.

Name of stakeholder: Jan Veenstra (Architect)
Type of stakeholder: Research and Knowledge groups
Description: Architect who designed the set-up for a saltwater Aquaponic system with fish, seaweed and sea vegetables. Partner with NoordOogst Aquaponics.

Name of stakeholder: Alfred Wegener Institute (Bremerhaven)
Type of stakeholder: Research and Knowledge groups (in discussion)
Description: Centre for Polar and Marine research, focusing on understanding the complexities of system Earth. Partner with NoordOogst Aquaponics.

For-profit firms and partners - supply side

Name of stakeholder: KYBYS engineers and consultants
Type of stakeholder: For-profit firm partners
Description: Consultancy and engineering firm. In 2017 Marcel van Gendt from KYBYS partnered with Blue Acres.

Description: Name of stakeholder: Aquaponics Webshop
Type of stakeholder: For-profit firm partners
Description: Blue Acres founder Jos Hakkennes also active in Duurzame kost) is involved (Blueacres.nl 2018). Offers Dutch and Belgian aquaponics systems: demo, design and construction.

Name of stakeholder: Futuris Zorg & Werk B.V
Type of stakeholder: For-profit firm partners
Description: Partner of Duurzame kost Futuris Zorg & Werk supports vulnerable disadvantaged adults. Partner of Duurzame kost.

Name of stakeholder: Philips Lighting
Type of stakeholder: For-profit firm partners
Description: It provides the special LED growth lighting system for Aquaponics installation of Duurzame kost in Eindhoven (Theeuwen 2017). Partner of Duurzame kost.

Name of stakeholder: Sint Trudo
Type of stakeholder: For-profit organization partners
Description: Partner of Duurzame kost. real estate company that owns of the Veemgebouw where Duurzame kost has its Aquaponics installation (Ed.nl 2016, Duurzame Kost 2018).

Name of stakeholder: Space & Matter
Type of stakeholder: For-profit firm partners
Description: Architect partner of Metabolic @ De Ceuvel.

Name of stakeholder: WaterNet
Type of stakeholder: For-profit firm partners
Description: Water company for Amsterdam and the surrounding area. Partner with Metabolic @ De Ceuvel.

Name of stakeholder: ID3AS
Type of stakeholder: For-profit firm partners
Description: Consultancy and engineering firm partner with NoordOogst Aquaponics.

Non-profit organization partners

Name of stakeholder: De Stuurgroep Landbouw Innovatie Noord – Brabant (Stuurgroep LIB)
Type of stakeholder: Non-profit organization partners
Description: Supporter of Duurzame kost in 2016 with one time financial contribution.

Name of stakeholder: Urgenda
Type of stakeholder: Non-profit organization partners
Description: Partner with Metabolic @ De Ceuvel.

Name of stakeholder: Foundation Doen
Type of stakeholder: Non-profit organization partners
Description: Partner with Metabolic @ De Ceuvel.

Name of stakeholder: Zeewier Platform (Noordzee Boerderij)
Type of stakeholder: Non-profit organization partners
Description: Working to develop the sustainable seaweed sector and platform to share knowledge. Partner with NoordOogst Aquaponics.

Name of stakeholder: Toentje
Non-profit organization partners
Description: A social enterprise working to grow fresh produce for the Groningen food bank and partner with NoordOogst Aquaponics.

Name of stakeholder: Graanrepubliek
Type of stakeholder: Non-profit organization partners
Description: Cooperation between farmers and grain processing companies to encourage and support a local economy and the growth of a variety of grains. Partner with NoordOogst Aquaponics.

Name of stakeholder: Mondriaan Fonds, Stimuleringsfonds voor de Creatieve Industrie and Amsterdams Fonds voor de Kunst
Type of stakeholder: Non-profit organization partners
Description: Mediamatic is sponsored by Mondriaan Fonds, Stimuleringsfonds voor de Creatieve Industrie and Amsterdams Fonds voor de Kunst.

For profit firms and partners - demand side - Shops and restaurants

Name of stakeholder: Cucina Italiana
Type of stakeholder: Shops and restaurants
Description: Sells Duurzame kost products.

Name of stakeholder: ’t Genot in Vierlingsbeek
Type of stakeholder: Shops and restaurants
Description: Sells products by Duurzame kost, former Blue Acres.

Name of stakeholder: Vershal het Veem shop and restaurant
Type of stakeholder: Restaurants and shops
Description: Sells Aquaponic trout from Duurzame kost.

Product users/public

The current product users and the public or the potential product users.

Plant and animal wellbeing organizations

Name of stakeholder: Partij voor de Dieren Party for the Animals
Type of stakeholder: Plant and animal wellbeing organizations
Description: Among its main goals are animal rights and animal welfare.

Non-human stakeholders inside/outside of the Aquaponic system

Description: Non-human stakeholders inside the Aquaponic system are Fish and Plants and the whole ecosystem inside an Aquaponic system.

Non-human stakeholders outside the Aquaponic system are the whole ecosphere.

Incumbent farmers

Description: Farmers engaged in traditional farming.

5.3. Stakeholder Map

In this section, all the stakeholders involved in the Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders are presented in Figure 5.1. The stakeholders involved in the Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders are shown in chapter 5.2. Stakeholder Description and in Appendices in chapter 11.3. Stakeholders contact data (Duurzame Kost n.d., De Ceuvel n.d., De Ceuvel 2018b, Mediamatic 2018a, Tgsbusiness.com 2018a, Noordoogst.nl 2018a, Noordoogst.nl. 2018d, Blueacres.nl 2018, Interview with Jos Hakkennes 2020, Interview with Andrei Radu Beca 2020, Interview with Erik Moesker 2020, Interview with Bouke Kappers 2020, Interview with Geert Wilms 2020, Sikkema 2017, Seijdel 2018a, WUR 2017f, Tannis 2016, Futuris Zorg & Werk n.d., Theeuwen 2017, Ed.nl 2016, Theeuwen 2017).

Blue Acres is a partner with Aquaponics Webshop (For-profit firms and partners - supply side), KYBYS engineers and consultants (For-profit firms and partners - supply side), ’t Genot in Vierlingsbeek (For profit firms and partners - demand side - Shops and restaurants) and Municipality Aalburg (National and transnational governmental organizations).

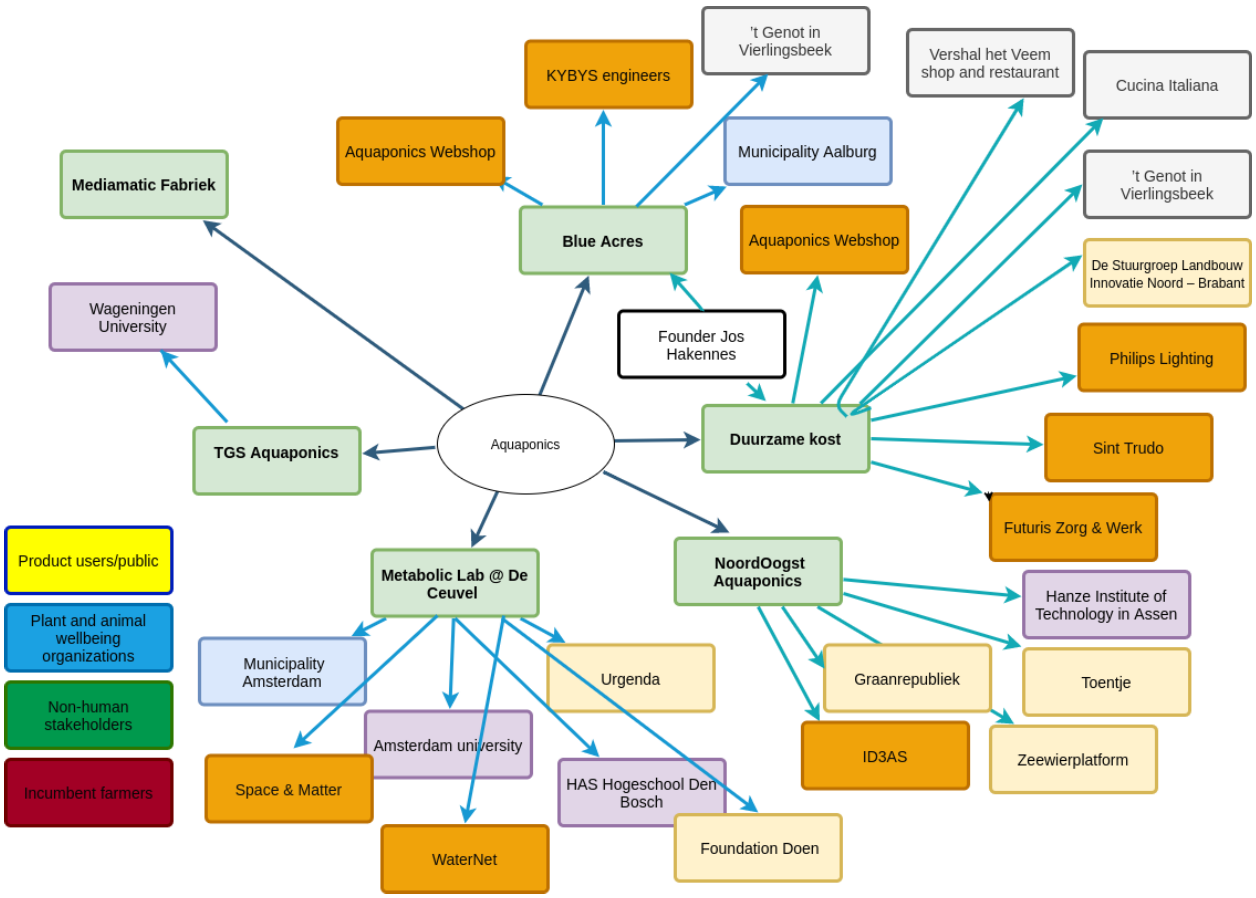
Both Duurzame kost and Blue Acres are founded by Jos Hakennes. Duurzame Kost is a partner with Aquaponics Webshop (For-profit firms and partners - supply side), Vershal het Veem shop and restaurant (For profit firms and partners - demand side - Shops and restaurants), Cucina Italiana (For profit firms and partners - demand side - Shops and restaurants), ’t Genot in Vierlingsbeek (For profit firms and partners - demand side - Shops and restaurants), De Stuurgroep Landbouw Innovatie Noord – Brabant (Non-profit organization partners), Philips Lighting (For-profit firms and partners - supply side), Sint Trudo (For-profit firms and partners - supply side) and Futuris Zorg & Werk B.V. (For-profit firms and partners - supply side). Both Duurzame kost and Blue Acres are founded by Jos Hakennes.

NoordOogst Aquaponics is a partner with Hanze Institute of Technology in Assen (Research and knowledge groups), Toentje (Non-profit organization partners), Zeewier Platform (Non-profit organization partners), Graanrepubliek (Non-profit organization partners), ID3AS (For-profit firms and partners - supply side).

Metabolic Lab @ De Ceuvel is a partner with Urgenda (Non-profit organization partners), Foundation Doen (Non-profit organization partners), HAS Hogeschool Den Bosch (Research and knowledge groups), Amsterdam university (Research and knowledge groups), WaterNet (For-profit firms and partners - supply side), Space & Matter (For-profit firms and partners - supply side), Municipality Amsterdam (National and transnational governmental organizations).

TGS Business & Development Initiatives TGS Aquaponics is a partner with Wageningen university (Research and knowledge groups).

Mediamatic is sponsored by Mondriaan Fonds, Stimuleringsfonds voor de Creatieve Industrie and Amsterdams Fonds voor de Kunst but due to the fact that there was no information found about the connection of these organizations to Aquaponic installation of Mediamatic, these connections are not presented in Figure 5.1.



Legend

Current Aquaponic producers

Non-profit organization partners

National and transnational governmental organizations

Research and knowledge groups

For-profit firms and partners - supply side

For profit firms and partners - demand side - Shops and restaurant

Product users/public

Plant and animal wellbeing organizations

Non-human stakeholders

Incumbent farmers

Figure 5.1. The stakeholders involved in the Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders based on the stakeholder description in chapter 5.2. Stakeholder Description and chapter 11 Appendices with stakeholders contact data (Duurzame Kost n.d., De Ceuvel n.d., De Ceuvel 2018b, Mediamatic 2018a, Tgsbusiness.com 2018a, Noordoogst.nl 2018a, Noordoogst.nl. 2018d, Blueacres.nl 2018, Interview with Jos Hakkennes 2020, Interview with Andrei Radu Beca 2020, Interview with Erik Moesker 2020, Interview with Bouke Kappers 2020, Interview with Geert Wilms 2020, Sikkema 2017, Seijdel 2018a, WUR 2017f, Tannis 2016, Futuris Zorg & Werk n.d., Theeuwen 2017, Ed.nl 2016, Theeuwen 2017).

6. BARRIER ANALYSIS FOR AQUAPONICS IN THE NETHERLANDS

In this chapter, the direct and indirect stakeholders are distinguished, missing actor representation is explained and institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical barriers hindering Aquaponics as an emerging value-conscious socio-technological innovation system in the Netherlands are presented. The identification of the direct and indirect stakeholders and missing actor representation is important for the further ethical barriers assessment in chapter 6.8 Ethical Barriers.

6.1. Direct, Indirect Stakeholders and Missing Actor Representation

In this section, the stakeholders involved are subdivided into direct and indirect stakeholders and it is stated if their values are represented by an actor or not. In order to fully identify stakeholders as direct or indirect and if they are represented by actors, desk research and interviews focused on how the stakeholders interact with the technology and its products and how they are influenced by it, were performed. Distinction of direct, indirect stakeholders and missing actor representation is important according to VSD prism in order to see the wide impact of technology and later equalize power in between the groups of stakeholders with unequal decision power or influence. It is a crucial step, as explained in chapter 2 Methodology Overview, when attempting to identify the benefits and harms of innovation for each group of stakeholders (Friedman et al. 2002) as shown later in chapter 6.8 Ethical Barriers.

As explained in chapter 3.5. Value Sensitive and Value Conscious Design Towards Responsible Innovation, according to the VSD approach, the identification of values, emerging value tensions and the following challenge of facing the value trade-offs (Manders-Huits 2009) while incorporating them into the design process are crucial for successful technology development. In order to identify the values of various stakeholders in the new technology and later identify and diminish the emerging value conflicts, VSD uses an integrative and iterative tripartite methodology: conceptual, empirical and technical investigations.

In the conceptual phase, firstly, the direct and indirect stakeholders are identified (Friedman et al. 2013). A stakeholder is a person or group who has a positive or negative interest or values in an enterprise, technology development or a project and whose support is required in order for an enterprise, technology development or a project to be successful or not. A stakeholder is distinguished from an actor (Okoro 2016). The stakeholders are positively or negatively affected by change or a decision. Stakeholders are entities that have a stake in the case in some way. Sometimes their values are not covered by actors or value advocates (Manders-Huits and Zimmer 2009). Direct stakeholders use (or will use) a given technology or product of it. They directly interact with them. Indirect stakeholders are entities whose lives are (or will be) influenced through others' use (Davis & Nathan 2015).

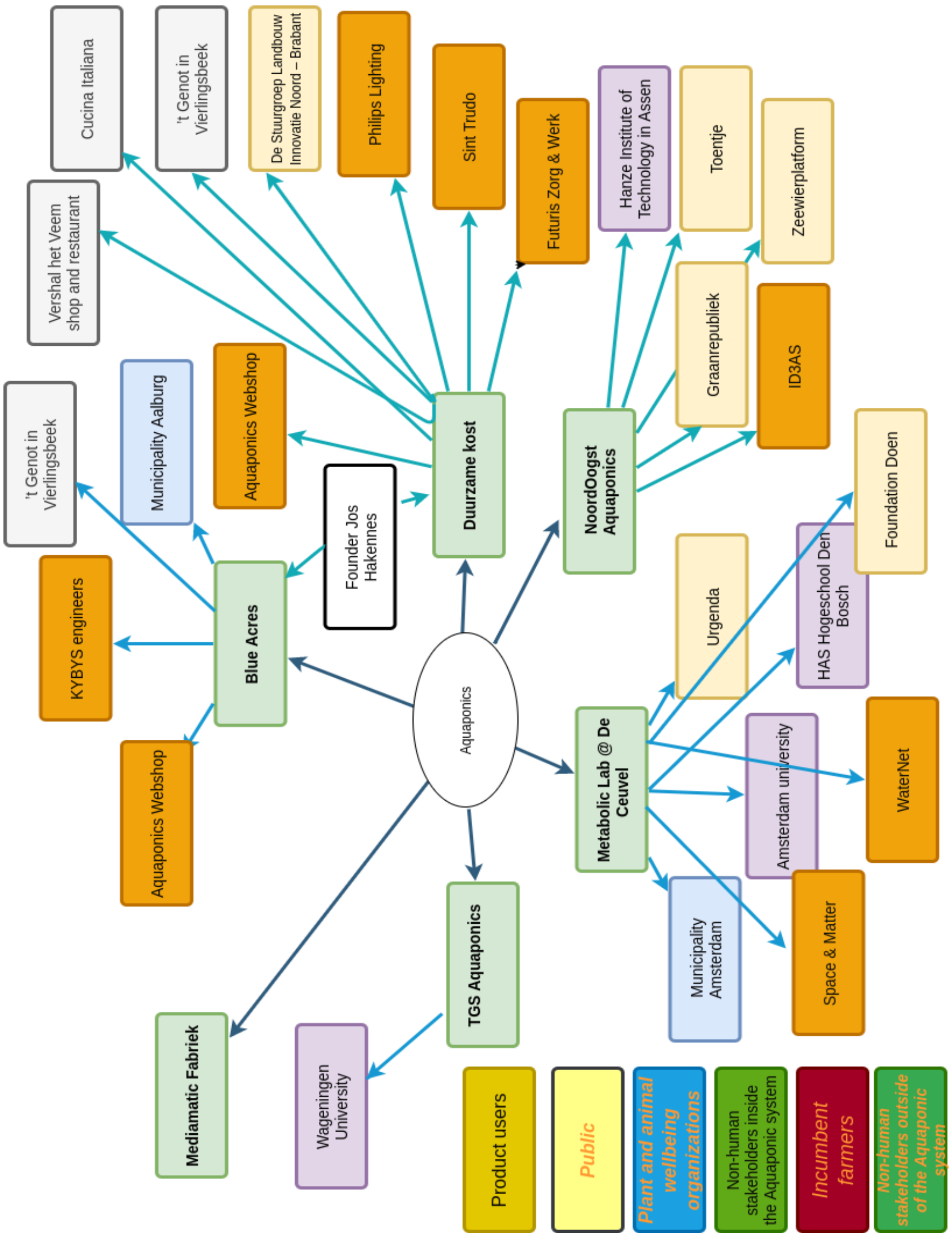
In Figure 6.1 the direct and indirect stakeholders involved in Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders based on description in Figure 5.1 are shown. The following stakeholders were identified as direct, according to the definition of Davis & Nathan (2015), due to the fact that they directly interact with Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, namely with Aquaponics technology or its products: all Current Aquaponic producers due to the fact that they manage their Aquaponics installations (Duurzame Kost n.d., De Ceuvel n.d., Mediamatic 2018a, Tgsbusiness.com 2018a, Noordoogst.nl 2018a, Blueacres.nl 2018, Interview with Jos Hakkennes 2020, Interview with Andrei Radu Beca 2020, Interview with Erik Moesker 2020, Interview with Bouke Kappers 2020); Research and knowledge groups due to the fact that they perform research of the technological innovation and its products and publish their Aquaponics related research which can influence or diminish the interest in Aquaponics (Bosma et al. 2017, Bosma 2017, Sikkema 2017, Seijdel 2018a, WUR 2017f); Product users due to the fact that they can choose to consume fish and plants from Aquaponics installations and support or not support it that way; National and transnational governmental organizations due to the fact that they influence the legislation considering the Aquaponics (Milliken 2018, Joly 2018, Hoevenaars et al. 2018); For-profit firms and partners - supply side due to the fact that they supply the Aquaponics producers with necessary technical equipment or labour (Tannis 2016, Blueacres.nl 2018, Futuris Zorg & Werk n.d., Duurzame Kost n.d., Theeuwen 2017, Ed.nl 2016, Duurzame Kost 2018); For profit firms and partners - demand side - Shops and restaurants due to the fact that they use and sell further Aquaponic products (cucinare_italia 2018, Vershalhetveem.nl 2018); Non-profit organization partners due to the fact that they help to flourish Aquaponics by providing a financial or other support in the form of space or partnerships to Aquaponics producers (Theeuwen 2017, Ed.nl, 2016, Duurzame Kost n.d., Noordoogst.nl. 2018d, De Ceuvel 2018b) and Non-human stakeholders inside the Aquaponic system due to the fact that they live in the Aquaponics system, are used in it or are consumed as its products. They are directly influenced, influencing or involved and have a vested interest in the Aquaponics.

In the research, the following stakeholders were identified as indirect, according to the definition of Davis & Nathan (2015), due to the fact they do not directly interact with Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, namely with Aquaponics technology or its products but their lives are (or will be) influenced through other stakeholders' interactions or use of this technology or its products: Incumbent farmers due to the fact that they are active in the agriculture sector like Aquaponics producers and their business can be influenced by Aquaponics flourishment, however, they do not engage in Aquaponics in a direct way (Interview with Interviewee B 2020); Public and Non-human stakeholders outside of the Aquaponic system due to the fact that they do not engage with the Aquaponics directly but might be affected by somebody's use of this technology or products; Plant and animal wellbeing organizations whose goal is to advocate for the well-being of non-human beings used in agricultural practice and who, as explored in the research, do not engage in Aquaponics in a direct way, nor directly advocate for plants' and fish' wellbeing in Aquaponics in the Netherlands (Partij voor de Dieren 2019). The mentioned stakeholders are affected and have no direct control over the distribution and assignment of resources considering Aquaponics.

The next distinction in this research considers the fact that the stakeholders can be underrepresented by an actor or a value advocate. If the interests or needs of a stakeholder are not presented and acted on by an actor or a value advocate in the form of a person or organization in Aquaponics discourse, the actor representation is missing. Value advocates can be seen as actors acting on behalf of stakeholders that steer the direction of technological development. Value advocates are recommended to get involved in order to strive for the interests of stakeholders who cannot participate in the technological development themselves due to their age or traits or limited cognitive competency (Friedman, Kahn & Borning 2008: 2015). Stakeholders not represented by actors or some sort of 'value advocates', 'value defenders or promoters' still have an interest 'a stake' in the technological development, however, they cannot necessarily influence its trajectory and therefore their views might not be taken into consideration (Van de Poel & Royakkers 2011). Due to the fact that this goes against morality and ethics, Value sensitive and Value conscious design demand that any stakeholders with values in technological development, no matter how weak or insignificant according to certain justifications, will be taken into consideration.

In the research, the following stakeholders were identified as underrepresented by actor or value advocate due to the reason that no information was found about their interests or needs being presented by an actor or a value advocate in the form of a person or organization acting on their behalf in Aquaponics discourse: Public due to the fact that that no information was found about their interests or needs being presented by an actor or a value advocate in the form of a person or organization acting on their behalf in the Aquaponics discourse as well as Non-human stakeholders in the Aquaponic system due to the fact that no information was found about their interests or needs being presented by an actor or a value advocate in the form of a person or organization acting on their behalf in the Aquaponics discourse. There is no specific legislation for Aquaponics (Hoevenaars et al. 2018). Party for the animals does not have Aquaponics on their agenda (Partij voor de Dieren 2019).

To summarize, special attention is to be paid to the indirect stakeholders who might unknowingly be strongly affected by the technology (Friedman et al. 2008) and to stakeholders whose actor representation is missing, therefore their needs, interests and values might be neglected in the technological development (Van de Poel & Royakkers 2011). In this research, Non-human stakeholders living in the Aquaponics system, used in it or consumed as its products, are the only group of Direct stakeholders with Missing actor representation. Due to that there are ethical barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands in the form of values of these stakeholders which are not covered by actors or value advocates, therefore not taken into consideration in the current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.



Aquaponics
Blue Acres
Duurzame kost
NoordOogst Aquaponics
Metabolic Lab @ De Ceuvel
TGS Aquaponics
Mediamatic Fabriek
Founder Jos Hakennes
Aquaponics Webshop
KYBYS engineers
't Genot in Vierlingsbeek
Municipality Aalburg
Aquaponics Webshop
Vershal het Veem shop and restaurant
Cucina Italiana
't Genot in Vierlingsbeek
De Stuurgroep Landbouw Innovatie Noord – Brabant
Philips Lighting
Sint Trudo
Futuris Zorg & Werk
Hanze Institute of Technology in Assen
Toentje
Zeewierplatform
Graanrepubliek
ID3AS
Foundation Doen
Urgenda
HAS Hogeschool Den Bosch
Amsterdam university
WaterNet
Municipality Amsterdam
Space & Matter
Wageningen University
Product users
Public
Plant and animal wellbeing organizations
Non-human stakeholders inside the Aquaponic system
Incumbent farmers
Non-human stakeholders outside of the Aquaponic system

Figure 6.1 The direct and indirect stakeholders involved in the Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders based on description in Figure 5.1 and description in chapter 6.1. Direct, Indirect Stakeholders and Missing Actor Representation. The indirect stakeholders: Incumbent farmers (Interview with Interviewee B 2020), Public, Non-human stakeholders outside of the Aquaponic system and Plant and animal wellbeing organizations (Partij voor de Dieren 2019) are shown in an italics orange font. The direct stakeholders are shown in a non-italics black font and constitute of Current Aquaponic producers (Duurzame Kost n.d., De Ceuvel n.d., Mediamatic 2018a, Tgsbusiness.com 2018a, Noordoogst.nl 2018a, Blueacres.nl 2018, Interview with Jos Hakkennes 2020, Interview with Andrei Radu Beca 2020, Interview with Erik Moesker 2020, Interview with Bouke Kappers 2020); Research and

knowledge groups (Bosma et al. 2017, Bosma 2017, Sikkema 2017, Seijdel 2018a, WUR 2017f); Product users; National and transnational governmental (Milliken 2018, Joly 2018, Hoevenaars et al. 2018); For-profit firms and partners - supply side (Tannis 2016, Blueacres.nl 2018, Futuris Zorg & Werk n.d., Duurzame Kost n.d., Theeuwen 2017, Ed.nl 2016, Duurzame Kost 2018); For profit firms and partners - demand side - Shops and restaurants (cucinare_italia 2018, Vershalhetveem.nl 2018); Non-profit organization partners (Theeuwen 2017, Ed.nl, 2016, Duurzame Kost n.d., Noordoogst.nl. 2018d, De Ceuvel 2018b) and Non-human stakeholders inside the Aquaponic system.

6.2. Institutional Barriers

In the following chapter, socio-technical, ethical barriers and newly found barriers are assessed. The proposed primary theoretical framework Piptová 1 (2018) shown in chapter 4.2. Primary Theoretical Framework Piptová 1 (2018) serves as a tool to guide the search for the analysis. For each barrier it is provided to which extent it constitutes a barrier hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, if and why a certain barrier does not consider the Aquaponics or if no information was found during the research about a certain potential barrier being indicated as a barrier for the Aquaponics. Additional barriers were identified in the research and are described at the end of each section dedicated to a particular dimension. Additional dimensions with barriers identified in the research are situated at the end of this chapter. In order to improve the readability, summaries of barriers for each dimension are provided at the end of each section.

Technology related

1.1.a Low alignment with current legislation

Aquaponics is in alignment with the current legislation (Interview with Interviewee C 2020). There is no specific EU framework for Aquaponics (Hoevenaars et al. 2018). This has not been mentioned by the stakeholders as an issue. Any installation, production or distribution connected to Aquaponics falls under CEFAS (Centre for Environment Fisheries and Aquaculture) and existing Fisheries and Aquaculture legislation (Joly 2018). It is less regulated than the life-stock industry. Aquaponics is considered to be fish as well as plant production, therefore the Common Agriculture policy and the Common Fisheries Policy, the European (EU) Food Safety and Nutrition Policy, and the EU Environmental Policy apply (Hoevenaars et al. 2018, Joly et al. 2015). There is, however, an issue with the ‘organic’ definition in the legislation affecting the Aquaponics which produces without the use of fertilizers, pesticides or antibiotics. This fact was added as an additional institutional barrier at the end of this section.

1.2.a Low level of lobbying

There's no lobby from within the Aquaponics movement (Interview with Interviewee E 2020). The existing agro-food oriented European organizations, such as Sustainable Food Initiative, Transition Coalition Food or Food Nexus working towards the 2050 United Nations sustainability goals in the Netherlands do not focus on Aquaponics. This lack of advocacy coalition constitutes an issue within the striving for the legitimacy of the Aquaponics and prevents the formation of new markets. The lobby on European level done by European Aquaponics Hub for qualifying Aquaponics production as organic has not been successful (Miličić et al. 2017).

1.3.a Absence of regulatory pressures

There is no regulatory pressure and no incentive to produce plants and fish in one circular system like Aquaponics does. Circular economy regulations are still in development. The Dutch vegetable and aquaculture producers already produce very little waste, following the legislation, otherwise they would have to pay a fine. There is no economic incentive to reduce waste anymore. No win from that because the horticultural greenhouse systems here in the Netherlands are already efficient (Interview with Interviewee A 2020). There is already a circular agriculture which uses manure from livestock. Combination of growing fish and plants in one location is not necessary. That's not an added value and Aquaponics in practice confirms that (Interview with Interviewee B 2020).

1.4.a Lack of clarity on how to use waste hierarchy

There is a lack of clarity about how to use the waste management hierarchy according to a concept known as 'Ladder van Lansink' in the Netherlands. It was concluded in a final report Raw material or waste - Recommendations for waste laws and regulations and the implementation towards a circular economy published by the Waste Review Working Group which was set up by the Ministry of Infrastructure and Water Management in order to provide the government with the assessment of barriers to CE in waste legislative activities (van Veldhoven-van der Meer 2019). It was observed that the most issues with CE are in the processes of the CE implementation and not in the regulation formulation phase. Innovative solutions with a great CE implementation such as Aquaponics are not directly supported by governmental policies. Aquaponics is a great example of closed loop thinking and its practical implementation. In Aquaponics the wastewater is reused and circulated instantly, therefore, there is no waste water and being wasteful is prevented (Interview with Interviewee A 2020, Godek 2017).

1.5.a Recycling rates focus on quantity not quality

In the Netherlands the solutions supporting design-for-recycling style persist (Kamerbrief met kabinetsreactie op de transitie agenda's circulaire economie 2018). System innovation, such as Aquaponics with its environmentally defensible reduced use of raw materials and high quality products grown without the use of fertilizers, pesticides or antibiotics (Interview with Interviewee A 2020, Interview with Interviewee C 2020, Interview with Interviewee D 2020) are not supported by any specific legislation (Hoevenaars et al. 2018). The focus in the transition towards CE is currently on size of the residual flows in the recycling instead of implementation of the aspects of the waste hierarchy placed higher up on the 'Lansink's Ladder', such as prevention, re-use and services (Rood and Kishna 2019). There are challenges and inevitable limits to material reuse connected to the up-cycling and generation of high-quality remanufactured goods from low-value materials (Gregson et al. 2015). Furthermore, refurbished, repaired, reused and recycled products and materials have a negative image (Tukker 2015).

1.6.a Cartel formulation legislation hinders collaboration between companies

In order to protect consumer interests in the Netherlands, the European and national competition policy adopted by the Netherlands forbids intensive cooperation in the form of the cartels via the EEC/EU prohibition principles in Article 6 of the Competition Act (Jaspers 2019).

1.7.a No CE standards for products

There is a lack of uniform CE standards to measure the performance of offered services and products, which might hinder circular initiatives among established incumbent technologies (Kirchherr et al. 2018, van Veldhoven-van der Meer 2019). Hanemaaijer et al. (2018) from the Netherlands Environmental Assessment Agency published a proposal "Circular Economics: What We Want to Know and Can Measure" with suggestions about how to measure the progress in case the Netherlands wants to become fully circular by 2050.

It is difficult to measure the advantages of Aquaponics in the current setting. In the Netherlands, the greenhouse industry or the hydroponics industry are very elaborate and well developed, already trying to reduce waste. It is difficult for an outside technology such as Aquaponics with its closed loop recirculation in one system to enter the market and compete with these existing sophisticated systems (Interview with Interviewee E 2020) when there are no stricter requirements.

1.8.a CE is not integrated in innovation policies of the government

The CE recommendations are often explained, understood and implemented in various ways. Using the new production processes is complicated and not supported by the governmental innovation policies through economic incentives (Pheifer 2017). These new production trials therefore stay small scale (van Veldhoven-van der Meer 2019). Another fact is that the governmental initiatives within the CE are not broad enough and focus on recycling and not prevention which is more up the R ladder as explained in the Directive 2008/98/EC on waste (Waste Framework Directive)(Rood and Kishna, 2019). Aquaponics follows a zero-waste approach to innovation. This closed loop innovation is based on water recirculation and does not use fertilizers or antibiotics (Interview with Interviewee A 2020, Godek 2017). That a priori implies pollution prevention. Because CE is not integrated in innovation policies of the government through subsidised help or tax reliefs, businesses based on CE become high risk operations and run a high risk of becoming bankrupt (Seijdel 2018a). Aquaponics requires high starting investment, which can put investors at significant risk (Mann 2015, Interview with Interviewee A 2020, Interview with Interviewee E 2020, Interview with Interviewee E 2020, Interview with Interviewee B 2020). Aquaponics installations Uit je eigen stadt and Urban farmers have gotten bankrupt (Mulders 2017, Ketelaar 2018)

1.9.a No clarity on ownership, liability and responsibility in new business models

The role of the enterprises and consumers in the CE shift from the ownership of a product to fostering a services based economy in closed-loop supply-chains and product-service systems is still rather poorly understood (Mativenga et al. 2017, Jesus & Mendonça 2018). There are uncertainties about how consumers can fit into their new role as 'users' and not 'owners' (Lazarevic and Valve 2017). This does not consider the Aquaponics due to the fact that there is no shift from the ownership of a product towards servicing the product in the Aquaponics.

1.10.a Regulations change slowly

Non-conducive legal systems, path dependency and lock-ins in the current consumption and production styles, conflicting policies and misaligned incentives cause administrative issues and inertia in the behaviour of consumers and businesses (Jesus & Mendonça 2018). As mentioned earlier, even when there is a lot of discussion about CE, but circularity mind-set is still not integrated in innovation policies of the government (van Veldhoven-van der Meer 2019) and there is still no specific legislation for Aquaponics (Hoevenaars et al. 2018). Moreover, changes in Aquaponics specific legislation are not happening and therefore the transition from the incumbent unsustainable linear production towards a more circular bioeconomy is hindered (Gregg et al. 2019).

Product related

1.1.b Low alignment with current legislation

Same applies as in 1.1.a Low alignment with current legislation in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

1.2.b Absence of regulatory pressures

Same applies as in 1.2.a Absence of regulatory pressures in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

There were the following additional institutional barriers identified during the research:

The label 'organic' in the legislation applies only to production in the soil

The legislation permits the label 'organic' only for products grown in the soil (Interview with Interviewee C 2020, Interview with Interviewee E 2020, Interview with Interviewee C 2020, Interview with Interviewee F 2020). This puts Aquaponics producers into disadvantage compared to other traditional organic producers (Interview with Interviewee C 2020) Interviewee E thinks, however, that legislation is not a big issue right now and that one has to shift the manner of branding. Interviewee E said that one cannot call Aquaponics organic but one can call it grown in an ecological way and one can say that the fish feed is organic; it is a matter of marketing (Interview with Interviewee E 2020).

To summarize, there are institutional barriers in the form of a lack of lobbying for Aquaponics; a lack of legislative pressure and incentive to produce plants and fish in one circular system due to the sophisticated horticultural greenhouse systems in the Netherlands; a lack of clarity on how to use waste hierarchy in the transition towards CE; CE strategies focus more on quantity than on quality of the residual flows; a legislation forbidding intensive cooperation between companies through cartel formation prohibition; a lack of standardization, metrics and data about the CE efforts; a persistent lack of regulatory pressures to include circularity into innovation. through advantages for CE implementing enterprises; uncertainties about how the enterprises and new 'users' can fit into their roles with new opportunities and responsibilities in the shift towards a CE paradigm; conflicting policies, non-conducive legal systems perpetuating the path dependency and lock-ins together with misaligned incentives causing inertia and unnecessary hurdles in the behaviour of businesses and users; labelling 'organic' in the legislation which applies only to production in the soil and, therefore, constitutes a disadvantage for the Aquaponics producers.

6.3. Technical Barriers

Technology related

2.1.a Uncertainties and risks related to the technology

The technology is not risky when handled properly and when correct food hygiene and safety precautions are applied (Hollyer et al. 2009).

2.2.a Lack of LCA studies to prove the effect of CE principles

There are studies and increasing interest in the life cycle assessment and impact of circular economy principles (Valencia 2017). Local circular supply firms have been found to have lower emissions than linear supply firms, supporting the hypothesis that CE principles are more environmentally friendly in terms of carbon emissions (Genovese et al. 2017). In the study of Cohen et al. (2018) Aquaponics production has been found more efficient in terms of its environmental impacts compared to the additive life cycles of traditional lettuce and tilapia production. It has shown lower impact on eutrophication, water usage, and diminished geographic footprint. The material inputs or fish feed stay a challenge in order for Aquaponics to become a resilient food production system. The large reduction in water use and on the other hand, electricity use and the fish feed as the main contributing factors to environmental impact were determined in the study of Boxman et al. (2017). More LCA studies to prove the effect of CE principles and the Aquaponics benefits are necessary.

2.3.a Products are designed for end-of-life

It is not applicable in the case of Aquaponics. The products of the Aquaponics are eaten. This is, however, a persistent issue in the transition towards CE (Circular-economy-related opportunities 2020).

Product related

2.1.b Risks are associated with product

There are no risks found to be associated with the product or the technology for the product or technology users or the public. There are, however, safety and health hazards for fish and plants inside the system which was added as an additional technical barrier at the end of this section.

2.2.b Quality of product is limited

There are no issues with the product quality. The Aquaponic installations in the Netherlands are focused on a healthy production and high quality of organic foods grown without the use of fertilizers, pesticides or antibiotics (De Ceuvel 2018b, Interview with Interviewee C 2020). Labelling organic is ,however, not allowed because it is not grown in soil (Interview with Interviewee E 2020).

There were the following additional technical barriers identified during the research:

Fine-tuning of the system

The requirements of the fish for nutrients are rarely in the balance with demands of the plant section of the Aquaponics (Bosma 2017, Interview with Interviewee C 2020, Interview with Interviewee D 2020). In the Aquaponics the fine-tuning of the system by a skilled practitioner is crucial in order to prevent malfunctions (Interview with Interviewee C 2020, Interview with Interviewee D 2020, Bosma 2017). This happens through trial and error. The Aquaponics set up and maintenance is also labour intensive which presents a large portion of the operational costs, especially in the industrialised countries (Bosma 2017).

The EU Aquaponics Hub released several documents to help with the vocational training and education on Aquaponics for the new generation of Aquaponics practitioners to gain better technical skills (Junge 2018). Low technical skills constitute an obstacle in ability to force change towards sustainability (Jesus & Mendonça 2018).

Safety and health hazards for non-human beings in the system inside the system

There are safety and health hazards for fish, plants and ubiquitous microorganisms inside the system that have been encountered and there have been accidents with fish tanks overheating in Mediamatic (Mediamatic 2019e). There needs to be equilibrium in the system between green crops and fish, and the different combinations between species. Bosma from the research group Aquaculture and Fisheries chair group at Wageningen University & Research advises to start first small, learn, get the know-how, fine-tune the fish and plants (needs) ratios and then expand the facilities, installation and production (Sikkema 2017). Small units are less vulnerable to dysfunctions and are easy to scale up (Bosma et al. 2017). Experimenting with fine-tuning and compatibility are crucial because the nutrients from fish farming often do not entirely meet the needs of vegetables (Sikkema 2017). Mistakes in the control of the balance between the plants and animals can have severe consequences in terms of their welfare (Mediamatic 2018a). Fish, plants, and ubiquitous microorganisms suffer when there are temperature fluctuations (Lopes et al. 2018). Also, fish in captivity in a farm cannot perform the full repertoire of its behaviours like in nature (Sandøe et al. 2015).

To summarize, there are technical barriers in the form of safety and health hazards for fish, plants and ubiquitous microorganisms inside the system due to the novelty of the system and difficulties with the set up and the calibration of the installations. Additionally, there is a lack of LCA to prove the effect of CE principles.

6.4. Financial (Economic) Barriers

Technology related

3.1.a Low amount of competitors and new companies in the field

Based on the theory of FIS there need to be competitors and new companies in the field. Currently there is an insufficient number of competitors and new companies that are crucial to flourish learning, innovation and experimenting within the area of Aquaponics. There are not enough of Aquaponics enthusiasts to cooperate and thereby alter “the status quo”. There have been less projects since 2016 and multiple bankruptcies occurred in recent years - Uit Je eigen stad and Urban Farmers both closed (Seijdel 2018a).

3.2.a Low investments in research

The domain of Aquaponics is transdisciplinary and very little research has been done so far (Godek 2017). There is a necessity to research more the factors contributing to an appropriate level of returns (fish plant combination) in the Aquaponics system (Dormaar 2017). The EU Aquaponic hub funded several research papers into Aquaponics (EU Aquaponics Hub 2018b), however, so far there have been only three research projects in cooperation with Wageningen University & Research in the Netherlands. They all concluded that farming fish in the Netherlands would be too expensive (Sikkema 2017).

There is a new 4-year project Prototyping citizen-centred urban agrifood systems led by Metabolic Institute funded in 2020 by the EU Commission. It will investigate citizen-driven urban food initiatives, including Aquaponics, calibrated to local needs (FOODE: Creating sustainable food systems for European cities 2020). In 2019 NoordOogst Aquaponics received an MIT subsidy in order to research a marine Aquaponics(FOODE: Creating sustainable food systems for European cities 2020).

More research is needed on how to promote Aquaponics as a more beneficial synergistic closed-loop practice for improved food security and nutrition compared to traditional aquaculture and horticulture. Nowadays research shows that up to date Aquaponic system components have not fully reached their full potential when it comes to its cost effectiveness and technical capabilities (Rakocy & Bailey 2003, Vermeulen & Kamstra 2013). Aquaponics is a promising technology which can foster global and urban sustainable food production and at the same time diminish resources use and water pollution (Boxman et al. 2017). This can happen in the future when there might be no more abundance of fresh water (Interview with Interviewee E 2020).

3.3.a Negative landscape developments

Besides a corona pandemics slowing down the economy (Michelsen et al. 2020) and transition towards CE, there is a demand-sided development for a higher amount of resources which causes resource depletion and on the other hand supply-sided development with higher resource price and volatility. This requires solutions offering cost mitigation, increased environmental standards and stability. Consumer awareness, business routines changes and new solutions rewire the market and society slowly (Jesus & Mendonça 2018).

3.4.a Financial support for linear or incumbent systems (or absence of tax system supporting sustainable products)

There is no EU Aquaponics specific policy and no special support for Aquaponics. Investors could be attracted by the “innovative” and exciting nature of Aquaponics installations (Mann 2015). Dutch governmental initiative “Green deals” encourages and supports sustainable and environmentally friendly businesses, with Aquaponics potentially being eligible for this support (Greendeals.nl 2018). However, the risk of the high investment needed to start an Aquaponic installation and prominent poor examples (Bankruptcy cases of Urban Farmers and Uit Je Eigen Stad) can cause preference for incumbent systems. Aquaponics is not profitable in the moment (Dormaar 2017). Investors may be less interested if the installation will take a longer time to recuperate their investment.

3.5.a Not enough financial resources available

Many Aquaponics installations and developers are small companies, making it less likely for them to receive financial services such as loans for any significant sum. Starting an Aquaponics system requires a high investment. At the same time there is no way to earn back this high investment due to the fact that Aquaponics is not allowed to get certification for organic production. Hence, the Aquaponics practitioners have to sell their products for a similar price as conventional growers who have a significantly lower investment (Interview with Interviewee F 2020).

The Aquaponics system of Duurzame kost in Eindhoven setups was sponsored. Lightning was provided by Phillips. Labour in an Aquaponics company is also expensive (Bosma 2017). Urban agriculture is not profitable without the subsidised labour force and accompanying activities at this moment (Interview with Interviewee E 2020). The example of this is Duurzame Kost who cooperates with Futuris Zorg & Werk and has been using the subsidised labour force in their facility (Duurzame Kost 2018, Interview with Interviewee E 2020). Duurzame Kost is at the moment profitable due to the fact that they offer a mix of products, such as tours, workshops and sell their fish and plants to local restaurants and citizens. Interviewee C said that at this phase, after many trial and error when the system is set up and running smoothly, the maintenance is less labour-intensive (Interview with Interviewee 2020).

3.6.a Investment calculations are based on one lifecycle instead of more cycles

This has to do with the high upfront investment costs and long payback period which discourage the investors (Mont et al. 2017).

3.7.a Labour is taxed instead of materials

In the Netherlands, taxing labour instead of taxing the use of virgin materials has not changed yet (What policies are still necessary? - Kennis Kaarten - het Groene Brein 2020).

3.8.a High amount of investment costs

Starting an Aquaponics system requires a high investment (Interview with Interviewee F 2020, Bosma 2017, Dormaar 2017). It is a technology that is difficult and expensive to initially implement.

3.9.a Long payback period

A recent global study found that more than a half of 200 surveyed Aquaponics farms made losses (Love et al. 2015). Aquaponics installations Uit je eigen stadt and Urban farmers have gone bankrupt (Mulders 2017, Ketelaar 2018). Aquaponics is not profitable at the moment (Dormaar 2017). Investors may be less interested if the installation will take a longer time to recuperate their investment. Duurzame kost makes a current profit from Aquaponics in the Netherlands due to the fact that they have had their lighting sponsored and labour subsidised (Interview with Interviewee E 2020). They also offer tours, workshops and sell their products to local restaurants and citizens (Interview with Interviewee 2020).

Product related

3.1.b Application is too narrow

Aquaponics products in order to be generating profit need to be an expensive vegetable and an expensive fish in a niche market. This is difficult in the Netherlands at this moment (Interview with Interviewee A 2020). Urban farmers who have gone bankrupt sold 31 varieties of products, but could not compete with established agricultural businesses, especially Westland - a large greenhouse complex primarily producing large variety food for export (Seijdel 2018b).

3.2.b Price/performance ratio is bad

Aquaponics with its products is not profitable at the moment (Dormaar 2017, Interview with Interviewee F 2020, Interview with Interviewee E 2020, Interview with Interviewee A 2020).

3.3.b Financial resources for consumer are lacking

The Netherlands is fairly affluent, with there being no indication that consumers' financial resources are lacking. However, it might be the case for "specialised" products. Aquaponics products are as expensive as organically labelled ones (Duurzame kost city farm tour with Jos Hakkennes 2020). There is a potential to work with food banks to provide fresh Aquaponics produce for people on low income and thereby tackling urban food poverty (Noordoogst.nl 2018d).

3.4.b Price of raw material is lower than recycled products

Virgin materials are still cheap (Mont et al. 2017, Hartley & Kirchherr n.d.).

3.5.b Externalities are not reflected in price

The Green Revolution with its neoliberal 'one size fits all' growth-oriented discourse on food security and sustainability reduced to rapid production and initial profit creates perceived benefit only when a high number of costs (human, ethical, biophysical limits of our earth) so called "externalities" are ignored (Tegtmeier and Duffy 2004, Weis 2010). There is a New Food System Paradigm Shift needed (Milliken & Stander 2019).

CE has many ecological benefits and there are more environmental policies being made (Jesus & Mendonça 2018). Environmental and social costs of a product are, however, still not calculated in the final price (Pheifer 2017, Vollebergh et al. 2017). The Netherlands has set an overarching target in "The Netherlands Circular by 2050" (2016) and has set up the Versnellingshuis Nederland Circulair in order to stimulate CE activities and environmentally friendly policy implementations, such as Plastic Pact and the Room in Rules programme. The regulations, however, change slowly. The environmental impact of mainstream farming (such as pesticide pollution and water use) is still not fully considered in the price according to the ' polluter pays principle'. This fact makes it harder for Aquaponics with its sustainable products, according to the definition of Lehman et al. (1993), to compete. NoordOogst Aquaponics is working to reduce food miles through Aquaponics (Noordoogst.nl 2018a). In the field of Aquaponics, there are still improvements to be made with more ecological systems (Sikkema 2017).

There were the following additional financial (economic) barriers identified during the research:

Dutch horticulturalists serve the vegetable market at a low price and imported fish is too cheap and The current market situation development in the Netherlands is still not beneficial for sustainable farming with Aquaponics. Aquaponics is not profitable at the moment (Interview with Interviewee

A 2020, Duurzame kost city farm tour with Jos Hakkennes 2020, Interview with Interviewee E 2020). Aquaponics fish and vegetables are an expensive commodity to sell. Dutch glasshouse horticulture sector is very advanced (Dormaar 2017) and Dutch horticulturalists serve the vegetable market at a much lower price (Bosma et al. 2017).

Aquaponics requires a combination of high-value vegetable and high-value niche market fish

Aquaponics in order to be profitable requires a combination of high-value vegetable and high-value niche market fish. Niche Market is not available in the Netherlands. The research group Aquaculture and Fisheries chair group at Wageningen University & Research concluded that Aquaponics only makes sense if the entrepreneur establishes a good niche market for expensive fish and combines this with relatively expensive vegetables (Dormaar 2017). The prospect of Aquaponics is set primary by the high-value vegetable part. Fish present a smaller compartment of the Aquaponics production but it also has to have a stable high price and exist in a niche market (Bosma et al. 2017). There is no such mix of an expensive plant component and fish in the Netherlands. In the interview Interviewee A mentioned that in the Netherlands cannabis might be suitable (Interview with Interviewee A 2020). Tilapia or catfish are not suitable because they are far too cheaply exported from Asian countries.

Rebound effect

According to Jevons (1999) Berkhout et al. (2000) every action improving the eco-efficiency along with the initial environmental gains is a subject to boosting the consumption and therefore the appearance of the rebound effect. This constitutes a problem in the concept of CE which has not been addressed by the CE promoting scholars yet (Korhonen et al. 2018).

To summarize, there are financial (economic) barriers in the form of a low amount of competitors and new companies and low investments into research which is crucial in order to perform experiments, learn from them, disrupt the incumbent infrastructure and promote Aquaponics as a more beneficial synergistic closed-loop practice for improved food security and nutrition compared to traditional aquaculture and horticulture; negative landscape developments offering no incentive to produce plants and fish in one circular system like Aquaponics does; the funding for circular projects is limited and rather supporting the incumbent regime; high upfront investment costs and long-payback periods discourage the investors; calculations are often made for short-term and not long-term benefits; taxing labour instead of taxing the use of virgin materials has not changed yet, the Aquaponics product use is limited; Aquaponics is not profitable at the moment even when consumers in the Netherlands are rather affluent and products are as expensive as the organic labelled ones; virgin materials are still cheap and environmental and social costs of a product are still not calculated in the final price; the rebound effect; the fact that Aquaponics in order to be profitable requires a combination of high-value vegetable and high-value niche market fish and Dutch horticulturalists serve the vegetable market at a much lower price than Aquaponic producers and imported fish is too cheap.

6.5. Infrastructural Barriers

Technology related

4.1.a Complementary services & products are lacking

There are no complementary services & products at the moment in the case of Aquaponics. No information was found during the research about this being indicated as a barrier for the Aquaponics.

4.2.a Scale of supply is too small

The Aquaponics is in the early stage of development and no information was found during the research about the above mentioned potential barrier being indicated as a barrier for the Aquaponics in the current situation.

4.3.a Low alignment with incumbent infrastructure

The incumbent infrastructure functions on linear rather than circular principles (Webster 2017). Aquaponics functions on the circular principles (Godek 2017). The technology and its products are in line with the incumbent infrastructure. No information was found during the research about this being indicated as a barrier for the Aquaponics.

4.4.a Incomplete production chain for technology or products

No inconsistencies or missing elements were found in the production chain for technology or products in a desk research nor in the interviews. No information was found during the research about this being indicated as a barrier for the Aquaponics.

4.5.a Companies are relying on external providers to adopt CE principles

No information was found during the research about this being indicated as a barrier for the Aquaponics.

Product related

4.1.b Complementary services & products are lacking

Same applies as in 4.1.a Complementary services & products are lacking in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

4.2.b Scale of supply is too small

Same applies as in 4.2.a Scale of supply is too small in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

There were the following additional infrastructural barriers identified during the research:

Not the 'fittest' but the 'first' survives

According to Norton et al. (1998) there are path dependencies and lock-ins in the current infrastructure which prevent innovation from succeeding among established enterprises. According to Korhonen et al. (2018) the CE efforts and decisions are locked-in our current limited thinking preventing us for future decades to make radical innovations and reach long-term intergenerational goals. This is the case of Aquaponics which has a hard time competing with established technologies. It is difficult for technologies entering the market to succeed among the more conventional ones (Interview with Interviewee E 2020). This slows down the investment payback time and therefore the economic feasibility of technological innovation becomes endangered (Pearce 2015, Roy 2017, Schipper 2019).

Scalability

Aquaponics needs a niche market and cannot compete with the unequal big production scale of the incumbent aquaculturalists and horticulturalists (Gregg et al. 2019). This is set in an interplay of an infrastructural, technical and economic context. There are only very few Aquaponics producers as shown in Figure 5.1 The stakeholders involved in the Aquaponics in the Netherlands and the connections of the current Aquaponics producers to the other types of stakeholders. The Aquaponics installations are smaller than incumbent commercial hydroponics and aquaculture productions. The government gives to Aquaponics no special attention and has no special policy for it. Aquaponics producers have the knowledge and assemble their own installations using required, often second-hand aquaculture and horticulture equipment (Duurzame kost city farm tour with Jos Hakkennes 2020, Interview with Interviewee E 2020). Scalability of Aquaponics production embedded among the other regime actors is an issue. The question is if it should be scaled up or not. As mentioned earlier, Bosma advises to start first small, learn, get the know-how, fine-tune the fish and plants needs ratios and then expand the facilities, installation and production (Sikkema 2017). The small units are less vulnerable to storms and are easy to scale up according to Bosma et al. (2017). Aquaponic method provides vegetables and herbs for small cafes, but at this moment it is not focused on large scale production (De Ceuvel n.d., Mediamatic 2018b). More research is necessary in order to be able to have large scale Aquaponic installations. Currently, Aquaponics fails to compete with large-scale agriculture from the Westlands (Seijdel 2018a). It is unable to compete with cheap large scale horticulture or aquaculture production. It is often suggested that successful systems can be run in the small scale (400sq metres), however, successful Aquaponics producers suggest that over 4000sq metres holding over 2500sq metre of Aquaponics system is needed to be commercially viable (Mann 2015). Interviewee E thinks that the Aquaponics producers in the Netherlands and also in Europe should scale up from the current suboptimal size and try Aquaponics on a bigger scale in order to see its full potential (Interview with Interviewee E 2020).

To summarize, there are infrastructural barriers in the form of the incumbent infrastructure functioning on linear rather than circular principles and the paradigm that not the ‘fittest’ but the ‘first’ established and convenient technologies survive due to the path dependencies and societal lock-in.

6.6. Knowledge Related Barriers

Technology related

5.1.a Lack of knowledge dissemination

Aquaponics knowledge is based on fine tuning the system via trial and error (Bosma 2017, Interview with Interviewee C 2020). This knowledge is scarce in the Netherlands due to the fact that there are only few developers running Aquaponics installations. In the online Aquaponics community, people do share their knowledge and experience with Aquaponics (Interview with Interviewee D 2020).

There is a growing interest and willingness to learn are high among groups interested in sustainability and food production (Mediamatic 2018b). Several Aquaponics developers and producers, such as Mediamatic, Metabolic, TGS Business & Development Initiatives and Duurzame kost run outreach and training workshops and tours for both the general public and those interested in setting up their own Aquaponics systems (Mediamatic 2018b, Duurzame Kost n.d., Tgsbusiness.com 2018b). Several training school workshops were funded under the COST project (EU Aquaponics Hub 2018c). Interviewee E said that the Dutch Aquaponics producers try to help each other and do not protect their knowledge (Interview with Interviewee E 2020). Interviewee D talks about Metabolic Aquaponics installation as an open-source formation (Interview with Interviewee D 2020).

5.2.a Low amount of R&D and pilot projects

There are only a few Aquaponics projects in the Netherlands. Many installations have failed due to financial issues. TGS Business & Development Initiatives, WUR and Addis Ababa University are collaborating on R&D and pilot schemes here in the Netherlands (Tgsbusiness.com 2018a). There are collaborative research projects into salt water aquaponics (Noordoogst.nl 2018c, Interview with Interviewee E 2020). In 2019 NoordOogst Aquaponics received an MIT subsidy in order to research a marine Aquaponics (FOODE: Creating sustainable food systems for European cities 2020).

5.3.a Lack of human capital

As an Aquaponics farmer you need a transdisciplinary knowledge. You need to know about physics, chemistry, biology, be a handyman and an engineer as well. (Interview with Interviewee D 2020). Aquaponics is very labour intensive, labour force is expensive and setting up the system requires a lot of trial and error (Bosma 2017, Interview with Interviewee E 2020). Bosma confirms that specialist knowledge in Europe is expensive and difficult to get (Dormaar 2017).

5.4.a Gap between research and practical needed information

Several organisations are 'experimenting' with Aquaponics, however these remain on a small scale, with questions of scalability and application to commercial enterprises unanswered (Mann 2015). Interviewee E thinks that all of the projects and proofs of concepts so far even globally have been on a suboptimal scale (Interview with Interviewee E 2020). To have an economically viable system, you need to scale up, such as Duurzame kost plans to do (Interview with Interviewee C 2020).

5.5.a Low cooperation between firms

There seems to be significant interest in cooperation in the Aquaponics community, sharing knowledge and experiences through websites and blog posts (Mediamatic 2018b). There is a large number of consultancy services, suggesting cooperation when financially beneficial (Mediamatic 2018b, Tgsbusiness.com 2018b). There is more organizational synergy needed between companies in a transition towards CE (Hartley & Kirchherr n.d.)

5.6.a Lack of awareness between intermediaries on developments

Due to the small scale, Aquaponics goods are not yet stocked by any mainstream supermarkets or food suppliers, potentially due to a lack of awareness from these suppliers about this growing technology.

5.7.a Lack of knowledge required to develop, produce and control technology

The same applies as in 5.3.a Lack of human capital. Knowledge and skills in Aquaponics are rare (Duurzame Kost n.d.a, Interview with Interviewee A 2020). This technology is still in a stage of an early development, with the knowledge base growing quickly through experimentation (Interview with Interviewee C 2020, Interview with Interviewee D 2020). The technical skills to set up an Aquaponics system are not well followed by good business skills according to Interviewee F which can be seen on bankrupted Urban farmers from the Hague (Interview with Interviewee F 2020).

5.8.a Lack of skills or knowledge to apply/deal with technology

The same applies as in 5.7.a Lack of knowledge required to develop, produce and control technology. Additionally, according to the Interviewee F, some Aquaponics producers lack the skills to produce a good business plan in order to make the Aquaponics application successful, as confirmed by the several bankruptcies (Interview with Interviewee F 2020. The Aquaponics business requires accompanying activities, such as tours, seminars and workshops at this moment (Interview with Interviewee C 2020).

5.9.a Lack of data on material flows

There is an information deficit about the economy-wide material flows attributes. Everything is interconnected at the national, regional, and local level and therefore to gather such verifiable and transparent information is an ongoing challenge (Hartley & Kirchherr n.d.). Moreover, the definition and concept of flow and waste is dynamic and changing, varied in different countries, therefore, it is difficult to grasp it or measure it (Korhonen et al. 2018).

5.10.a Lack of knowledge on roles of companies in CE

There are ideas that the big players in the economy should be a role model for other companies to “pull” the CE strategies and sustainability practices (Hartley & Kirchherr n.d.). The corporate culture in the Netherlands is hesitant towards promoting and implementing the CE strategies (Kirchherr et al. 2018). Business in general is rigid in its practices towards CE (Jesus & Mendonça 2018). There is a better communication needed to induce the altered behavioural changes about the value of CE (Hartley & Kirchherr n.d.). CE frameworks are present in Aquaponics producers' ideas (Noordoogst.nl 2018e).

Product related

5.1.b Lack of knowledge or awareness on CE by producers and consumers

The concept of circular economies is gaining prominence in academia, industry and policy makers, however, it is lacking in the general public of the Netherlands (Geissdoerfer et al. 2017). There is growing interest and attention in Asian nations, however this is not being mirrored in Western Europe (Andersen 2007). The consumer interest is lacking (Kirchherr et al. 2018). There is an ethical consumption attitude and actual buying behaviour discrepancy which preserves the status quo (Carrington et al. 2016). The initial support and commitment are not in harmony with the actual uptake (Masi et al. 2018). The Dutch consumer is unwilling to value refurbished or remanufactured goods due to ideas that they are not good enough (Hartley & Kirchherr n.d.).

5.2.b Lack of skills or knowledge to apply or deal with product

No information was found during the research about this being indicated as a barrier for the Aquaponics.

There were the following additional knowledge-related barriers identified during the research:

Large-scale demonstration projects are missing

There are large-scale projects lacking (Kirchherr et al. 2018). Many Aquaponics projects focus on a small scale, such as community based markets and therefore are failing to encourage CE principles on a big scale. This might limit their future growth. There are only a few installations in the Netherlands and all are small scale. Interviewee E stated that they are of the suboptimal size and he thinks that people need to experiment with Aquaponics on a big scale to see the full potential of it and gain the necessary knowledge (Interview with Interviewee E 2020).

To summarise, there are knowledge barriers in the form of a low amount of R&D and pilot projects; a lack of human capital with transdisciplinary knowledge and skills in order to develop, produce, manage and control the technology; a gap between research and practical information due to the low amount and suboptimal size of demonstrations. When it comes to transition towards CE, there is additionally a general lack of cooperation and trust between firms; a lack of data on material flows and insufficient transparency in the supply-chain; a lack of knowledge on roles of companies in CE and a lack of knowledge or awareness on CE by producers and consumers.

6.7. Socio-Cultural Barriers

Technology related

6.1.a No belief in potential technology

The interviews with the Aquaponics producers suggest high interest and belief in the technology (Interview with Interviewee A 2020, Interview with Interviewee B 2020, Interview with Interviewee C 2020, Interview with Interviewee D 2020, Interview with Interviewee E 2020, Interview with Interviewee F 2020). In the context of the circular economy and the recycling of raw materials, it sounds great to grow vegetables on water from a fish pond full of nutrients (Sikkema 2017). Aquaponics might be important in the future in big cities when people need fresh specific herbs or veggies (Interview with Interviewee A 2020). The Aquaponics is a big hype at the moment (Tumsek et al. 2020).

Interviewee C also believes that Aquaponics has a future because it is more efficient than organic agriculture and products are more fresh and have a better taste. They are transported locally straight from the city farm to the table. This is especially important due to the predictions that 70 percent of all people will be living in cities and therefore having issues with waste management. Using waste of humans for nutrients for plants might be an option in Aquaponics too. There are also trials set up for Duurzame kost in order to find out if Aquaponics products are more nutritious than organic and regular agricultural products (Interview with Interviewee C 2020).

Interviewee E also thinks that Aquaponics will be crucial in the future due to the nitrogen crisis and salinization of the soil on the coast of the Netherlands. He has been experimenting with marine Aquaponics and thinks that Aquaponics developers should upscale their production to see the full potential of Aquaponics (Interview with Interviewee E 2020).

Interviewee B also brought big successful farmers to see Aquaponics and they have found it very interesting in order to get farming into the city (Interview with Interviewee B 2020). Significant belief in the potential of Aquaponics as an urban farming technique that could change the global food system, is shown in the mission statement of Mediamatic (Mediamatic 2018c).

6.2.a No belief in the potential of product

Same applies as in 6.1.a No belief in potential technology in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands. Increasing research shows that Aquaponics products are safe, however they need to be campaigned to the product user (Fox et al. 2012).

6.3.a No clear vision

There is a vision about the future farming in big cities where people will need fresh food (Interview with Interviewee B 2020, Interview with Interviewee C 2020, Interview with Interviewee A 2020). Aquaponics might change the global food system (Metabolic 2018). All interviewees were enthusiastic about the future believing that the Aquaponics Interviewee E and Interviewee C want to scale up their productions (Interview with Interviewee E 2020, Interview with Interviewee C 2020), others think it needs to stay small-scale serving niche markets (Interview with Interviewee A 2020). Interviewee E also thinks that there is a great future for the Marine Aquaponics due to the salinization of the coast and abundance of salty water. He also thinks that the production of medical plants is promising (Interview with Interviewee E 2020). Interviewee C believes in cooperation with nature and between people in the form of social and ecological sustainability towards producing seasonal local healthy food. He is working on making a more sustainable fish feed based on insects grown on the food rests from the Aquaponics production (Interview with Interviewee C 2020). TGS Business & development initiatives believe that the Aquaponics is a promising technology, especially for the urban and soil depleted areas anywhere in the world. They promote the decoupled Aquaponics where the fish environment is controlled separately from the plant section (Tgsbusiness.com 2018b). Interviewee A said with a laugh that cannabis could be great for the successful Aquaponics production in the Netherlands (Interview with Interviewee A 2020).

6.4.a Negative landscape developments

There are positive socio-cultural landscape movements. The environmental and social literacy is increasing (Jesus & Mendonça 2018). This seems to be more a driver for the Aquaponics. Growing interest of society in sustainable food production drives consumers towards city farming (Metabolic 2018). Trials for production and consumption in a socially and ecologically sustainable manner are visible (Duurzame Kost, n.d.a), despite increased industrialization of the society. Aquaponics is a socio-technical innovation that fosters food innovation through inter-, trans-disciplinary collaboration between various sectors of the workforce as a form of technology diffusion (Junge et al. 2017). There are trends "to bring the food back to the city" to the people who are currently disconnected from the food production (Zasada 2011) and transform the cities from being only the consumers of the food (Zezza & Tasciotti, 2010) to the participants in their own food production. There is a need to steer the consumer demand from conventional unsustainable consumption towards a more innovative alternative local, organic and conscientious consumption of Aquaponics fish species and vegetables (Gregg et al. 2019).

6.5.a Sense of urgency is missing

Mainstream governments, investors, and consumers do not feel an immediate sense of urgency in relation to changing the food supply (Poore & Nemecek 2018). Aquaponics has better chances in the future than currently (Interview with Interviewee E 2020, Interview with Interviewee C 2020). On the other hand, the nitrogen crisis and salinization of the soil on the coast of the Netherlands might speed up the interest in Aquaponic (Interview with Interviewee E 2020). Mont et al.(2017) mentions the hesitancy of companies and consumers and a persisting general lack of awareness and urgency to support CE pilots. Pheifer (2017) talks about rigid managerial silos unable to change their mind-set towards a more circular future.

6.6.a Stakeholders have short-term thinking (with focus on benefits)

Aquaponics requires a significant time investment, meaning benefits may not be immediately available or visible. EU Aquaponic Hub was only funded for 4 years, however this rapidly developing industry requires further support from legislative bodies (EU Aquaponics Hub 2018a). Community driven and supported projects still need to sustain themselves.

6.7.a Waste management is focused on discarding waste with minimal societal damage instead of focused on recycling

Label 'waste' inhibits its further utilisation due to the waste management legislation which restricts the handling of 'waste'. Governments should address the waste management inertia and recalibrate its policy (Hartley & Kirchherr n.d.). Traditional regulatory paradigm in the Netherlands is connected to the end-of-pipe solutions in the form of action support for design-for-recycling (Kamerbrief met kabinetsreactie op de transitie agenda's circulaire economie 2018) which is also not optimal. System innovation such as Aquaponics with its environmentally defensible reduced use of raw materials, such as water is not supported by any specific legislation (Hoevenaars et al. 2018). Focus on recycling and its image among the public should be instead redirected to the implementation of the aspects of the waste hierarchy placed in the higher positions of the van Lansink ladder, such as prevention, re-use and services (Rood and Kishna 2019).

6.8.a Incumbent companies not willing to cooperate and resist changing status quo

There is no willingness to collaborate (Kirchherr et al. 2018). Incumbent big scale companies with mainstream cheap and abundant products are providing more of a competition than cooperation and smaller enterprises cannot compete with them (Seijdel 2018a). There is a need for reciprocity and symbiosis. Learning platforms and parks stimulating the collaborations in the value chains should be supported by the policies and subsidies (Hartley & Kirchherr n.d.).

6.9.a GDP as a measure of welfare

GDP is still widely used even when it is not a suitable measure of welfare. There are other indicators that go beyond the financial wealth and include the social and environmental benefits as a part of a more objective grasp of welfare (Giannetti et al 2015).

6.10.a. Lack of trust between companies

In order to form new industrial networks and symbiotic relations, creating and improving the trust between the stakeholders is necessary (Hewes & Lyons 2008). Developing a trust in order to achieve a win–win situation via collaborative behaviour between firms is central and challenging (Gibbs & Deutz 2005). Interviewee E said that the Dutch Aquaponics producers try to help each other and do not hide their knowledge from each other (Interview with Interviewee E 2020). Interviewee D sees the aquaponics knowledge as an open source one (Interview with Interviewee D 2020).

6.11.a Acceptance of service products instead of ownership of products

Same applies as in Product related barrier 6.1.b Acceptance of service products instead of ownership of products..

6.12.a Consumers interest in sustainability is not reflected in buying behaviour

Same applies as in Product related barrier 6.3.b Consumers interest in sustainability is not reflected in buying behaviour in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

Product related

6.1.b Acceptance of service products instead of ownership of products

Not applicable in the case of Aquaponics due to the nature of Aquaponics products which are eaten and cannot be serviced. There is a need for the shift from ownership of things to the services sharing economy (Jesus & Mendonça 2018).

6.2.b Sense of urgency is missing

Same applies as in 6.5.a Sense of urgency is missing in the current chapter 6 Barrier Analysis for Aquaponics in the Netherlands.

6.3.b Consumers interest in sustainability is not reflected in buying behaviour

There was a closure of several outlets due to lack of sales (Seijdel 2018a, Uitjeeigenstad 2018a). There is an 'attitude–behaviour gap' or 'values–action gap' when buyers report that they deeply care about the environment and are interested in green consumption and ethical foods but fail to follow their concerns when making a purchase (Young et al. 2010). There is an obsession with health, healthy living and eating in the city (Bratman & Knight 2000), however, green consumption means everyday decisions, time, space, money and effort which might not fit into people's complex lifestyles. Price and not environmental or social concerns is the primary driver in the buying process (Pheifer 2017).

To summarise, there are socio-cultural barriers in the form of the sense of urgency, trust between enterprises and manifested willingness to collaborate missing; companies and consumers being hesitant and rigid in their procurement behaviours exhibiting 'attitude–behaviour gap' and deciding primarily according to the price; CE projects overlooked by short-term sightedness despising a significant time and financial investment; waste management activities focused on the aspects of the waste hierarchy placed in the lowest positions of the 'van Lansink ladder'; GDP as a measure of welfare. Beyond Aquaponics in the transition toward CE, there is also an issue with the shift from the ownership of the products towards their sharing in the service economy.

6.8. Ethical Barriers

In this section, the ethical barriers are identified for the groups stakeholders as distinguished in chapter 5.2. Stakeholder Description who were identified to be experiencing value tensions or had an actor representation missing in the course of the desk research and interviews. These were Current Aquaponic Producers, Incumbent farmers, Product users/public and Non-human stakeholders inside the Aquaponic system. There were no risks found to be associated with the product or the technology for the Product users/Public and Non-human stakeholders outside the Aquaponic system in barrier 2.1.b Risks are associated with product and in barrier 2.1.a Uncertainties and risks related to the technology in chapter 6 Barrier Analysis for Aquaponics in the Netherlands, therefore their wellbeing is not at stake in Aquaponics.

The results for Technology related ethical barriers and Product related ethical barriers are merged due to the fact that they are interconnected and mutually inclusive. Interviews were the main source of information in order to determine the tensions between values and values not covered by actors as ethical barriers. Values have a dynamic and emergent character and their a priori evaluation might be complicated (Correljé et al. 2015).

First, the benefits and harms of Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands for various stakeholder group were identified, corresponding values were attached to harms and benefits; a conceptual investigation of discovered key values was performed and finally potential value conflicts and values of stakeholders which are not covered by actors were recognized (Friedman et al. 2008). In the following section the two types of ethical barriers are presented:

- Tensions between Values of various stakeholders involved in Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Values of various stakeholders in Aquaponics development are connected to the harm and benefit of Aquaponics development for the stakeholders.
- Values of stakeholders which are not covered by actors or value advocates and therefore, not taken into consideration in current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Identification of Value Tensions

6.8.1. Identification of Value Tensions

In this section, the final results - the ethical barriers in the form of Value tensions between stakeholders are presented. They are preceded by the intermediary steps of Harm and benefit identification, followed by Values identification. Special attention is to be paid to the harms for indirect stakeholders who might unknowingly be strongly affected by the technology (Friedman et al. 2008).

6.8.1.1. Harm, Benefit and Values of Stakeholders

First, the Harm, Benefit and Values of Stakeholders were identified for the Current Aquaponic Producers.

Harm

Aquaponics producers face financial instability and difficulty generating profit in the current situation, market outlook is currently bad (Sikkema 2017). Aquaponics is at this moment not profitable in the Netherlands due to advanced and cheap greenhouse production (Interview with Interviewee A 2020, Duurzame kost city farm tour with Jos Hakkennes 2020, Interview with Interviewee E 2020). One needs a fine combination of expensive fish and vegetables in the system (Interview with Interviewee A 2020, Bosma et al. 2017, Sikkema 2017). UrbanFarmers bacrupted in 2018 and Uit Je Eigen Stad in 2016. Duurzame kost uses gratis labour from Futuris Zorg & Werk (Futuris Zorg & Werk n.d., Duurzame Kost n.d.). The grower must learn how to fine-tune the system according to compatibility which is crucial due to the fact that nutrients from fish farming often do not entirely meet the needs of vegetables (Sikkema 2017). In addition, specialist knowledge in Europe is expensive. In order to be able to apply aquaponics within the company, you need extra knowledge. Skilled workers are expensive and difficult to employ according to Bosma (Dormaar 2017). Also, it has high initial installation costs, as can be seen on bankruptcy cases of Urban Farmers and Uit Je Eigen Stad.

Benefit

Aquaponics and its circularity is in fashion (Valenzuela and Böhm 2017: 25 and 26) and in line with the Circular economy. There are future business possibilities due to further knowledge development and hopefully new legislation. Aquaponics is currently a huge hype according to Bosma (2017), who compares it to the hype around the energy crop jatropha a few years ago. In the context of the circular economy and the recycling of raw materials, it is ideal to grow vegetables on water from a fish pond full of nutrients (Sikkema 2017). It provides an opportunity to have a better resilient food system in the time of nitrogen crisis and salinization of the soil issues (Interview with Interviewee E 2020).

Values

The following values were identified in the research by looking for common themes: ‘Innovation’, ‘Ecological and social benefit’, ‘Financial viability’, ‘Efficiency’, ‘Fresh local food straight from the city’ and ‘Anthropocentric thinking’.

‘Innovation’ including circular thinking and knowledge sharing represent an important value for the current Aquaponic producers. Aquaponics is a new trendy circular way of producing symbiotically two products recirculating nutrients and water which can be energy efficient. All Aquaponics installations are trying to improve their performance. In an innovative way. Blueacres.nl give aquaponics demonstrations/workshops about design, build and supply professional Aquaponic systems for individuals and business (Blueacres.nl 2018). Duurzame Kost offers guided installation tours (Duurzame Kost n.d.). There are workshops to encourage individuals to set up “mini-Aquaponics”, as well as tours and consultation appointments offered (Mediamatic 2018b). Metabolic offers knowledge about Aquaponics to the public as open source. Metabolic institute is working on Prototyping citizen-cantered urban agrifood systems (FOODE: Creating sustainable food systems for European cities 2020).

‘Ecological benefit’ represents a value for the current Aquaponic producers. Mediamatic Fabriek calls itself an eco-friendly oasis for urban agriculture (Mediamatic 2018a). Duurzame kost recirculates water that enables them to use 90% less water than in traditional gardening. They also recirculate nutrients in the system and therefore there is no waste. Aquaponic installation does not depend on fertile soil, nor uses heavy polluting agro machinery. Energy efficiency is crucial; only 50 watt is needed to run the pump and 12 watt aeration (Duurzame Kost n.d.a.). It is an optimally combined fish and plant production innovation project (Tannis 2016). There are possibilities of co-production of algae that are used as food supplements or in cosmetics (Tannis 2016). To grow medical plants and herbs, while closing the cycle, is also an option (Interview with Interviewee E 2020). Metabolic lab- De Ceuvel grows vegetables and herbs consumed straight in their own Cafe De Ceuvel using a closed-loop Aquaponics system aiming to recycle energy, waste and nutrients, also utilising recycled urine and worms. The installation is in an ecologically deprived area on a heavily polluted land and various soil remediation and regeneration techniques have been used. Food in Aquaponics is produced with 10% of the land and 5% of the water needed for conventional farming (De Ceuvel n.d., Metabolic 2018). ‘Social benefit’ is another value of Current Aquaponic Producers encountered in the research. The current Aquaponics installations Mediamatic, Metabolic and especially Duurzame kost organize workshops and tours to enable the public, children from school to see and make their own Aquaponic systems and building communities of people connecting to their food in the city (De Ceuvel n.d., Metabolic 2018, Mediamatic 2018b). Duurzame kost offers work placement for autistic youth - people who are disadvantaged on the job market, through Futuris Zorg & Werk in their premises (Futuris Zorg & Werk n.d., Duurzame Kost n.d., Duurzame Kost n.d.a., Theeuwen 2017). Blue acres support communal social projects through engaging people who are on the side-lines of the labour market in their workshops and employing them in the maintenance of the Aquaponic system (Blueacres.nl 2018). According to Veludo et al. (2012), increased urban living satisfaction with better food quality and food safety represent other social benefits of Aquaponics.

‘Financial viability’ represents a value for the current Aquaponic producers. In the current incumbent system, financial viability is a must. At the moment, Aquaponics is not profitable. Several installations went bankrupt, such as Uit Je Eigen Stad (Uitjeeigenstad.nl 2018b) and Urban Farmers in July 2018 (Seijdel 2018a). Duurzame Kost uses subsidised labour by cooperating with Futuris Zorg & Werk (Duurzame Kost n.d.).

Food quality in the form of ‘Fresh local food straight from the city’ represents another important value for the current Aquaponic producers. Duurzame kost grow and locally sell fresh veggies, such as liquorice plant, basil, turnip, crest and fish - trout on Fridays in the Vershal het Veem shop (Duurzame Kost n.d., Hakkennes 2018, cucinare_italia 2018). They call themselves ‘locally rooted’ and aim to grow healthy food together nearby, without pesticides, artificial fertilizers, hormones, harmful fish food additives, antibiotics or other medication and in a socially and ecologically sustainable manner (Duurzame Kost n.d., Duurzame Kost n.d.a., Theeuwen 2017). Organic edible violets, veggies and fish are produced and sold directly from the greenhouse Aquaponics of Blueacres in Vortum Mullem (Blueacres.nl 2018). Metabolic lab- De Ceuvel grows vegetables and herbs used fresh straight in their own Cafe De Ceuvel (De Ceuvel n.d.). Mediamatic aims for sustainable food production (Mediamatic 2018c). The reactions of the public are that people like eating a product that is 100% free of pesticides and chemicals and freshly harvested (Interview with Interviewee D 2020).

'Efficiency' represents a value for the current Aquaponic producers. Information technology and high-tech technical feasibility is taking over agriculture in the form of smart farming (The Economist 2019) using an artificial and controlled environment (Endut et al. 2009). Aquaponics with its current high tech installations in the Netherlands is a part of this growing trend. Interviewee C said that people tend to believe the story that food grown in sunlight is much healthier than growing in artificial light. Also, there are people who object to the fact that they use fish as a source for the nutrients for the plants (Interview with Interviewee C 2020, Interview with Interviewee D 2020). Another problem is with the fact that Aquaponic products are grown organically but because it is not in soil, it cannot be legally labelled organic. He thinks that what is grown in soil is much more unnatural than Aquaponics products but that needs an explanation for people who do not know Aquaponics (Interview with Interviewee C 2020).

'Anthropocentric thinking' represents a value for the current Aquaponic producers. Aquaponics is done for the benefit of people and non-human beings are used for it. During the desk research and during the interviews there was mentioned that Aquaponics is better than traditional aquaculture practice because in Aquaponics no fertilizers, antibiotics or another medicine is used (Interview with Interviewee C 2020, Interview with Interviewee D 2020, Interview with Interviewee E, 2020). Interviewee A said that a good farmer and businessman strives to have healthy animals and then there are no issues with the welfare of animals. Unhealthy animals signal a social problem of a farmer or economic constraints or it is an issue of not well trained staff. A cat in a house is not different from a fish in a tank (Interview with Interviewee A 2020). Interviewee D and Interviewee A also mentioned that there are certain types of fish who prefer to be in higher densities (Interview with Interviewee A 2020, Interview with Interviewee D 2020). Interviewee D added that that has an advantage due to the fact that then the fish are less territorial and do not fight each other (Interview with Interviewee D 2020). He also mentioned that the fish production is actually the most sustainable meat production in the world using less space, recirculating and therefore wasting much less water than traditional agriculture. There are many varieties of fish to be grown that leave the smallest impact, the smallest footprint on the environment in comparison with other livestock, such as cattle and sheep (Interview with Interviewee D 2020). Finally, the Interviewee D mentioned that even when he personally does not like the idea of treating animals like objects, that is the case in the current society (Interview with Interviewee D 2020). Those are anthropocentric perspectives.

Next, the Harm, Benefit and Values of Stakeholders were identified for the Incumbent farmers. No incumbent farmers were able to participate in an interview due to the fact that they knew nothing about Aquaponics. The information comes from the interviews with other stakeholders who talked about their experience with incumbent farmers.

Harm

According to Interviewee D incumbent farmers and also permaculturalists consider Aquaponics unnatural, synthetic and inorganic because it does not use soil even when Aquaponics is a solution to many wicked contemporary sustainability issues (Interview with Interviewee D 2020, Interview with Interviewee C 2020). They want to sustain themselves. The loss of their market share to new products made with a different ecologically sound technology might be threatening. They would need to abolish their production techniques and invest into new technological equipment, knowledge and labour., which is financially demanding at this moment. Initial investment costs are rather high (Dormaar 2017).

Benefit

In the future the farmers might turn to Aquaponics for inspiration due to the fact that it offers a possibility to grow food in the city (Interview with Interviewee B 2020). A significant belief in the potential of Aquaponics as an urban farming technique that could change the global food system, is shown in the mission statement of Mediamatic (Mediamatic 2018c). Due to the salinization of the coast, marine Aquaponics might offer new farming solutions (Interview with Interviewee E 2020).

Values

The following values were identified in the research by looking for common themes: 'Business as usual' and ' Old-school organic'.

'Business as usual' represents value at stake for the Incumbent farmers due to the fact that they grow food in a more linear than circular Aquaponics way. The Dutch producers have already reduced amounts of waste. At this moment, there is no economic incentive to reduce waste even more and recirculate it in one system (Interview with Interviewee A 2020). Also the Incumbent farmers represent and are embedded and functioning in the contemporary incumbent infrastructure.

'Old-school organic' meaning organic products grown in soil according to the tradition and current legislation represents a value for the Incumbent farmers (Interview with Interviewee C 2020, Interview with Interviewee E 2020, Interview with Interviewee F 2020). One of the incumbent farmers said after googling what Aquaponics means that they would not be interested in Aquaponics because they focus on producing organically meaning in the soil and not soilless.

Next, the Harm, Benefit and Values of Stakeholders were identified for the Public. No Product users/public were able to participate in an interview due to the fact that when asked about Aquaponics, they knew nothing about it. The information comes from the interviews with other stakeholders who talked about their experience with Product users/public.

Harm

There were no risks found to be associated with the product or the technology for the Product users/Public and Non-human stakeholders outside the Aquaponic system in barrier 2.1.b Risks are associated with product and in barrier 2.1.a Uncertainties and risks related to the technology in chapter 6 Barrier Analysis for the Aquaponics in the Netherlands, their wellbeing is not endangered through Aquaponics. Some representatives of the Public were, however, concerned about the fact that there are animals being used for the vegetable production, therefore, concerning the vegetables not vegetarian or vegan and therefore not 'animal cruelty free' (Interview with Interviewee C 2020, Interviewee D 2020). The Public were the visitors of the Aquaponics premises participating in tours and excursions.

Benefit

The Aquaponics offers access to the fresh and locally grown fish and vegetables straight from the Aquaponics farm. It has many advantages compared to the traditional horticulture or the aquaculture, such as no use of pesticides, herbicides and antibiotics along with a lowered use of water.

Values

Value 'Veganic vegetables' of some representatives of the Public accentuates the fact that (organic) farming should exclude the use of animals. This represents one of the ideals of veganic farming which refuses to use un-vegan methods to grow vegetables on the contrary to organic agriculture which involves animal manure, blood meal as well as bone meal in order to support the vegetable growth (White 2018, Badgley 2018). Currently not only vegans but also vegetarians express their unacceptability of the products produced by utilizing animals (Garg & Johri 1994). The Aquaponics vegetables are grown by using captured fish as a source for the nutrients for the plants and some people from Public have asked about this during the tour (Interview with Interviewee C 2020, Interview with Interviewee D 2020).

This corresponds with the value concerned about the 'Non-human well-being' described in the next section. This value was identified as important both for Non-human stakeholders inside the Aquaponic system and the Public stakeholders.

Next, the Harm, Benefit and Values of Stakeholders were identified for the Non-human stakeholders inside the Aquaponic system.

Harm

Safety and health hazards for fish and plants have been encountered and there have been accidents with fish tanks overheating in Mediamatic (Mediamatic 2019e). Fish and plants in Aquaponic installations live mostly indoors, using "smart farming" technology without access to fresh water, air and natural daylight. Many Aquaponic installations are in urban areas in old warehouses and factories or other old and disused old warehouses, abandoned plants industrial buildings, such as Urban Farmers located in old Philips factory (Seijdel 2018a, Specht et al. 2016). They have been translocated or probably born in captivity and being captured there. Their ability to behave like in their natural environment is rather limited due to the monotonous environment in combination with higher fish densities. Nevertheless, even if the fish in captivity appear to behave naturally and have the ability to multiply, the research indicates that their natural behaviour in captivity is restricted (Midling et al. 2002).

There is limited research information on appropriate levels of minerals, suspended solids, faeces particle size and their settling ratio and ratio to water and plant and fish amount. This compromises health and welfare of fish in captivity (Midling et al. 2002).

Benefit

Fish in captivity in Aquaponics are protected from predators. There are no antibiotics used, such in a traditional aquaculture or agriculture. This protects them from the extensive use of antibiotics in animal farming and for agricultural purposes which causes environmental pollution and further damage to the organisms (Martinez 2009).

Values

The following values were identified in the research by looking for common themes: 'Non-human well-being'.

'Non-human well-being' is a value for the Non-human stakeholders inside the Aquaponic system important in the Aquaponics development. There is a risk that Aquaponics with scaling up will go through a process of intensification like aquaculture or agriculture. The animal welfare debate is in the centre of attention of consumers, governmental organizations, scholars, practitioners and ethicists (Solgaard and Yang, 2011, Lund et al., 2007, Mejdell et al., 2007) due to the fact that fish which are not free but live in captivity are not able to live 'naturally' meaning perform the full repertoire of their behaviours like in nature. This puts their well-being at stake (Sandøe et al. 2015). Moreover, 'Non-human well-being' in Aquaponics as a value is not recognised by being underrepresented by an actor or a value advocate in an Aquaponics discourse.

6.8.1.2. Value tensions

'Innovation' vis-à-vis 'Business as Usual' and 'Old-school Organic'

There is a tension between the values 'Innovation' and ' Business as Usual' including 'Old-school organic. It can be perceived as a tension between 'New Circular' and 'Linear'. Innovation pushed by Aquaponics producers is facing the conditions of ' Business as Usual' which is perpetuated by Incumbent farmers and governmental organizations through policy making supporting the incumbent infrastructure, still linear way of producing food and the labelling 'organic' of products which are only grown in soil. Current Aquaponic producers aim for innovative improvements and functioning in a new circular manner that goes along the trend of future sustainability and CE. Transition to CE in the Netherlands through innovation policy still needs to happen (Cramer 2014, Webster 2017).

'Financial Viability' vis-à-vis 'Ecological and Social Benefit'

There is a tension between the values 'Financial Viability' and 'Ecological and Social Benefit' in Aquaponics discourse. Aquaponics producers strive to bring an innovative more ecologically and socially sound solution for the future communities living in big cities in order to grow food fresh straight there and combat the climate change, nitrogen crisis, soil depletion and salinization of the coast of the Netherlands but are experiencing clashes with the current financial unprofitability and need for their own sustenance.

'Anthropocentric' vis-à-vis 'Ecocentric'

There is a tension between the values 'Anthropocentric' and 'Ecocentric' between and also within the communities of Aquaponics producers, Product users/Public, Plant and animal well-being organizations and Governmental organizations making the policies about to what extent and how should be the Non-human stakeholders' interest, needs and values taken into consideration.

'Efficiency' vis-à-vis 'Naturalness'

There is a tension between the values 'Efficiency' and 'Naturalness' when Aquaponics developers that strive to calibrate and optimize an efficient circulatory system in a closed loop by using nutrients dissolved in water straight in the middle of the cities in abandoned warehouses and unused brownfield yards using high tech equipment clash with the ideas of some Product users/public, Governmental organizations and Incumbent farmers that food tastes better when grown in the sun or that food is organic when grown in soil (Interview with Interviewee C 2020).

On the other hand, there is another different connotation of 'Efficiency' vis-à-vis 'Naturalness' tension. It exists between the Incumbent farmers and Aquaponics producers due to the fact incumbent modern big scale aquacultural and horticultural Incumbent farmers build intensified high output production to get nature out and optimize either their nutrition solution or climate. Interviewee C thinks that what we need to do here is to leave nature alone. In Aquaponics different techniques are used and the aim is to let nature run its course producing a sound, healthy and earnest product. It is like Formula One racing vis-à-vis Rally driving (Interview with Interviewee C 2020).

6.8.2. Identification of Values of Stakeholders not Covered by Actors

In this section, the Values of Stakeholders not Covered by Actors as ethical barriers are identified.

Non-human well-being

Non-human well-being was identified as a Value for Non-human stakeholders inside the Aquaponic system and the Public underrepresented by an actor or a value advocate according to the explanation in chapter 6.1. Direct, Indirect Stakeholders and Missing Actor Representation. There was no organization or a person identified who would represent the needs, values and interests of these direct stakeholders in the Aquaponics system. No animal or plant wellbeing organization was found to have specifically Aquaponics on their agenda. In the desk research and interviews, little information was encountered about to what extent is the Non-human well-being of Non-human stakeholders inside the Aquaponic system represented in the discourse about Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The interviewee A mentioned that the wellbeing is a matter of fish species choice and that some fish, such as catfish like to be in high densities. He does not believe in the concept of welfare of plants. It is important that plants do well so they can be sold. He also added that if a farmer wants to be successful, he needs to have healthy animals and plants (Interview with Interviewee A 2020). As mentioned in chapter 6.8.1.1. Harm, Benefit and Values of Stakeholders in the section about harm for Non-human stakeholders, captured fish are unable to perform their natural behaviour which hinders their wellbeing (Midling et al. 2002). Interviewee D mentioned that he personally does not like the idea of selling animals as if they were objects but that is unfortunately the case in nowadays society and after their koi fish grows to a certain size, it will be sold as a fish to make a pond more aesthetic (Interview with Interviewee D 2020).

The fact that values of Non-human stakeholders inside the Aquaponic system are not represented by actors or value advocates, as explained in chapter 3.5. Value Sensitive and Value Conscious Design towards Responsible Innovation about stakeholder engagement, represents an ethical barrier hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.

Responsible innovation is characterised by stakeholder engagement and longitudinal participation throughout the innovation process therefore the Non-human well-being should be a part of the development process. Proponents of Responsible innovation approach emphasise the urgency of taking stakeholders' opinions, values, beliefs, expectations and needs into consideration when proceeding with innovation which is not happening in this case. According to ethical justification, if technology has influence on stakeholders, causing them harm or benefit, then these stakeholders should be involved in its design and further implementation (Pols 2017). The Non-human well-being in Aquaponics should be represented by some actor or a value advocate. This reasoning 'taking values into account' is in line with the Value sensitive design approach. We are obliged to 'listen' to the stakeholders. Morality and ethics call for inclusion of stakeholders' interests, even when these stakeholders might be powerless (Van de Poel & Royakkers 2011) which is true in this case. The fact that Non-human stakeholders inside the Aquaponic system have no representative ensuring their wellbeing goes against one of the requirements of 'fairness and equality' in ethics of technology according to the definition of Manders-Huits (2017).

'Veganic vegetables'

'Veganic vegetables' was identified as a value of Public stakeholders not covered by actors or value advocates in the Aquaponics discourse. This value 'Veganic vegetables' expresses the concern of some potential consumers who might have an issue with consuming the Aquaponics vegetables knowing the fact that in the Aquaponics fish is used as a source for the nutrients for the plants (Interview with Interviewee C 2020, Interview with Interviewee D 2020). Only two Current aquaponics producers mentioned this fact and there was no information found about this in the desk research. This leads to the conclusion that it is not well debated or taken into consideration in the Aquaponics discourse and according to the definition of Van de Poel & Royakkers (2011) might be neglected in technological development and therefore constitutes an ethical barrier.

To summarize, there are ethical barriers in the form of Value tensions, such as 'Innovation' vis-à-vis 'Business as Usual' and 'Old-school Organic', 'Financial Viability' vis-à-vis 'Ecological and Social Benefit', 'Anthropocentric' vis-à-vis 'Ecocentric' and 'Efficiency' vis-à-vis 'Naturalness'; and on the other hand Values underrepresented by an actor or a value advocate, such as 'Non-human well-being' and 'Veganic vegetables'.

The following additional dimensions and barriers have been identified in this research:

6.9. Biophysical Barriers

There are biophysical aspects of our Earth. CE is limited by them. They constitute a barrier to CE and innovations connected to this concept (Korhonen et al. 2018). They are a part of a transition towards a higher sustainability. Marginal improvements in sustainability posed in the time of the Anthropocene are insufficient (Milliken & Stander 2019). Sustainability benchmarks are multi-dimensional and depend on the context. There are trade-offs which challenge the varied sustainability dimensions according to the perception and framing processes of humans (Kuyper & Struik 2014). This also considers 'sustainable intensification' in the food production which aims to maximize the profit in a 'sustainable way' and capitalize on agroecosystems. Agro business is the biggest contributor to the environmental pollution happening in the Anthropocene (Struik and Kuyper 2014).

There is a risk of collapse when the pressure exceeds the sustainability limits of a certain system (Daly 1996). The business-as-usual linear extract-produce-utilise-throw away paradigm is unsustainable (Frosch and Gallopoulos 1989). Scholars, such as Václav Smil call for the end of endless expansion of economic "growth" which he calls "an anthropogenic insults to ecosystems" in order to prevent a further deterioration of the environment and finally its collapse.

The biophysical limits mixed together with the diverse factors of production and consumption bring, as Funtowicz and Ravetz (1995) call it, many "uncertainties, contestation and irreducibility" and they do not respect human made and defined boundaries (Korhonen et al. 2018).

Thermodynamic limits

Due to entropy, even systems cycling the resources and waste will ultimately end up with the issues of resource depletion and pollution (Korhonen et al. 2018).

Physical flows of materials and energy do not respect man constructed boundaries

Physical flows of materials and energy cross organizational, administrative and geographical boundaries. They flow across man-made organizational, administrative and geographical boundaries and borders, It is difficult to manage, measure or steer them. They are inter- intra- and trans- sectoral, national and organizational. Their definition is ambivalent, emergent, volatile and dynamic (Korhonen et al. 2018).

Time and space boundary limitations

There is a limited amount of resources of energy and materials on Earth and problems and solutions to them get shifted to other aspects of reality, such as other areas, populations, resources, sectors, phases of a life-cycle and time periods (Korhonen et al. 2018).

Geographical conditions in the form of a cold climate

The cold climate in the Netherlands causes problems for the Aquaponics due to the need of heating. Interviewee E said that in Australia, Asia or America one does not need any heating to produce the fish there. Crawfish, perch or tilapia grow without the heating outside due to the fact that it is warm there. That fish can be produced there very cheaply even when it must be exported all the way here to Europe. The cold climate in the Netherlands implies that the fish do not grow fast enough. Species originating in the Netherlands do not grow that fast and that has to do with the climate. The environment needs to be controlled through greenhouse settings and heat pumps. If one wants to produce a local Dutch species of fish, such as eel, more time - one or two years are needed for the eel to be suitable to be put on a plate. It is not worth growing tilapia here due to the fact that it is expensive and not popular either. Niche market fish is needed (Interview with Interviewee E 2020). Other interviewees have not mentioned the cold Dutch climate connected to the local fish production or better said lack of farmed fish production tradition as an issue compared to Aquaponics possibilities in other countries.

To summarise, there are biophysical barriers in the form of the thermodynamic limits; the fact that physical flows of materials and energy do not respect man constructed boundaries; geographical conditions n the form of a cold climate in the Netherlands; and time and space boundary limitations when considering the resources and problem shifting.

7. ADAPTATION OF PRIMARY THEORETICAL FRAMEWORK PIPTOVÁ 1 (2018)

In this chapter, what needs to be adapted, added to or removed from the primary theoretical framework Piptová 1 (2018) in order to make it suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands, is described. It is based on the results of application of the primary theoretical framework Piptová 1 (2018) to the current case of Aquaponics via desk research and in-depth interviews.

In all seven categories of barriers - institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions, Technology related barriers and Product related barriers distinction was removed. Technology and Product related barriers were merged due to the fact that they are interconnected and not mutually exclusive, as explored during the desk research and in-depth interviews and shown in chapter 6 Barrier Analysis for Aquaponics in the Netherlands. Moreover, there were the following changes done in the following dimensions:

7.1. Institutional Barriers

Technology related barriers and Product related barriers distinction was removed. Originally found in the primary theoretical framework Piptová 1 (2018) Product related barriers 1.1.b Low alignment with current legislation and 1.2.b Absence of regulatory pressures were merged with the Technology related barriers 1.1.a Low alignment with current legislation and 1.3.a Absence of regulatory pressures. The Technology related barrier 1.9.a No clarity on ownership, liability and responsibility in new business models was removed due to the fact that it does not consider the Aquaponics, as there is no shift from the ownership of a product towards servicing the product in the Aquaponics. There was an additional institutional barrier 1.9. The label 'organic' in the legislation applies only to production in the soil identified during the research and added to the list. The newly added barriers are listed in italics.

The following barriers are the result of the adaptation:

1.1. Low alignment with current legislation

1.2. Low level of lobbying

1.3. Absence of regulatory pressures

1.4. Lack of clarity on how to use waste hierarchy

1.5. Recycling rates focus on quality, not quantity

1.6. Cartel formulation legislation hinders collaboration between companies

1.7. No CE standards for products

1.8. CE is not integrated in innovation policies of the government

1.9. The label 'organic' in the legislation applies only to production in the soil

1.10. Regulations change slowly

7.2. Technical Barriers

Technology related barriers and Product related barriers distinction was removed. Originally found in the primary theoretical framework Piptová 1 (2018) Technology related barrier 2.1.a Uncertainties or risks related to the technology and Product related barrier 2.1.b Risks associated with product were removed due to the fact that there are no uncertainties or risks related to the technology and products. The Technology related barrier 2.3.a Products are designed for end-of-life was also removed due to the fact that it is not applicable in the case of Aquaponics since the products of the Aquaponics are eaten. The Product related barrier 2.5. B Quality of product is limited was also removed due to the fact the Aquaponic installations are focused on a healthy production and high quality of organic foods grown without the use of fertilizers, pesticides or antibiotics

Technology related barrier 2.2.a Lack of LCA studies to prove the effect of CE principles was extended to consider also the Aquaponics specifically too due to the fact that LCA studies about both CE and Aquaponics itself are crucial for further development of Aquaponics. It became barrier 2.2. Lack of LCA to prove the effect of CE and Aquaponics principles.

Product related barrier 2.1.b Risks are associated with product was extended with the concern for the safety and health hazards for non-human beings in the system due to the fact that there have been many system calibration malfunctions resulting in system overheating (Mediamatic 2018a) followed by the death of fish and plant. Interviewee C and Interviewee A also talk about the importance of fine-tuning the ratios and compatibility in the Aquaponics (Interview with Interviewee C 2020, Interview with Interviewee A 2020). The additionally identified technical barriers are 2.2. Fine-tuning of the system and 2.3. Safety and health hazards for non-human beings in the system. The additionally identified barriers are listed in italics.

The following barriers are the result of the adaptation:

2.1. Lack of LCA to prove the effect of CE and Aquaponics principles

2.2. Fine-tuning of the system

2.3. Safety and health hazards for non-human beings in the system

7.3. Financial (Economic) Barriers

Technology related barriers and Product related barriers distinction was removed. Originally found in the primary theoretical framework Piptová 1 (2018) Technology related barriers and Product related barriers were merged. Product related barrier 3.1.b Application is too narrow was changed into barrier 3.10 Application of products is too narrow.

Product related barrier 3.2.b Price/performance is bad was changed into barrier 3.11. Price/performance is bad. Product related barrier 3.3.b Financial resources for consumers are lacking was changed into barrier 3.12. Financial resources for consumers are lacking. Product related barrier 3.5.b Externalities are not reflected in price was changed into barrier 3.13.

Externalities are not reflected in price. There were additional financial barriers 3.15. Dutch horticulturalists serve the vegetable market at a low price and imported fish is too cheap and 3.16. Aquaponics requires a combination of high-value vegetable and high-value niche market fish and 3.17. Rebound effect identified during the research and added to the list. The additionally identified barriers are listed in italics.

The following barriers are the result of the adaptation:

3.1. Low amount of competitors and new companies in the field

3.2. Low investments in research

3.3. Negative landscape developments

3.4. Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product)

3.5 Not enough financial resources available

3.6. Investment calculations are based on one lifecycle instead of more cycles

3.7. Labour is taxed instead of materials

3.8. High amount of investment costs

3.9. Long payback period

3.10 Application of products is too narrow.

3.11. Price/performance is bad

3.12. Financial resources for consumer are lacking

3.13. Externalities are not reflected in price

3.14. Price of raw material is lower than recycled products

3.15. Dutch horticulturalists serve the vegetable market at a low price and imported fish is cheap

3.16. Aquaponics requires a combination of high-value vegetable and high-value niche market fish

3.17. Rebound effect

7.4. Infrastructural Barriers

Technology related barriers and Product related barriers distinction was removed. Originally found in the primary theoretical framework Piptová 1 (2018) Product related barriers 4.1.b Complementary services & products are lacking and the Technology related barriers 4.2.a Complementary services & products are lacking were removed due to the fact that no information was found during the research about these being indicated as the barriers for the Aquaponics.

The primary Product related barriers 4.2.b Scale of supply is too small and the Technology related barrier 4.2.a Scale of supply is too small were also removed due to the fact that no information was found during the research about these being indicated as the barriers for the Aquaponics.

Originally found in the primary theoretical framework Piptová 1 (2018) Technology related barriers 4.3.a Low alignment with incumbent infrastructure and 4.4.a Incomplete production chain for technology or products were also removed due to the fact that no information was found during the research about these being indicated as the barriers for the Aquaponics.

The primary barrier 4.5.a Companies are relying on external providers to adopt CE principles was removed from the framework due to the fact that there was no information found during the research about this being indicated as a barrier for the Aquaponics. Moreover, when revising the potential barriers in the Verhulst (2017) theoretical framework in chapter 3.4. Circular Economy, no other current reference from the scientific literature was found for this potential barrier to support the claims made by Kok et al. (2013) as cited in Verhulst (2017). However, in order to make a transition towards CE, there is a trust and cooperation between the participating companies needed (Kok et al. 2013, Pheifer 2017) which is identified and assessed later as an infrastructural barrier 6.10.a. Lack of trust between companies.

There were new infrastructural barriers identified during the research 4.1. Not the 'fittest' but the 'first' survives and 4.2. Scalability. The additionally identified barriers are listed in italics.

The following barriers are the result of the adaptation:

4.1. *Not the 'fittest' but the 'first' survives*

4.2. *Scalability*

7.5. Knowledge Related Barriers

Technology related barriers and Product related barriers distinction was removed. Technology related barrier 5.1.a Lack of knowledge dissemination and 5.5.a Low cooperation between firms and also Product related barrier 5.2.b Lack of skills or knowledge to apply or deal with product were removed due to the fact that no information was found during the research about this being indicated as a barrier for the Aquaponics. Barrier 5.1. Large-scale demonstration projects are missing was identified as an additional barrier in the research and added to the final theoretical framework Piptová 2.0 (2020). The additionally identified barriers are listed in italics.

The following barriers are the results of the adaptation:

5.1. *Large-scale demonstration projects are missing*

5.2. Low amount of R&D and pilot projects

5.3. Lack of human capital

5.4. Gap between research and practical needed information

5.5. Lack of knowledge or awareness on CE by producers and consumers

5.6. Lack of awareness between intermediaries on developments

5.7. Lack of knowledge required to develop, produce and control technology

5.8. Lack of skills or knowledge to apply/deal with technology

5.9. Lack of data on material flows

5.10. Lack of knowledge on roles of companies in CE

7.6. Socio-Cultural Barriers

Technology related barriers and Product related barriers distinction was removed.

Originally found in the primary theoretical framework Piptová 1 (2018) Technology related barriers 6.1.a No belief in potential technology, 6.2.a No belief in the potential of product, 6.3.a No clear vision, 6.4.a Negative landscape developments were removed due to the fact that no information was found during the research about these being indicated as barriers for the Aquaponics.

Technology related barrier 6.11.a Acceptance of service products instead of ownership of products and Product related barrier 6.1.b Acceptance of service products instead of ownership of products were also removed due to the fact that these potential barriers were not applicable in the case of Aquaponics due to the nature of Aquaponics products which are eaten and cannot be serviced.

Redundant Technology related barrier 6.12a Consumers interest in sustainability is not reflected in buying behaviour was merged with Product related barrier 6.3.b Consumers interest in sustainability is not reflected in buying behaviour creating the barrier 6.4. Consumers interest in sustainability is not reflected in buying behaviour. Also, redundant Product related barrier 6.2.b Sense of urgency is missing was merged with Technology related barrier 6.5.a Sense of urgency is missing creating a barrier 6.3. Sense of urgency is missing. There were no additional socio-cultural barriers identified during the research.

The following barriers are the results of the adaptation:

6.1. GDP is not a good measure of welfare.

6.2. Lack of trust between companies

6.3. Sense of urgency is missing

6.4. Consumers interest in sustainability is not reflected in buying behaviour

6.5. Incumbent industry is not willing to cooperate and resists changing status quo

6.6. Shareholders have short-term thinking (with focus on benefits)

6.7. Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling

7.7. Ethical Barriers

The ethical barriers identified in the research were defined and identified in two forms:

7.1. First as Tensions between Values of various stakeholders involved in Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. Values of various stakeholders in Aquaponics development are connected to the harm and benefit of Aquaponics development for the stakeholders. These were:

7.1.1, Value tension 'Innovation' vis-à-vis 'Business as Usual' and 'Old-school Organic',

7.1.2. Value tension 'Financial Viability' vis-à-vis 'Ecological and Social Benefit'

7.1.3. Value tension 'Anthropocentric' vis-à-vis 'Ecocentric'

7.1.4. Value tension 'Efficiency' vis-à-vis 'Naturalness'

7.2. Second as Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. These were:

7.2.1. 'Non-human well-being'

7.2.2. 'Veganic vegetables'

During the research the following additional dimension with provided barriers was identified and added to the list of barriers. They are listed in italics.

7.8. Biophysical Barriers

8.1. Geographical conditions in the form of a cold climate

8.2. Thermodynamic limits

8.3. Physical flows of materials and energy do not respect man constructed boundaries

8.4. Time and space boundary limitations

8. FINAL THEORETICAL FRAMEWORK PIPTOVÁ 2.0 (2020) OVERVIEW

In this chapter, the final theoretical framework Piptová 2.0 (2020) shown in Table 8.1 as a result of amending the primary theoretical framework Piptová 1 (2018) in the previous chapter 7. Adaptation of Primary Theoretical Framework Piptová 1 (2018) is presented. The final theoretical framework Piptová 2.0 (2020) is the result of this research and can be used to identify barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. It contains institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions. The barriers additionally identified in the research are listed in italics.

Barriers	Technology and product related
	1.1. Low alignment with current legislation 1.2. Low level of lobbying 1.3. Absence of regulatory pressures 1.4. Lack of clarity on how to use waste hierarchy 1.5. Recycling rates focus on quality, not quantity 1.6. Cartel formulation legislation hinders collaboration between companies 1.7. No CE standards for products 1.8. CE is not integrated in innovation policies of the government *1.9. The label 'organic' in the legislation applies only to production in the soil* 1.10. Regulations change slowly
	*2.1. Lack of LCA to prove the effect of CE and Aquaponics principles* *2.2. Fine-tuning of the system* *2.3. Safety and health hazards for non-human beings in the system*

	3.1. Low amount of competitors and new companies in the field 3.2. Low investments in research 3.3. Negative landscape developments 3.4. Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product) 3.5 Not enough financial resources available 3.6. Investment calculations are based on one lifecycle instead of more cycles 3.7. Labour is taxed instead of materials 3.8. High amount of investment costs 3.9. Long payback period 3.10. Application of products is too narrow 3.11. Price/performance is bad 3.12. Financial resources for consumer are lacking 3.13. Externalities are not reflected in price 3.14. Price of raw material is lower than recycled products *3.15. Dutch horticulturalists serve the vegetable market at a low price and imported fish is cheap* *3.16. Aquaponics requires a combination of high-value vegetable and high-value niche market fish* *3.17. Rebound effect*
	4.1. *Not the 'fittest' but the 'first' survives* 4.2. *Scalability*
	5.1. *Large-scale demonstration projects are missing* 5.2. Low amount of R&D and pilot projects 5.3. Lack of human capital 5.4. Gap between research and practical needed information 5.5. Lack of knowledge or awareness on CE by producers and consumers

	5.6. Lack of awareness between intermediaries on developments 5.7. Lack of knowledge required to develop, produce and control technology 5.8. Lack of skills or knowledge to apply/deal with technology 5.9. Lack of data on material flows 5.10. Lack of knowledge on roles of companies in CE
	6.1. GDP is not a good measure of welfare 6.2. Lack of trust between companies 6.3. Sense of urgency is missing 6.4. Consumers interest in sustainability is not reflected in buying behaviour 6.5. Incumbent industry is not willing to cooperate and resists changing status quo 6.6. Shareholders have short-term thinking (with focus on benefits) 6.7. Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling
	7.1. Value tensions: 7.1.1 Value tension 'Innovation' vis-à-vis 'Business as Usual' and 'Old-school Organic' 7.1.2. Value tension 'Financial Viability' vis-à-vis 'Ecological and Social Benefit' 7.1.3. Value tension 'Anthropocentric' vis-à-vis 'Ecocentric' 7.1.4. Value tension 'Efficiency' vis-à-vis 'Naturalness' 7.2. Values of stakeholders not covered by actors or value advocates: 7.2.1. 'Non-human well-being' 7.2.2. 'Veganic vegetables'
	*8.1. Geographical conditions in the form of a cold climate* *8.2. Thermodynamic limits* *8.3. Physical flows of materials and energy do not respect man constructed boundaries*

	8.4. Time and space boundary limitations

Table 8.1 The final theoretical framework Piptová 2.0 (2020). It contains institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions (Icons' attribution text: Institution by Mike Wirth from the Noun Project, Technology by Icongeek26 from the Noun Project, Finance by Aneeque Ahmed from the Noun Project, Infrastructure urban by Eucalypt from the Noun Project, Knowledge by Alena from the Noun Project, Social by Park ji sun from the Noun Project, Ethical by Priyank and Biophysical by Mynamepong from the Noun Project). The newly added barriers are listed in italics.

9. CONCLUSION, REFLECTION AND RECOMMENDATION

9.1. Conclusion

In this section, the result of answering each sub-question and finally the main research question are summarized.

9.1.1. Answers to the Research Sub-questions

- What initial theoretical framework and approaches can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

The Verhulst (2017) theoretical framework based on FIS and CE and additional VSD and VCS approaches with potential barriers listed have been initially used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands.

- How to include the ethical barriers into an initial theoretical framework and amend it so that it can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

The ethical barriers have been integrated into an initial theoretical framework by following a VSD and VCD approach. This way a primary theoretical framework Piptová 1 (2018) which can be used to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands has been created. It contains institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions. The detailed process of including the ethical barriers into an initial theoretical framework can be found in chapter 2 Methodology Overview and chapter 4 Primary Theoretical Framework Piptová 1 (2018) Overview.

- How can this methodological framework be applied to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

This methodological primary framework Piptová 1 (2018) has been applied via desk research of grey and white literature and via in-depth interviews with stakeholders in order to systematically assess the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The result of applying this theoretical framework to the Aquaponics case is a List and description of barriers to be found in chapter 6 Barrier Analysis for Aquaponics in the Netherlands. These barriers are connected to the incumbent linear infrastructure which does not support entrant farmers, such as Aquaponics producers; issues with scalability, current unprofitability of Aquaponics in the Netherlands due to strong current regime actors who are able to efficiently produce high-output cheap vegetables and which Aquaponics cannot compete with its more expensive and niche products; high initial investment costs in order to start Aquaponics; cold Dutch climate which requires the heating of Aquaponics installations and inability to distinguish Aquaponics products as organic due to legislation.

- What has to be adapted, added to or removed from the theoretical framework in order to make it suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands?

In order to make primary theoretical framework Piptová 1 (2018) suitable to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands, the indicators have been adapted, added and removed based on the results of barrier analysis in chapter 6 Barrier Analysis for Aquaponics in the Netherlands. The indicators are not mutually exclusive. The detailed process of revising primary theoretical framework Piptová 1 (2018) can be found in chapter 7 Adaptation of Primary Theoretical Framework Piptová 1 (2018).

9.1.2. Answers to the Main Research Question

- What theoretical framework can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands?

The final theoretical framework Piptová 2.0 (2020) can be used to analyse the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. It contains institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions that are not mutually exclusive. The final theoretical framework Piptová 2.0 (2020) can be found in chapter 8. Final Theoretical Framework Piptová 2.0 (2020) Overview.

9.2. Reflection

In this chapter, the reflection on research approach, methodology, theoretical models which served as a theoretical base in this research, such as the Verhulst (2017) theoretical framework based on Functions of Technological Innovation Systems and CE, VSD and VCD; reflection on primary theoretical framework Piptová 1 (2018); barrier analysis for Aquaponics in Netherland; adaptation of primary theoretical framework Piptová 1 (2018) and final theoretical framework Piptová 2.0 (2020) is provided.

9.2.1. Reflection on Research Approach

In order to investigate barriers hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands, a research approach of constructing a theoretical framework based on the Verhulst (2017) and extrapolating it to Aquaponics in the Netherlands through several steps was established which helped to answer gradually all research sub-questions and the finally the main research question. The desk research of scientific and grey literature and in-depth interviews with identified stakeholders were the main data sources which was limited due to the fact that it was not possible to reach all identified stakeholders in order to provide an interview, some refused to participate; and therefore, more information which was especially important for the identification of ethical barriers was not collected. The latter were identified based mainly on the claims and perceptions of Aquaponics producers. Focus groups as a more elaborate but also time intensive method in the future might be also helpful in order to identify the barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands based on the themes considering the institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions. The technical investigation, besides conceptual and empirical one, as a part of research according to the VSD approach was not possible to be performed within the scope of this study, and the author is well aware of this deficit.

The order of the research, first performing the desk research and then in-depth interviews seemed sometimes counterintuitive due to the fact that the used initial framework by the Verhulst (2017) was constructed in opposite research steps order - first interviews and then desk research of available literature. Interviews with Current Aquaponics producers and a Research and knowledge stakeholder provided a substantial amount of qualitative data which made the navigation of research more clear in the later phase of research. Other groups of stakeholders declined to be interviewed, in the disadvantage of the current study, or there were also ones who recommended a certain Current Aquaponics producer that should be contacted or they stated they do not know anything about Aquaponics. That might be due to the fact that, as mentioned earlier, Aquaponics is according to König et al. (2018) still in an early stage of the technology development process with low economic activity and therefore not yet fully known or legitimised. Participation in conferences, tours and other events promoting Aquaponics in order to gain a better overview was useful.

A completely inductive approach with a goal of constructing a completely new framework to identify the barriers for the Aquaponics in the Netherlands 'from the scratch' could have also been performed. First, the qualitative data would be collected, then synthesized and analysed resulting in a novel theory and framework construction as recommended by the pioneers of the Grounded theory approach Glaser and Strauss (1967).

The current research along with its findings is crucial since it provides a guide for identifying barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands from an Industrial ecology perspective embracing a multi-faceted trans- and beyond- disciplinary approach while including a plethora of stakeholders with diverse values in the form of matters to be won or lost in the era of Anthropocene.

9.2.2. Reflection on Methodology

The methodological steps enabled a gradual construction of the final theoretical framework Piptová 2.0 (2020) through transparent steps of enriching the initial Verhulst (2017) framework with crucial ethical barriers and building the theoretical framework Piptová 1 (2018) and later enhancing it further as listed in chapter 7 Adaptation of Primary Theoretical Framework Piptová 1 (2018).

Difficulties were encountered in the ethical barrier analysis step of the research due to the fact that, as noted by Davis & Nathan (2015), VSD provides no exact guidance about how to identify harms and benefits or how to extract the values and conceptualise them. The values were identified in the research by looking for common themes which at the beginning proved to be not easy. Solution to this provided a rigorous manual annotation and highlighting of the various sections of attitudinal data focusing on determining patterns of meaning for one specific topic at a time across a dataset and repeating the action one again later. This method enabled a more transparent harm, benefit and values identification. Hence rigorous approach suggested by Braun et al. (2019) consisting of initial data-set study in order to recognize certain patterns and appearing themes, coding the themes and patterns by using different colours to differentiate them, theme developing, sorting according to emerging themes, linking them back to the data and revision process is recommended.

According to another commentator on VSD methodological flaws Manders-Huits (2010), there is a concern about the implications of the author's or producer's own normative assumptions which might influence the relevance of some values and lower the importance of other ones. This issue was indeed encountered during the research in a recognition that VSD and its practitioners account only for anthropocentric values and ignore the ecocentric ones. Taking into consideration also the values of Non-human stakeholders in the process of identifying the barriers, addressed the issue.

Friedman et al. (2013) says that some values are universal. This constitutes a naturalistic fallacy that appeals to the way how things are done, what is normal or natural and therefore good (Curry 2006). It also constitutes a danger due to the fact that it gives a green light to certain stakeholders; who have a certain set of values based on their culture, education, status, religion or belief, which they consider universal; to impose these values on other stakeholders (Borning & Muller 2012). This could be the author of the thesis but also other stakeholders. Practitioners engaging in VSD should, according to the recommendation of Jacobs & Huldtgren (2008), state at the beginning of a process when utilising VSD, explicitly, what moral principles they stand for. In this research, the author stated the ecocentric academic orientation. This orientation 'quietly' clashed with a value of one of the interviewee during an interview who stated that plant well-being is a fallacy and that one who does have a cat or a dog in a house should be quiet about fish in tanks.

There are scholars who call for the paradigm shift towards the responsibility for the wellbeing, protection and stewardship of plants due to the fact that they have an inherent value, independent from the evaluations of their worth by humans, and they contribute to the flourishing of our planet (Dunlap et al. 2000). The balance of the Earth is paramount and the human population does not have a bigger right to live well than plants or animals (Borland & Lindgreen 2013). Maybe we are " blinded by the present-day science" in our human domain like Silverstone (2011) says.

It can be stated that there is little known about the intricate degrees of complexity in behaviours, cognitive and conscious nature of plants and other biological species besides the humans. The extensive scientific recognition of an inherent plant intelligence, outside of human cognitive territory, via experiments with stimulation, stress priming, testing the memory abilities and signalling skills and the observation that plants have their own neurotransmitters opened new research horizons in the plant domain (Sopory & Kaul (2019).

There is research done confirming that, despite the lack of scientific agreement on the fact if fish are sentient beings or not, rearing them without stimulating, allowing and actively enabling their natural behaviours presents acute and chronic stressors for fish in aquaculture (Martins et al. 2012).

Hence, Manders-Huits (2011) notes that VSD application requires a clear demarcation of values via a complementary ethical theory in order to bound and ground the values so they stay moral according to what should be attended to in the current VSD project. This aspect is currently missing in the VSD approach. Technology is not neutral but carries a moral connotation (Roeser 2012) which ought to be morally plausible (Manders-Huits and Zimmer 2009). The author of this thesis aimed for presenting the values of all stakeholders in an objective manner viewed from the position of human as well as non-human stakeholders.

9.2.3. Reflection on Theory

In this chapter, the reflection on theoretical models which served as a theoretical base in this research, such as the Verhulst (2017) theoretical framework based on Functions of Technological Innovation Systems and CE, VSD and VCD is provided.

The initially used the Verhulst (2017) theoretical framework based on Functions of Technological Innovation Systems and CE served as a base for the development of a further theoretical framework. It provided an initial tool for identification of barriers hindering a different type of technology than initially intended by Verhulst. The Verhulst framework can serve as a useful guide to map the barriers hindering the actual socio-technical system and also a larger scope trends of CE entrant technologies that are currently being developed as a part of broader efforts shifting from linear towards a more CE paradigm. This proved to be valid during the research due to the fact that identified barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands has to do with large landscape movements, established institutions and current regime actors who are failing in implementing CE through the current production and consumption patterns. Some barriers in the Verhulst framework were changed, others merged due to redundancy and some removed in order to fit more the identification of barriers hindering the Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands. The changes and explanations were listed in chapter 7 Adaptation of Primary Theoretical Framework Piptová 1 (2018).

In the Verhulst (2017) theoretical framework, however, the identification of barriers of the ethical nature was missing. This was solved by adding the ethical dimension in order to grasp the stakeholders' value awareness promoted via responsive and responsible character of Responsible innovation trends. Suurs (2009) distinction in the Verhulst (2017) theoretical framework was not used due to the fact that the current study focuses on identification of barriers according to a different distinction based on various dimensions of social reality.

When using the Verhulst (2017) theoretical framework, further limitations in the form of under-explained and poorly theoretically embedded indicators were encountered, which caused ambivalence in the meaning of the barriers and their further interpretation. This was solved by revising them, providing an additional explanation as well as introducing references from a more recent scientific literature. In the later phases, more indicators hindering CE and specifically the Aquaponics were added. In order to better theoretically embed barriers connected to CE more theoretical sources and Multi-level perspective on transitions could be used. Technology, including the Aquaponics development does not exist in isolation. On the contrary, it is embedded in certain established socio-technical contexts, as shown in Figure 9.1, presenting the Multi-level perspective on transitions. This radical 'technological innovation' in the form of 'technological niche' emerges along the established 'technological regimes' and is fully influenced by them. Figure 9.1 shows how Aquaponics' technological niche transitions as an emerging technology in time while the structuration of activities in local practices increases. This all happens on the background of the established 'socio-technical regime' and 'socio-technical landscape' which are currently represented by the Circular economy and Responsible innovation trend. 'Socio-technical regime' term emphasises the fact that every technology is embedded in a social, economic, environmental and political set of circumstances. Various contexts and communities of stakeholders are involved, including "technological, science, user and market, policy and socio-cultural regime" in the environment of 'socio-technical landscape' (Geels 2005 as cited in Raven 2005:29).

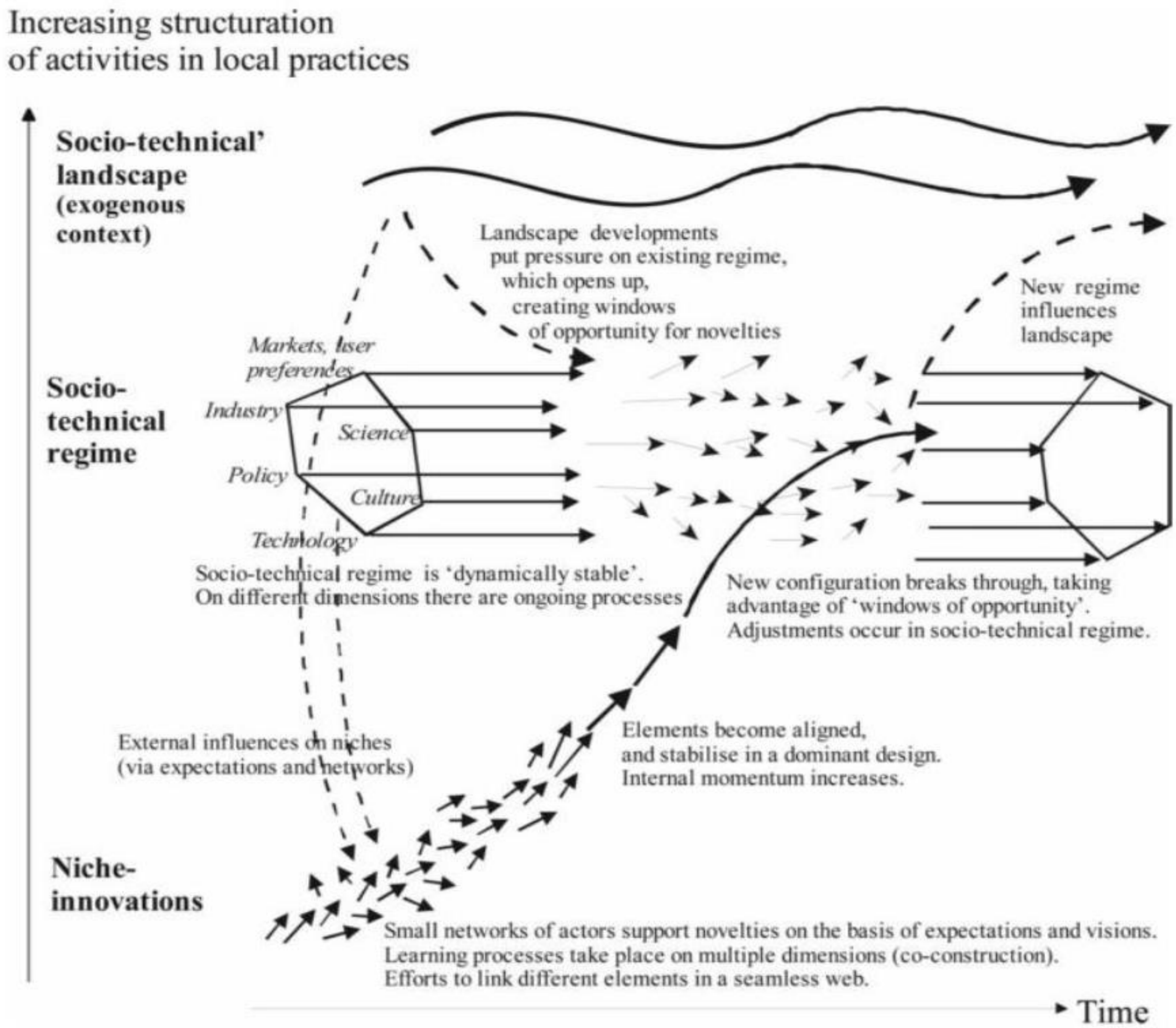


Figure 9.1 Multi-level perspective on transitions presenting the various levels on which an emerging value-conscious technological innovation system in the Netherlands exists.. Adopted from Geels (2002:1263). 'Technological niche' emerges along the established 'technological regimes' and is fully influenced by them. This all happens on the background of the established 'socio-technical regime' and 'socio-technical landscape' which are currently represented by the Circular economy and Responsible innovation. 'Socio-technical regime' constitutes a social, economic, environmental and political set of circumstances. Various contexts and communities of stakeholders are involved, including "technological, science, user and market, policy and socio-cultural regime" in the environment of 'socio-technical landscape'(Geels 2005 as cited in Raven 2005:29).

In the Verhulst (2017) theoretical framework it was not clear which indicators are based on FIS and which on CE theory which made understanding the indicators more difficult and less traceable.. This has been solved by identifying and labelling them as shown in chapter 4.2. Primary Theoretical Framework Piptová 1 (2018).

Further theoretical approaches used in the research of a theoretical framework that can be used to analyse the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands were VSD and VCD. These proved as suitable to address the ethical barriers existing in the Aquaponics development due to the fact that technology has ethical implications and is value laden. New technologies challenge the ethics and ethics challenges the new technologies. This is the newly recognised objection in the current technological developments (Manders-Huits 2011). VSD and VCD recognize the fact that innovation is intertwined with the values of stakeholders. The personal values of the technology developers come into play too. The technology developers are influenced by their personal values. This can be seen in their work contributions. According to the VSD prism, the technology developers are able to steer the technology development and also the values of the stakeholders by creating desired innovative approaches or, on the other hand, overcoming the unwelcome ones (Zimmer 2010). The tensions between values of participating stakeholders, such as developers, users and other stakeholders constitute obstacles for further technological development as an emerging value-conscious socio-technical system. The difference between VSD and VCD is the VCD proponents' recognition that technology developers have an ethical responsibility connected to creating new technologies based on their own values. During the research, these findings were confirmed due to the fact that all Aquaponics producers believed in their work and were striving to develop Aquaponics as a new resilient food system for a more socially and ecologically sustainable future.

The limitations of VSD and VCD are that they do not recognize non-human values which are at stake in the circular bioeconomy which Aquaponics is a part of. They are Anthropocentric theories which fail to face the fact that fish in captivity in a farm cannot perform the full repertoire of its behaviours like in nature and that is why its well-being is at stake (Sandøe et al. 2015). Additionally, the issue of non-human well-being being at stake is not recognised as a value by this value not being represented by an actor or a value advocate.

Responsible innovation is to be sensitive to specific cultural, political and economic factors. In order to deal with the benefits and harms of technology and science in general, Van der Velden (2008) suggests also cultivating Cognitive justice, meaning respecting the diversity of human knowledge as an indicator of a democratisation of science. The author of this thesis extrapolates the approach from Human stakeholders and their needs to Non-human stakeholders and their needs according to the ecocentric approach which recognizes intrinsic value in all lifeforms, abiotic elements and wider ecosystems independent from human evaluation or approval (Washington et al. 2017). VSD and VCD with their reductant attitude as parts of a Responsible innovation trend ignore the complex ecocentric aspects of life.

Values of stakeholder have a dynamic character, they emerge and evolve; therefore Value sensitive design approach does not have an ambition to be a blueprint but rather to serve as a tool which is context dependent and flexible (Correljé et al. 2015). That means that in the future it could get more flexible and broaden its reach from an anthropocentric towards a more ecocentric one.

Another limitation is that VSD and VCD fail to provide a detailed guide of how their approaches can be translated into actual steps to make decisions about technology to become more value sensitive and conscious. VSD does not offer comprehensive explicit ethical theory recommending how to handle value trade-offs (Manders-Huits 2017). VSD is not specific enough and does not help to indicate harms and benefits of technological development for various stakeholders which was encountered in the later phases of desk research and in-depth interviews.

There are also issues with the conceptualization of values where some VSD authors recommend to use a heuristic toll for value identification and operationalisation. Other authors, such as Le Dantec et al. (2009) argue that the first contact with values in research is to be empirical, happening in the local context rather than based on researcher's anticipation and discursive analysis. Values are to be discovered in their context and in a local vocabulary according to two-step: identify/apply logic (Le Dantec et al. 2009).

There exists no one universal correct perception or interpretation of values. They vary in different situations. This pluralistic approach can mean, at one hand, exaggeration of certain values and underestimation of others. This brings diversity and also conflict into the VSD discourse (JafariNaimi et al. 2015).

According to VSD and VCD tensions between values can happen between groups, within a group, can be interpersonal and intrapersonal. Values are based on stories and narratives of each stakeholder (JafariNaimi et al. 2015) and can be perceived differently by different people. Their concept is fuzzy and this caused some uncertainty and ambiguity in the identification of ethical barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands.

9.2.4. Reflection on Primary Theoretical Framework Piptová 1 (2018)

Combining theories into a one primary theoretical framework Piptová 1 (2018) proved challenging due to the fact that the Verhulst (2017) theoretical framework focused on phosphate recycling and did not involve or account for any non-human beings. There was also no recommendation about how this framework could be applicable to another type of technology barriers identification. This was solved by amending the Verhulst framework by changing, renaming and merging suitable barriers for the current thesis needs.

Some barriers in the constructed primary theoretical framework Piptová 1 (2018) seemed to be redundant and ambivalent to interpret during the course of literature review and in-depth interviews due to the fact that they are not mutually exclusive. The line between barriers is blurred due to the fact that the described barriers manifest themselves as processes and phenomena and do not exist in isolation but are interconnected. This, however, also brought an advantage in the form of flexibility and less rigidity due to the fact that social processes and phenomena do not respect human-made boundaries and are emergent and volatile. Due to this fact, the results of this thesis are to be perceived as interconnected and nested in various multi-levelled contexts, such as economic, social, ethical and political ones at the same time.

9.2.5. Reflection on Barrier Analysis for Aquaponics in the Netherlands

The barriers were analysed and described to what extent they constitute a barrier and to what not which shows the multidimensional character of the technology development. There were some conflicting opinions on the barriers hindering Aquaponics development as an emerging value-conscious socio-technical system in the Netherlands by the Aquaponics producers. Some see the lacking 'organic' labelling as an issue. Some consider the fact that Aquaponics cannot be legally branded 'organic' as a barrier and others not. Some stakeholders see scaling up as a financial disaster and some as an unavoidable calculated step in order to see the Aquaponics full potential. Some see the cold Dutch climate connected to the local fish production or better said lack of farmed fish production tradition as an issue compared to Aquaponics possibilities in other countries. There is, however, a common agreement between the interviewees that the vegetables in the Netherlands along with the imported fish are too cheap. Could the coproduction of cannabis, as suggested with laugh by one of the interviewees, or medicinal plants in general, as suggested by the second one, and a Dutch species of eel, the North Atlantic eel, as mentioned by the second interviewee, be the solution?

There are a few crucial barrier themes which are all interconnected and keep repeating during the course of the literature review and in-depth interviews. In the author's view, the most Aquaponics development impeding barriers are the following: High investment costs, Scale up or not?, 'Organic' labelling?, Fine-tuning the Aquaponic system which requires a specialist multi-disciplinary knowledge and skills, Aquaponics need a combination of high-value niche vegetable and high market value fish, Current unprofitability, Cheap imported fish, Cheap Dutch vegetables, Sophisticated and efficient incumbent Dutch greenhouse industry and the Rule of the 'first', not the 'fittest'. They are all interconnected and are shown in Figure 9.2.

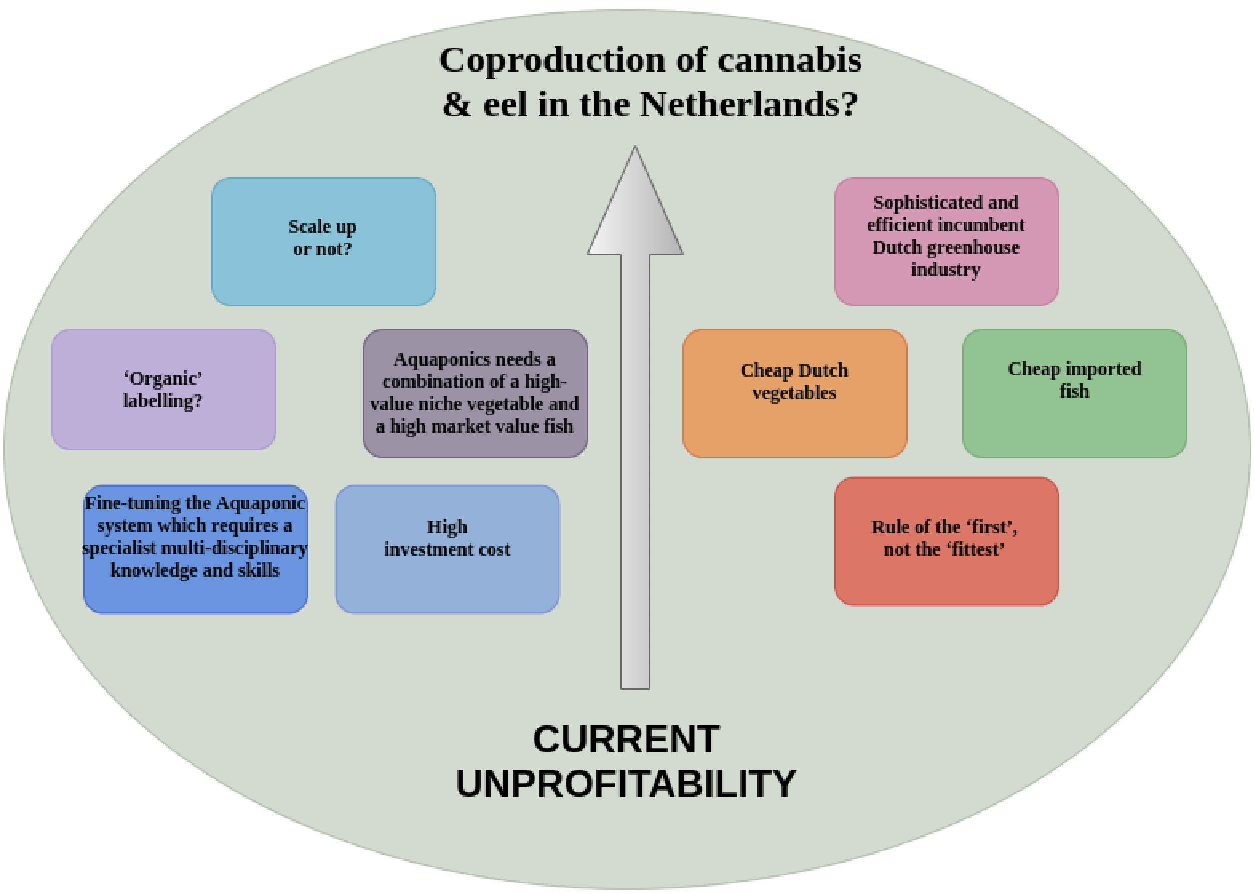


Figure 9.2 The most Aquaponics development hindering barriers in the author's view. These are the following: High investment costs, Scale up or not?, 'Organic' labelling?, Fine-tuning the

Aquaponic system which requires a specialist multi-disciplinary knowledge and skills, Aquaponics needs a combination of high-value niche vegetable and high market value fish, Current unprofitability, Cheap imported fish, Cheap Dutch vegetables, Sophisticated and efficient incumbent Dutch greenhouse industry and the Rule of the 'first', not the 'fittest'. Could the coproduction of cannabis, as suggested with laugh by one of the interviewees, or medicinal plants in general, as suggested by the second one, and a Dutch species of eel, the North Atlantic eel, as mentioned by the second interviewee, be the solution?

The results of the current research confirm the findings of Turnsek et al. (2020) about the Aquaponics in the European context. There are issues with the fine-tuning of the system with occasional malfunctions; it is labour intensive and knowledge is scarce; large-scale units are lacking; there are high investment costs; no 'organic' labelling and issues with lacking knowledge or information about the existence of the Aquaponics were also encountered when none of the questioned Incumbent farmers nor Public heard of the Aquaponics but this would require a further research. Turnsek et al. (2020) also mention the lack of the Aquaponics specific regulation; this, however, has not been mentioned by the stakeholders as an issue.

Financial unprofitability and fine-tuning issues requiring a highly skilled expensive labour was also confirmed like mentioned in the article by Bosma (2017).

The results of the current research confirm the findings of König et al. (2018), who have analysed Aquaponics as an emerging technological innovation system in Germany using TIS, that there are difficulties for the Aquaponics as an entrant technology to overcome hurdles connected to the strong establishment of incumbent vegetable and aquaculture production. The visions of the stakeholders on the Aquaponics in the Netherlands were connected to the issues of scalability, as mentioned earlier, and positive expectations about the growth of city farming where people will need fresh food. The interviews with the Aquaponics producers suggest high interest and belief in the technology. Unlike by König et al. (2018) who identified that in Germany there are no united visions about the future of Aquaponics by various stakeholders and missing long-term ideas about how to develop the Aquaponics, in order to determine this a further research examining more specifically the future visions of the stakeholders would be necessary. Missing knowledge on how to modify the established institutions in order to shift from regime lock-ins towards a more resilient sustainable food system paradigm identified by König et al. (2018) was also not possible to establish due to the fact that the current research was more focused on the current state of the Aquaponics in the context of CE and not on how to overcome the institutional hurdles. There is further research on future visions on the Aquaponics among various stakeholders and strategies on how to overcome the institutional hurdles in the Netherlands needed.

The limitations of the analysis of barriers hindering the Aquaponics in the Netherlands lie in the fact that, as mentioned earlier, not all groups of stakeholders participated in the interview due to their refusal or according to them none or limited knowledge on the Aquaponics. This might have influenced the barrier analysis for Aquaponics in the Netherlands results; especially the identification of ethical barriers which are based on stakeholders' beliefs.

9.2.6. Reflection on Final Theoretical Framework Piptová 2.0 (2020) and Adaptation of Piptová 1 (2018)

The result of this study is the final theoretical framework Piptová 2.0 (2020) which can be used in the future to identify barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. Along with the research on barriers hindering Aquaponics in the Netherlands by Godek (2017), Bosma (2017) and Sikkema (2017) it does not provide only an extended list and description of barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands, but also an elaborated steps for identifying these barriers in a methodological systematic way.

There were barriers added into the final theoretical framework Piptová 2.0 (2020). These were absent in the primary theoretical framework Piptová 1 (2018) and the Verhulst (2017) theoretical framework. These findings could not be established ex ante. The final theoretical framework Piptová 2.0 (2020) provides a complex research tool in order to identify barriers. It could be used as an initial guide in order to identify barriers hindering other technological developments connected to the innovations based on avoiding the technical end-of-pipe solutions or disposal; and rather enforcing the utilisation of the upper levels of the concept known as 'Lansink's Ladder', such as prevention, reuse, recycle and recovery of the resources, nutrients, energy and materials as emerging value-conscious socio-technical systems globally. In order to do this, it is quintessential to construct a theoretical framework with improved generalizability, as described later in this chapter, and amend the barriers by the certain technology specifics based on the initial brief desk research of available literature on the studied technology in the institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical context.

The final theoretical framework Piptová 2.0 (2020) can be considered more holistic and more within the current trends in science and technology scholarship and practice than the Verhulst (2017) theoretical framework due to the added value of ethical aspects of barriers. The final theoretical framework Piptová 2.0 (2020) also encounters for the non-human values which are not mentioned in Verhulst approach. It enriches anthropocentrically oriented FIS perspective with innovative ecocentrically oriented lens. The limitations of the Final theoretical framework Piptová 2.0 (2020) are that there are many barriers and their identification can be lengthy and redundant due to the fact that the indicators are interlinked and embedded in the nested systems of a wide social context.

The proposed final theoretical framework Piptová 2.0 (2020) shown in Table 8.1 serves as a tool to guide the search for the barriers hindering the Aquaponics as an emerging value-conscious socio-technical system in the Netherlands. The indicators in the theoretical framework are mutually inclusive. They are to be assessed via using information found in desk research of available literature and via in-depth interviews with various stakeholders. The ethical barriers of the proposed final theoretical framework Piptová 2.0 (2020) defined in two forms: Tensions between Values and Values of stakeholders not covered by actors or value advocates, which are of a dynamic and emergent nature, are to be identified by utilising the steps described in chapter 2 Methodology Overview.

According to Ulrich Beck (1998) contemporarily we live in the state of ‘organized irresponsibility’ in a ‘risk society’, where the ones in the position of power and influence, the decision makers, who benefit from the high risk are not held responsible for the damages occurred and do not carry any burden of the negative consequences. It is about an unfair distribution of not 'goods' but 'bads', meaning the risks (Blechar & Hanseth 2007). Damage is done and nobody who helped to produce it is held accountable (van Bueren et al. 2014). What change is needed and how can be the problem identified? Via utilizing the fundamental capabilities of the theoretical framework Piptová 2.0 (2020) and amending it, in order to be able to reach a higher variety of innovations and detect a wider horizon of developmental bottlenecks from the systemic Industrial ecology perspective, a novel generally applicable theoretical tool can be created. A theoretical framework with an improved generalizability can be employed by various actors in order to execute improvements according to the needs in other countries.

Industrial ecology aims to gain a broad understanding of interlinked industrial processes and identify hotspots of stakeholders' discourse clashes embedded in and transcending simultaneously several dimensions of our 'risk society'. Moreover, its goal is to provide rather complex than fragmented strategies in order to mitigate negative changes and their further unintended consequences. This occurs on several levels starting from providing innovative socio-technical solutions to changing production, consumption and disposal patterns, steering industrial practices, influencing policymaking and identifying opportunities towards further technological development; and on the other hand, bottlenecks hindering it. The final theoretical framework Piptová 2.0 (2020), as a result of implementing the systemic ecocentric lens, can serve as a tool for transparent identification of areas for enhancements in, not only the Aquaponics in the Netherlands, but also other emerging socio-technical systems changing the 'set and setting' elsewhere. This can be done via the process of its generalization in order to increase its generalizability and later its adaptation in order to meet the specific goals of various innovations.

In order to generalize the final theoretical framework Piptová 2.0 (2020) for the purpose of utilising it to identify barriers hindering other technological developments as emerging value-conscious socio-technical systems globally from the Industrial ecology perspective, the framework should be amended in the following way, as shown in Figure 9.3.

First, it needs to be expanded in order to entail, not only the final Dutch Aquaponics specific realities presented in the final theoretical framework Piptová 2.0 (2020), but also the ones encountered in the earlier phase of the research when reviewing the primary theoretical framework Piptová 1 (2019). The latter one contains a broader variety of barrier indicators which might be applicable to a wider variety of innovations emerging as value-conscious socio-technical systems. As suggested earlier, the general theoretical framework is tailored to determine the barriers hindering those technological developments that specifically aim to embody the processes from the 'top shelves' of the 'waste hierarchy'. Those are the top ranking waste management practices that are preferable in order to prevent and diminish any pollution. The general theoretical framework is based on the bellow explained expansion and combination, on one hand, of the barriers newly encountered during the research and listed in the final theoretical framework Piptová 2.0 (2020), especially the novel ethical and biophysical ones; and on the other hand, of the barriers originally to be found in the primary theoretical framework Piptová 1 (2019) and to be traced back to the initial Verhulst (2017) theoretical framework.

Second, in order to create the general theoretical framework the barriers in all dimensions should be split, as in the primary theoretical framework Piptová 1 (2019), into Technology related barriers and Product related barriers. This distinction ought to be reintroduced due to the fact that some barriers are connected to the technology prospects and others to the handling of the product of the technology. This is crucial in cases, such as phosphorus or water recycling and recovery when the technology is allowed but the handling and use of the product is limited by various factors, such as legislation and health risks.

Later, when performing the barrier analysis for a certain technological development in a specific country, some barriers might need to be reviewed and eliminated based on the plethora of facets connected to a certain innovation. Further, novel barriers, emerging through the prism of a certain innovation and a regime connected to it, might need to be added.

The barriers and elements to be changed or added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics.

1 Institutional barriers

The Technology related barrier from the primary theoretical framework Piptová 1 (2019) 1.9.a No clarity on ownership, liability and responsibility in new business models removed from the final theoretical framework Piptová 2.0 (2020) should be added back to the general framework due to the fact that the role of the enterprises and consumers in the CE shift from the ownership of a product to fostering a services based economy in closed-loop supply-chains and product-service systems is not transparent (Mativenga et al. 2017, Jesus & Mendonça 2018) and therefore represents a barrier of CE promoting innovations. Originally found in the primary theoretical framework Piptová 1 (2018) Product related barriers 1.1.b Low alignment with current legislation and 1.2.b Absence of regulatory pressures should stay separated from the Technology related barriers 1.1.a Low alignment with current legislation and 1.3.a Absence of regulatory pressures. The barrier 1.9. The label 'organic' in the legislation applies only to production in the soil from the final theoretical framework Piptová 2.0 (2020) should be removed due to the fact that it is a Aquaponics specific barrier and it is too specific for other innovations promoting the upper levels of the concept known as 'Lansink's Ladder', such as prevention, reuse, recycle and recovery of the resources, nutrients, energy and materials as emerging value-conscious socio-technical systems.

The barriers and elements recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

1.1.a Low alignment with current legislation

1.2.a Low level of lobbying

1.3.a Absence of regulatory pressures

1.4.a Lack of clarity on how to use waste hierarchy

1.5.a Recycling rates focus on quality, not quantity

1.6.a Cartel formulation legislation hinders collaboration between companies

1.7.a No CE standards for products

1.8.a CE is not integrated in innovation policies of the government

1.9.a No clarity on ownership, liability and responsibility in new business models

1.10.a Regulations change slowly

Product related

1.1.b Low alignment with current legislation

1.2.b Absence of regulatory pressures

2 Technical barriers

Originally found in the primary theoretical framework Piptová 1 (2018) Technology related barrier 2.1.a Uncertainties or risks related to the technology and Product related barrier 2.1.b Risks associated with product and 2.2.b Quality of product is limited removed from the final theoretical framework Piptová 2.0 (2020) should be added back to the final theoretical Piptová 2 (2020) framework to create the general theoretical framework due to the fact that there might be some uncertainties, quality issues or risks associated with different technology implementation and its products. Technology related barrier 2.3.a Products are not designed for end-of-life was also added due to the fact that this constitutes an important issue in the transition towards CE.

The barrier 2.2. Lack of LCA to prove the effect of CE and Aquaponics principles from the final theoretical Piptová 2 (2020) framework was changed into the Technology related barrier 2.2.a Lack of LCA to prove the effect of CE principles and the current technology in order to make it more general and applicable to various technologies.

The concern for the safety and health hazards for non-human beings in the technological system the barriers 2.4. Fine-tuning of the system and 2.6. Safety and health hazards for non-human beings in the system were kept and became Technology related barriers 2.4.a Fine-tuning of the system and 2.6.a Safety and health hazards for non-human beings in the system due to the fact that this might consider other technologies working with certain levels of resources, nutrients, energy and materials in the system. These barriers are technology related due to the fact that they consider more the performance of the technology then the product.

The barriers changed or recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

2.1.a Uncertainties or risks related with the technology

2.2.a Lack of LCA to prove the effect of CE principles

2.3.a Products are not designed for end-of-life

2.4.a Fine-tuning of the system

2.5.a Safety and health hazards for non-human beings in the system

Product related

2.1.b Risks are associated with product

2.2.b Quality of product is limited

3 Financial (Economic) barriers

The barrier 3.15. Dutch horticulturalists serve the vegetable market at a low price and imported fish is cheap from the final theoretical Piptová 2 (2020) framework was changed to 3.10.a The incumbent producers and infrastructure serve the market at a lower price in the general theoretical framework in order to make it more general and being able to identify the incumbent technology and its prices as a barrier hindering the development of various future types of technologies.

The barrier 3.16. Aquaponics requires a combination of high-value vegetable and high-value niche market fish from the final theoretical Piptová 2 (2020) framework was removed and not placed into the general theoretical framework due to the fact that it is a Aquaponics specific barrier and it is too specific for other innovations promoting the upper levels of the concept known as 'Lansink's Ladder', such as prevention, reuse, recycle and recovery of the resources, nutrients, energy and materials as emerging value-conscious socio-technical systems. Barrier 3.17. Rebound effect from the final theoretical Piptová 2 (2020) framework became technology related barrier 3.11.a Rebound effect due to the fact that it considers more the performance of the technology then the product.

The barriers changed in the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

3.1.a Low amount of competitors and new companies in the field

3.2.a Low investments in research

3.3.a Negative landscape developments

3.4.a Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product)

3.5.a Not enough financial resources available

3.6.a Investment calculations are based on one lifecycle instead of more cycles

3.7.a Labour is taxed instead of materials

3.8.a High amount of investment costs

3.9.a Long payback period

3.10.a The incumbent producers and infrastructure serve the market at a lower price

3.11.a Rebound effect

Product related

3.1.b Application is too narrow

3.2.b Price/performance is bad

3.3.b Financial resources for consumer are lacking

3.4.b Price of raw material is lower than recycled products

3.5.b Externalities are not reflected in price

4 Infrastructural barriers

The following Technology related and Product related barriers, originally removed from the final theoretical framework Piptová 2.0 (2020) were added back to the general theoretical framework due to the fact that these might be the potential barriers hindering the development of other technologies as emerging value-conscious socio-technical systems. These are the Product related barriers 4.1.b Complementary services & products are lacking along with the Technology related barriers 4.2.a Complementary services & products are lacking, Product related barriers 4.2.b Scale of supply is too small along with the Technology related barrier 4.2.a Scale of supply is too small as well as the Technology related barriers 4.3.a Low alignment with incumbent infrastructure and 4.4.a Incomplete production chain for technology or products.

Barrier 4.1. Not the 'fittest' but the 'first' survives was changed into 4.6.a Not the 'fittest' but the 'first' survives in the general theoretical framework due to the fact that it is technology related and might constitute a barrier hindering the new technology due to the path dependencies and lock-ins in the current infrastructure as noted by Norton et al. (1998).

Barrier 4.2. Scalability the final theoretical framework Piptová 2.0 (2020) was changed into 4.7.a Scalability in the general theoretical framework due to the fact that it is technology related and might constitute a barrier hindering the new technology due to the fact that this considered technology requires a niche market and scaling it up would be not an option, desired or beneficial.

The primary barrier 4.5.a Companies are relying on external providers to adopt CE principles stayed removed from the general framework due to the fact that there was no information found during the research about this being indicated as a barrier for the Aquaponics. Moreover, when revising the potential barriers in the Verhulst (2017) theoretical framework in chapter 3.4. Circular Economy, no other current reference from the scientific literature was found for that potential barrier to support the claims made by Kok et al. (2013) as cited in Verhulst (2017).

The barriers changed or recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

4.1.a Complementary services & products are lacking

4.2.a Scale of supply is too small

4.3.a Low alignment with incumbent infrastructure

4.4.a Incomplete production chain for technology or products

4.5.a Companies are relying on external providers to adopt CE principles

4.6.a Not the 'fittest' but the 'first' survives

4.7.a Scalability

Product related

4.1.b Complementary services & products are lacking

4.2.b Scale of supply is too small

5 Knowledge related barriers

Technology related barrier 5.1.a Lack of knowledge dissemination and 5.5.a Low cooperation between firms and also Product related barrier 5.2.b Lack of skills or knowledge to apply or deal with product originally removed from the final theoretical framework Piptová 2.0 (2020) were added back in order to create a general theoretical framework. This is due to the fact that they might constitute the potential barriers hindering the development of other technologies as emerging value-conscious socio-technical systems. Barrier 5.1. Large-scale demonstration projects are missing originally found in the final theoretical framework Piptová 2.0 (2020) became Technology related barrier 5.11.a Large-scale demonstration projects are missing due to the fact that it considers more the performance of the technology then the product.

The barriers changed or recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics.

The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

5.1.a Lack of knowledge dissemination

5.2.a Low amount of R&D and pilot projects

5.3.a Lack of human capital

5.4.a Gap between research and practical needed information

5.5.a Low cooperation between firms

5.6.a Lack of awareness between intermediaries on developments

5.7.a Lack of knowledge required to develop, produce and control technology

5.8.a Lack of skills or knowledge to apply/deal with technology

5.9.a Lack of data on material flows

5.10.a Lack of knowledge on roles of companies in circular economy

5.11.a Large-scale demonstration projects are missing

Product related

5.1.b Lack of knowledge or awareness on CE by producers and consumers

5.2.b Lack of skills or knowledge to apply or deal with product

6 Socio-Cultural barriers

Originally removed from the final theoretical framework Piptová 2.0 (2020) Technology related barriers 6.1.a No belief in potential technology, 6.2.a No belief in the potential of product, 6.3.a No clear vision, 6.4.a Negative landscape developments, 6.11.a Acceptance of service products instead of ownership of products and Product related barrier 6.1.b Acceptance of service products instead of ownership of products were reintroduced in order to create a general theoretical framework. This is due to the fact that they might constitute the potential barriers hindering the development of other technologies as emerging value-conscious socio-technical systems.

Originally merged in the final theoretical framework Piptová 2.0 (2020) barrier 6.4. Consumers interest in sustainability is not reflected in buying behaviour was unmerged into Technology related barrier 6.12a Consumers interest in sustainability is not reflected in buying behaviour and Product related barrier 6.3.b Consumers interest in sustainability is not reflected in buying behaviour as in the primary theoretical framework Piptová 1 (2018). This is due to the fact that these potential barriers might differ for the potential technology and product of it.

Originally merged in the final theoretical framework Piptová 2.0 (2020) barrier 6.3. Sense of urgency is missing was unmerged into Technology related barrier 6.5.a Sense of urgency is missing and Product related barrier 6.2.b Sense of urgency is missing as in the primary theoretical framework Piptová 1 (2018). This is due to the fact that these potential barriers might differ for the potential technology and product of it.

The barriers amended or recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

6.1.a No belief in potential technology

6.2.a No belief in the potential of product

6.3.a No clear vision

6.4.a Negative landscape developments

6.5.a Sense of urgency is missing

6.6.a Shareholders have short-term thinking (with focus on benefits)

6.7.a Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling

6.8.a Incumbent industry is not willing to cooperate and resists changing status quo

6.9.a GDP is not a good measure of welfare

6.10.a Lack of trust between companies

6.11.a Acceptance of service products instead of ownership of products

6.12.a Consumers interest in sustainability is not reflected in buying behaviour

Product related

6.1.b Acceptance of service products instead of ownership of products

6.2.b Sense of urgency is missing

6.3.b Consumers interest in sustainability is not reflected in buying behaviour

7 Ethical barriers

The Aquaponics specific ethical barriers in the form of Value tensions and Values of stakeholders not covered by actors or value advocates were removed and made more general. The ethical barriers for the purpose of identifying barriers hindering the development of other technologies as socio-technical value-conscious systems via the general theoretical frameworks are to be identified in two forms, as suggested in the primary theoretical framework Piptová 1 (2018). They were split into Technology related barriers and Product related barriers in order to identify if the ethical barriers are connected more to the technology or the product of it which potentially might differ for some technologies. The Aquaponics terms were substituted for technology related terms in order to make the reference frame more general and applicable to other technologies. The barriers amended in the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

Technology related

7.1.a First as Tensions between Values of various stakeholders involved in technological development as an emerging value-conscious socio-technical system. Values of various stakeholders in technological development are connected to the harm and benefit of technological development for the stakeholders.

7.2.a Second as Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current technological development as an emerging value-conscious socio-technical system.

Product related

7.1.b First as Tensions between Values of various stakeholders involved in technological development as an emerging value-conscious socio-technical system. Values of various stakeholders in technological development are connected to the harm and benefit of technological development for the stakeholders.

7.2.b Second as Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current technological development as an emerging value-conscious socio-technical system.

8 Biophysical barriers

The barriers in the general framework were all changed to be technology related due to the fact that they consider more the performance of the technology then the product of it.

The barrier 8.1. Geographical conditions in the form of a cold climate from the final theoretical Piptová 2 (2020) framework should be changed to 8.1.a Geographical conditions in the general theoretical framework in order to make it more generalizable and applicable for the purpose of identifying barriers hindering the development of other technologies as socio-technical value-conscious systems.

The barriers changed or recently added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable creating a general theoretical framework are listed in italics. The following barriers in the general theoretical framework are the result of the adaptation:

8.1. a Geographical conditions

8.2. a Thermodynamic limits

8.3. a Physical flows of materials and energy do not respect man constructed boundaries

8.4. a Time and space boundary limitations

Barriers	*Technology related*	*Product related*
	*1.1.a Low alignment with current legislation* *1.2.a Low level of lobbying* 1.3.a Absence of regulatory pressures 1.4.a Lack of clarity on how to use waste hierarchy 1.5.a Recycling rates focus on quality, not quantity 1.6.a Cartel formulation legislation hinders collaboration between companies 1.7.a No CE standards for products 1.8.a CE is not integrated in innovation policies of the government *1.9.a No clarity on ownership, liability and responsibility in new business models* 1.10.a Regulations change slowly	*1.1.b Low alignment with current legislation* *1.2.b Absence of regulatory pressures*
	*2.1.a Uncertainties or risks related with the technology* 2.2.a Lack of LCA to prove the effect of CE principles *2.3.a Products are not designed for end-*	*2.1.b Risks are associated with product* *2.2.b Quality of product is limited*

	of-life 2.4.a Fine-tuning of the system 2.5.a Safety and health hazards for non-human beings in the system	
	3.1.a Low amount of competitors and new companies in the field 3.2.a Low investments in research 3.3.a Negative landscape developments 3.4.a Financial support for linear or incumbent systems (or absence of tax system supporting sustainable product) 3.5.a Not enough financial resources available 3.6.a Investment calculations are based on one lifecycle instead of more cycles 3.7.a Labour is taxed instead of materials 3.8.a High amount of investment costs 3.9.a Long payback period *3.10.a The incumbent producers and infrastructure serve the market at a lower price* 3.11.a Rebound effect	3.1.b Application is too narrow 3.2.b Price/performance is bad 3.3.b Financial resources for consumer are lacking 3.4.b Price of raw material is lower than recycled products 3.5.b Externalities are not reflected in price
	*4.1.a Complementary services & products are lacking* *4.2.a Scale of supply is too small* *4.3.a Low alignment with incumbent infrastructure* *4.4.a Incomplete production chain for technology or products* *4.5.a Companies are relying on external providers to adopt CE principles* 4.6.a Not the 'fittest' but the 'first'	*4.1.b Complementary services & products are lacking* *4.2.b Scale of supply is too small*

	survives 4.7.a Scalability	
	*5.1.a Lack of knowledge dissemination* 5.2.a Low amount of R&D and pilot projects 5.3.a Lack of human capital 5.4.a Gap between research and practical needed information *5.5.a Low cooperation between firms* 5.6.a Lack of awareness between intermediaries on developments 5.7.a Lack of knowledge required to develop, produce and control technology 5.8.a Lack of skills or knowledge to apply/deal with technology 5.9.a Lack of data on material flows 5.10.a Lack of knowledge on roles of companies in circular economy 5.11.a Large-scale demonstration projects are missing	5.1.b Lack of knowledge or awareness on CE by producers and consumers *5.2.b Lack of skills or knowledge to apply or deal with product*
	*6.1.a No belief in potential technology* *6.2.a No belief in the potential of product* *6.3.a No clear vision* *6.4.a Negative landscape developments* 6.5.a Sense of urgency is missing 6.6.a Shareholders have short-term thinking (with focus on benefits) 6.7.a Waste management is focussed on discarding waste with minimal societal damage instead of focussed on recycling	*6.1.b Acceptance of service products instead of ownership of products* *6.2.b Sense of urgency is missing* *6.3.b Consumers interest in sustainability is not reflected in buying behaviour*

	6.8.a Incumbent industry is not willing to cooperate and resists changing status quo 6.9.a GDP is not a good measure of welfare 6.10.a Lack of trust between companies *6.11.a Acceptance of service products instead of ownership of products* 6.12.a Consumers interest in sustainability is not reflected in buying behaviour	
	*7.1.a First as Tensions between Values of various stakeholders involved in technological development as an emerging value-conscious socio-technical system. Values of various stakeholders in technological development are connected to the harm and benefit of technological development for the stakeholders.* *7.2.a Second as Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current technological development as an emerging value-conscious socio-technical system.*	*7.1.b First as Tensions between Values of various stakeholders involved in technological development as an emerging value-conscious socio-technical system. Values of various stakeholders in technological development are connected to the harm and benefit of technological development for the stakeholders.* *7.2.b Second as Values of stakeholders which are not covered by actors or value advocates, and therefore not taken into consideration in current technological development as an emerging value-conscious socio-technical system.*
	*8.1.a Geographical conditions* *8.2.a Thermodynamic limits* *8.3.a Physical flows of materials and energy do not respect man constructed boundaries* *8.4.a Time and space boundary limitations*	

Table 9.3 The barriers in the general theoretical framework in the institutional, technical, economic, infrastructural, knowledge, socio-cultural, ethical and biophysical dimensions (Icons' attribution text: Institution by Mike Wirth from the Noun Project, Technology by Icongeek26 from the Noun Project, Finance by Aneeque Ahmed from the Noun Project, Infrastructure urban by Eucalypt from the Noun Project, Knowledge by Alena from the Noun Project, Social by Park ji sun

from the Noun Project, Ethical by Priyank and Biophysical by Mynamepong from the Noun Project). The barriers newly added to the final theoretical framework Piptová 2.0 (2020) in order to make it more generalizable are listed in italics.

This research is pioneering in the way that it researches Aquaponics also from an ethical point of view, taking into perspective human and non-human aspects of bioeconomy previously neglected by some stakeholders, including scholars as well as practitioners. Technology is value laden and stakeholders have causes to win and lose, and therefore, the ethical standpoint needs to be taken into consideration in any Industrial ecology or beyond related case of a technology development. The ethical perspective, motivations and consequences constitute a quintessence of a technological development.

9.3. Recommendations

In this chapter, the recommendations for the policy makers, current Aquaponic producers and for further research are provided based on the results of the current study. Collaborative approach between all actors beyond sector, national borders and discipline in order to find effective solutions to nowadays' society wicked problems connected to food access, quality and quantity is recommended.

9.3.1. Further Policy Recommendations

Several useful insights have been gained in this research. These might serve as a base for further policy recommendations. It is believed that Aquaponics may be prosperous in the future as a solution to the current Dutch nitrogen crisis due to the expansion of packed livestock operations of dairy, pig, and poultry farms which are a major source of nitrogen in the form of ammonia from animal waste (Pira 2019). Marine Aquaponics might be an answer to the soil salinization caused by seawater invasion in coastal and also inland aquifers from the neighbouring saline ones. This is a symptom of the sea-level rise and over-extraction of groundwater. In order to identify mitigation strategies for combating these, Aquaponics as a new resilient future food production system should be distinguished from the incumbent farming techniques and given its own legislation in the form of subsidies and tax reliefs based on the policy support for CE embodied technologies. There should be a higher pressure on producers to produce more circularly by the legislation and an heightened perception or sense of immediate threat or environmental crisis. The 'polluter pays principle' should be more enforced via policy. 'First" established and convenient technologies should be substituted for the 'fittest' for the 21st century.

Circularity and consideration for all directly and indirectly affected stakeholders, in close or further proximity in time and space, including the non-human ones, whether currently presented or not by an actor in the political discourse, should be included in any innovation. The Netherlands being, a so-called first world country, ought to reconsider the relation between sustainability, social justice and innovation. Price and not environmental or social concerns as the primary drivers in the buying process should be addressed. Policy makers should support further research into the qualitative and quantitative short- and long-term benefits of innovations which employ circularity principles.

The policy makers should reconsider the meaning of the 'organic' production label based on the fact that Aquaponics is soilless but produces organically.

Entrant technologies, such as Aquaponics should be given a helping hand by credit opportunities from the banking system, investments in the research of circularity benefits and subsidies from the government in order to overcome the risky trial and error phase of technological innovation development and minimise the low short-term return on investment costs currently experienced by the Aquaponics producers. There should be a reconsideration of the implications of the principle of economies of scale for the future especially after the Corona pandemics when global supply mass-production and distribution networks proved to be less safe, more fragile and high-risk compared to small local production and consumption systems of various goods and services. Intensification of production and consumption might not always be positive.

The new urban agriculture technologies, such as the Aquaponics, should be also seen as practical examples of a social cohesion implementation, and therefore, supported by the local government. Urban anonymous communities with weak social networks can be brought together and that way resilient diversified communities of the future can be created. Hence, urban agriculture should be stimulated by the policy and promoted further among the public due to the fact that it enables local production of food without wasting resources for transportation. Direct contact with fresh food in the times when we lost touch with how food is grown might contribute to lowering the food waste by igniting moral values in people without the use of orders or prohibitions via regulations. This might at the same time battle the existence of food desserts or fast-food swamps and enable a new generation of a healthier population in a climate-resilient future.

The policy makers and scholars promoting circularity but also the public should also be conscious or made conscious that there are thermodynamic limits and that due to entropy, even systems with subsystems for cycling the resources and waste will ultimately lead to resource depletion and pollution (Korhonen et al. 2018). Hence, in order to deal with the plethora of unfolding crises and to enhance the social and environmental wellbeing and equity, a paradigm shift towards redefining prosperity and even a 'degrowth' in industrialized countries, such as the Netherlands, might be a plausible option (Borowy & Schmelzer 2017).

Despite the Netherlands being an affluent country and presenting itself as a hotspot for CE activities, the tendency to negate the social and environmental consequences can be seen also in enterprises, governmental sector and consumers being hesitant and rigid in their procurement behaviours, exhibiting 'attitude–behaviour gap' and deciding primarily according to the price Contrarily, socially and environmentally friendly goods and services might be perceived as 'elitist' due to the fact that not everybody has time, money and energy to pursue them. They are not readily available. These are wicked problems which require not fragmented solutions but a systemic change. These, on the first sight, socio-cultural but actually the 'current paradigm' beliefs, as Kuhn (1970) would say, and an everyday reality for many should be addressed via supporting and promoting various long-term non-economic benefits of Aquaponics and other circular innovations in cooperation among stakeholders across all the sectors, industries and transdisciplinary globally. Innovating in a socially and environmentally sound manner, such as Aquaponics should be made profitable.

9.3.2. Recommendations for Current Aquaponic Producers

It is recommended that the Dutch Aquaponic producers continue to further communicate to other actors the benefits of Aquaponics for improved food security and nutrition compared to other less environmentally sound horticultural and aquacultural practices and present Aquaponics as a solution to the Dutch nitrogen crisis and soil depletion. It is critical that more potential consumers get to know Aquaponics as a local resilient food system of the future, which is especially convenient to be employed in the densely populated urban areas.

Activities connected to lobby for Aquaponics should be initiated in order to increase the legislative pressure to incentivize the production of plants and fish in one circular system and diminish a non-conducive legal system which perpetuates the path dependency and lock-ins causing inertia and unnecessary hurdles in the practice of Aquaponics for the businesses and public.

Further, it is recommended that the current Aquaponic producers lobby for the change in the policy of the label 'organic' to apply also to the organic soilless production. This might give them an advantage to level up the marketing of the quality of their products.

There is a gap between research and practical information to be overcome due to the low amount and suboptimal size of demonstrations. This needs to be addresses through further collaborations between scholars, policy makers and Aquaponics practitioners. There should be pressure from the side of the current Aquaponic producers on policy makers to invest into and promote research in order to prove the short- and long-term beneficial effect of circularity principles. Continuous knowledge sharing between the current and potential Aquaponics producers in order to share their beyond-disciplinary skills, more experiments, larger-size demonstrations and proof of concepts are needed. This is crucial especially for the marine Aquaponics as an answer to the invasive coastal soil salinization in the Netherlands and coproduction employing the cold-climate native fish species in the Netherlands. For the Dutch Aquaponics in order to be profitable and compete with the cheap domestic vegetables and the cheap imported fish, a further out-of-box experimentation through combining a high-value plant varieties and a high-value niche market fish is needed. As mentioned earlier, one of the interviewees suggested with a laugh that for the Dutch Aquaponics profitability, and therefore its survival, the production of cannabis in Aquaponics might be an option. Coproduction of cannabis in Aquaponics and eel actually might be a real option. That is due to the fact; that nevertheless the ongoing natural resources depletion, degradation of the environment and loss of biodiversity accompanied by the an alarming wealth inequality globally; social and environmental concerns seem to be still secondary to the primary instant financial profit in the Netherlands.

Further the Dutch Aquaponic producers should emphasise that Aquaponics might be a less 'cruel' and more fish, plants and ubiquitous microorganisms wellbeing friendly practice compared to the intensified production of fish and plants. There is more research required about this topic as mentioned in the next chapter 9.3.3. Recommendations for Further Research. Fish and plants in the Aquaponics as its products seem to be more healthy than in the intensified production due to the fact that they are produced 'organically' without the use of fertilizers, pesticides, herbicides, antibiotics or another medicine. However, the fish and plants are stilled produced in enclosed spaces and unable to exercise some of their natural behaviours. Therefore, it is crucial that Aquaponic producers continue to improve the conditions of the Aquaponic installations in order to improve the general wellbeing and prevent the safety and health hazards for fish, plants and ubiquitous microorganisms inside the system.

The above mentioned advantages of Aquaponics practice should be transparently brought into discussion by the current Aquaponic producers, on one hand, with the farmers utilizing the intensified production, farmers who grow organically, and on the other hand, with the proponents of ‘veganic farming’ or consumers who express their unacceptability of products produced by utilizing animals or employing other un-vegan methods to grow vegetables. That counts also for the discourse about the notion of what is ‘natural’ or ‘efficient’ as explained in chapter 6.8.1. Identification of Value Tensions. The fact that Aquaponics functions due to the sophistically calibrated collaboration and synergy between fish, plants and ubiquitous microorganisms, therefore win-win-win situation, might serve as an opening thought for a discussion between the stakeholders about what is acceptable and what not in our current transition towards a ’responsive and responsible’ society. Sustainability goes hand in hand with justice for both human and non-human entities (Washington et al. 2017).

9.3.3. Recommendations for Further Research

There is further research needed in order to utilise diverse approaches to determining the barriers hindering Aquaponics as an emerging value-conscious socio-technical system in the Netherlands.

Firstly, a complementary to this research, a technical investigation ought to be done. The current study followed the VSD approach. During the third phase of VSD approach, usually a technical investigation is performed, combining the findings from the other two previous investigations - conceptual and empirical (Manders-Huits 2011). The analysis of ethical barriers connected to the technical investigation, final design and actual implementation of the values and value trade-offs into the actual design of Aquaponics installations was not possible to be performed within the scope of this paper. This constitutes a deficit and further research of barriers based on the actual technological implementation by rigorously examining the technical aspects of the installations and how the values of various stakeholders are implemented in their design and functioning in the Netherlands is recommended.

An approach starting first with a brief initial scientific and grey literature review in order to map the Current Aquaponics producers and the existing Aquaponic installations is recommended. Interviews with Current Aquaponics producers and scholars involved should follow due to the fact that during the current research they proved to be the most informed stakeholders. This step can provide a substantial amount of qualitative data already at the beginning which can make the navigation of research less ambivalent. It is recommended to be followed by interviews with other stakeholders willing to participate in the research. The results of the interviews should be later supported by the review of available scientific and grey literature. This approach might offer a better and earlier clarity about the current barriers for the Aquaponics in the Netherlands. Participation in conferences, tours and other events promoting Aquaponics in order to gain a better overview about this technology is recommended.

Due to the fact that none of the questioned Incumbent farmers nor Public heard of the Aquaponics, further research about the spread of knowledge about the Aquaponics is recommended.

Utilising focus groups with groups of categorised stakeholder peers as a way of accessing and recognizing their perceptions, values and common trends followed by in-depth interviews in order to get under the surface of identified matters is also recommended. This is important in order to determine the visions about the future of the Aquaponics in the Netherlands by various stakeholders and how to establish the Aquaponics among the incumbent regime. Clear vision and unified long-term expectations are important for the further spread of the Aquaponics along with the knowledge about systematic strategies on how to overcome the institutional hurdles hindering the Aquaponics in the Netherlands.

Being able to involve other stakeholders, such as public, current Aquaponics products consumers, ethicists, ethologists, animal and plant well-being organizations representatives, incumbent infrastructure farmers and policymakers into the research is recommended with the aim to deepen the knowledge about their values, beliefs, interests and expectations.

In order to overcome emerging value tensions among various stakeholders, research identifying mitigation strategies to prevent or diminish Value conflicts (Winkler & Spiekermann 2018) is necessary. This can speed up the development of the Aquaponics as an emerging socio-technical system in the Netherlands.

A further research using the Grounded theory approach introduced by sociologists Barney Glaser and Anselm Strauss (1967) is also recommended. It would present a valuable addition to the current research to find out if and how the outcomes of an inductive research starting with qualitative data collection and finishing with a new theory and a theoretical framework proposal differ from the deductive one starting with a theory or a framework in mind and filling it in with data.

In order to better explain the process and interlinkages between the barriers hindering the Aquaponics, the introduction of Multi-level perspective on transitions is recommended. The survival of technology depends on the interplay of several micro- mezzo- and macro-dimensional factors, such as its financial viability to overcome institutional and incumbent infrastructural hurdles as shown in the case of Aquaponics in chapter 6 Barrier Analysis for Aquaponics in the Netherlands. It should be further explored.

VSD methodology in the further research, should take into consideration an ethical stand along with a clear demarcation of values desired in the project or study as suggested by Manders-Huits (2011) It would be also beneficial if the VSD scholars and practitioners extended its focus from human towards also non-human values and got inspired by scientific disciplines, such as Multispecies ethnology which accounts for non-human experiences.

Further recommendation considers the fact that VSD provides advice but no exact guidance about how to identify harms and benefits or how to extract the values and conceptualise them. Issues were encountered during the research causing impracticalities. This needs to be addressed in a separate research in order to make the harms, benefits and values identification more explicit and targeted. It is recommended that more exact and empirically tested methodological steps for the identification of harms, benefits and values of stakeholders are established. This becomes more crucial in the case of Non-human stakeholders inside the Aquaponic system who are underrepresented by an actor or a 'value advocate'. There should be a 'value advocate' ensuring that their values are 'heard and seen' like the values of other stakeholders as suggested by the VCD approach (Manders-Huits & Zimmer 2007, Manders-Huits & Zimmer 2009).

A scientific ethological study of animal or organism behaviour in the Aquaponic system would be also beneficial. Currently there is no study done on this topic. A comparative study on the behaviour of the utilised organisms including plants under natural conditions, conditions in the Aquaponic system and conventional aquaculture conditions would be beneficial. There is also a question if the

Aquaponics is less cruel than the aquaculture due to the fact that the Aquaponics does not use antibiotics or any herb or pest control means.

Further research considering a theoretical framework for identifying the barriers hindering other technological developments connected to the innovations promoting the upper levels of the 'Lansink's Ladder', such as prevention, reuse, recycle and recovery of the resources, nutrients, energy and materials as emerging value-conscious socio-technical systems globally from the Industrial ecology perspective, based on the amendment and use of the final theoretical Piptová 2 (2020) framework shown in Table 8.1 is recommended. For this purpose, the general theoretical framework shown in Table 9.3 is also recommended to be adapted and used in the future cases.

Further research into the qualitative and quantitative short- and long-term benefits of innovations based on circularity in general, as mentioned in chapter 9.3.1. Further Policy Recommendations, is needed.

An additional research of various technology assessment frameworks according to different subdivisions is recommended. The Strategic niche management theoretical approach (Kemp et al. 1998) which is suitable for the local, few demonstrations accomplished early user niche cases or in the cases of low-tech innovations is recommended. It is based on the existence of visions and expectations, social networks building and broadening and learning processes developments in the first- and higher- order.

Further assessment based on identifying the malfunctions of the system in the area of events connected to the seven functions of Technological Innovation Systems according to Hekker & Negro (2009) is recommended for more high-tech cases. There are categories with various key events happening or lacking, and therefore, signalising if the system is stimulated in order to perform well or, on the contrary, hindered and malfunctioning in identified areas. A further research identifying the barriers by using the Suurs's distinction based on the fact that Technological Innovation System is influenced by the vitality and performance of the elements, such as Actors, Institutions, Technology factors, Relationships and Networks (Suurs 2009) is also recommended. According to Suurs (2009) there are five substructures: government structure, supply-side, demand-side, knowledge and intermediary structure. These are interlinked and influence each other. Their function and structure also determines if the system flourishes or if there are bottlenecks in certain areas.

The final theoretical Piptová 2 (2020) framework or the general framework for identifying the barriers could be adapted and used for identifying the barriers of various types of disruptive, incremental or frugal technology application cases and approaches mimicking the ecosystem by prevention, reuse, recycle and recovery of the resources, nutrients, energy and materials; and on the other hand, for identifying the barriers of the curative and wastage preventive measures in the anthropocentric and industrial metabolism. It is recommended to be utilised for technologies and approaches which recognise the benefits of a CE approach.

The research could consider technologies; such as nitrogen and magnesium- ammonium-phosphate recovery technologies; energy recovery technologies using waste biomass anaerobic digestion; municipal solid waste phosphorus recovery together with the forward osmosis, membrane distillation and electro dialysis as advanced technological approaches in the area of wastewater nutrient recovery, efficient high-temperature processing technologies; novel approaches aimed at eco-design and increasing the eco-efficiency for the future needs, such as green engineering and sustainable manufacturing along with product stewardship and service economy top-down and grassroots initiatives. In order to support the implementation of the above mentioned technologies and approaches in global, a research identifying barriers hindering the novel CE oriented management systems and beyond-national governance efforts stimulating eco-marketing strategies, eco-audits, eco-investments, green policy, business model innovations, extended network building and transnational industrial symbiosis creations is essential.

In all cases, it is recommended to implement the ethical perspective in the theoretical framework and the processes of identifying the barriers hindering a particular technology from the Industrial ecology and beyond disciplinary or sectoral prism due to the fact that technology does not exist in isolation, it is embedded in a social context. It is not value neutral. On the contrary, it is value laden and there are permanently stakeholders present actively or passively with various stakes in the technology development to be won or lost. Values are always at stake. Technology ought to be responsible and responsive.

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10.2. Interviews, Email/Personal/Phone Communication, Excursions and Tours

Interview with Andrei Radu Beca the Aquaponics Manager in Metabolic face to face 2020

Interview with Bouke Kappers the CEO of TGS Business & Development Initiatives over the phone 2020

Interview with Erik Moesker the founder of NoordOogst Aquaponics over the phone 2020

Interview with Geert Wilms representing the Non-profit organization partners from De Stuurgroep Landbouw Innovatie Noord – Brabant face to face 2020

Interview with Jos Hakkennes the founder of Duurzame kost face to face 2020

Interview with Roel Bosma who used to work for Wageningen University & Research over the phone 2020

Email communication with Anja Goossens from restaurant Nillesen from ’t Genot Vierlingsbeek 2020

Personal communication with stakeholders from the public Dan Engevik in Amsterdam, Merel van der Weyde in Leiden and Francesca Reichert in Medemblik 2020

Phone communication with Floor Visser the owner of Landzicht Biologisch 2020

Phone communication with Richard Sjerps the owner Kwekerij Sjerps 2020

Phone communication with Ertrit Engels the owner of Bonaventura 2020

Metabolic Aquaponic farm excursion 2020

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11. APPENDICES

11.1. STEEPLE Analysis

In this chapter, the STEEPLE analysis identifying Political, Economic, Social, Technological Environmental, Ethical and Legal factors influencing the Aquaponics is presented..

S for Social

- Trials for production and consumption in a socially and ecologically responsible manner (Duurzame Kost n.d.a), despite increased industrialization of the society.
- Aquaponics as a socio-technical innovation that fosters food innovation through inter-, trans-disciplinary collaboration between various sectors of the workforce as a form of technology diffusion (Junge et al. 2017). Trends "to bring the food back to the city" to the people who are currently disconnected from food production (Zasada 2011). Transform cities from being only consumers of food (Zezza & Tasciotti 2010). Participate in your food production.
- Degrowth perspective as an answer to sectoral issues in agriculture, resource wastefulness and as a call for radical consumption reduction (Sekulova et al. 2013).
- Produce and consume in a more sustainable, circular and ethical way. Know where your food is coming from. Increasing interest by consumers for high quality food products with a clear geographical origin (Luykx & Van Ruth 2008)
- Use unused spaces in the city and peri-urban areas to produce food (Smit & Nasr 1992).
- Novel business models among emerging ideas of highly complex circular and local economies. Lower proximity from the food production place to your plate. Food freshness and local production is appreciated (Dos Santos 2016).
- Education about Aquaponics for schools and anybody interested in the form of DIY Aquaponics workshops. Combined food production with tourism and educational purposes in the form of seminars, organized tours and classes in schools for vocational training. (Duurzame Kost n.d.a; De Ceuvel 2018a).
- Help disadvantaged communities by involving them into urban agriculture (Futuris Zorg & Werk n.d.).
- Obsession with health, healthy living and eating in the city (Bratman & Knight 2000).

T for Technological

- Circularity in design (Moreno et al. 2016), such as Cradle to cradle (McDonough & Braungart 2010).
- Efficient use of energy, water, materials and nutrients and minimize waste (McDonough & Braungart 1998).

- Use of renewables (Lund 2007).
- Increased technology usage (Parette et al. 2010).
- Use of Big data, Google trends and Google analytics in order to steer technology and vice versa (Dos Santos 2018, Thiyagaraj et al. 2018).
- Increased use of Blockchain (Kosba et al. 2016; Tapscott & Tapscott 2016).
- Low-tech solutions in developing countries. Aquaponics by hobbyists and 'backyard DIY' solutions by and for communities with no access to good quality food. On the other hand, efficient professional commercial hi-tech installations in developed countries (Milliken & Stander 2019).
- Increased automation and precision in operating systems/modules according to the precision agriculture reaching towards food security (Talebpour 2015).
- Improved organic material cycles in order to further close the loop, especially when it comes to fish feeds and use of novel species in Aquaponics (Milliken & Stander 2019).

E for Economic

- Reductions in working hours is a key variable in the novel Degrowth theories. The longer working hours and their contribution to GDP, the higher resources use and carbon emissions per country. Higher amount of working hours increases ecological footprints (Coot et al. 2010).
- Community-based initiatives in the field of sustainability and "amateur economy" with their social benefits are connected to less-energy intensive household activities than the paid-sector (Sekulova et al. 2013). According to the recommendations of a Degrowth paradigm, the reduced labour productivity is reached by moving production from the capital-intensive professional economy into the more labour-intensive amateur economy (Nørgård 2013).
- Increase in grassroots movements, local economics, peer-to-peer groups, open source information and bottom-up approaches (Pick 2012).

E for Environmental

- Collapsing diminishing ecosystems along with 60% decline in wild animal populations in just over 40 years due to human interventions (WWF 2016).
- Increasing population rate while overshooting environmental limits (Singh 2016).
- Adverse effects of anthropocentric activity cause environmental disasters including degradation of human and non-human health (Hill 2010).
- Scholars are becoming cognizant that the existing environmental Anthropocentric paradigm does not provide the knowledge and theoretical base to account for nowadays wicked problems (Milliken & Stander 2019).
- The current global anthropogenic impacts on the Earth's wellbeing is unprecedented in the 200,000 years of human history (Rosa et al. 2010).

- The global ecological footprint (EF) is double compared to the state in 1966 (Knight et al. 2013).
- Biodiversity diminishes, even when global conservation conventions are being put in place (Kleijn et al. 2011). Aquatic biodiversity as one of the indicators of environmental health is declining (Clausen & York 2008).
- Save the land and use any spaces available (Nonhebel 2005).
- Increasing water scarcity (Kummu et al. 2010) despite preventive measures.
- Increased efforts to not use artificial pesticides, fertilizers, hormones, harmful additives, antibiotics and other medication (Duurzame Kost n.d.,Theeuwen 2017).
- Measures to ensure food security in the twenty-first century within sustainable planetary boundaries (Konig et al. 2016).
- Need for multi-faceted agro-ecological intensification of food consumption and production along with the decoupling from unsustainable resource usage (Dobermann & Nelson 2013, International Cooperation and Development 2018).

P for Political

- The EU is showing increased interest in the Aquaponics (Hoevenaars et al. 2018).
- Need for skilled producers in sustainable and innovative technologies in order to face the new challenges in the global food demand and supply in the EU in order to provide food security and sustainability (Junge 2018).
- Green growth is the main strategy of mainstream economists and policy makers to address climate change (Dos Santos 2018).
- Rise of lifestyle diseases is fuelling a market for organic produce and governmental support for "healthy" eating policies (Miličić et al. 2017).

L for Legal

- Stricter regulation in food safety (Padel et al. 2009).
- Stricter law and regulation on environmental pollution and health hazards (Charter 2017).
- Employment law and regulation change due to technological advances transforming the world of work and society in general (Stone et al. 2017).
- The Netherlands has a tax-haven reputation (Somo.nl 2016), missed by one vote to be put on an official blacklist of tax havens by European parliament in December 2017 (Tani 2018). It has an internationally oriented tax system, therefore it is susceptible to improper use as conduit of offshore finance. Almost a quarter of fiscal constructions has a Dutch link (Khan 2018).
- Currently no specific regulations regarding the Aquaponics in the EU (Joly 2018).
- Aquaponics cannot be labelled as organic under European Commission Regulation (Miličić et al. 2017).

- There is no code for the Aquaponics but only separate codes for animal or plant production in the EU (Miličić et al. 2017). This makes registration of Aquaponic businesses inefficient and complicated due to the fact that producers must register twice (as both plant and animal producers).
- Aquaponics cannot be subsidised by the Common Agricultural Programs (CAP) (Miličić et al. 2017).
- Low transparency of business practices and supply chains (Somo 2018)

E for Ethical

- Need for transition from Anthropocentrism towards Ecocentrism in science (Kopnina 2012).
- New radical ideas of sustainable food systems and food itself as a commons anchored in social justice. New bonds of trust built among the participants. At this moment, the food system is enriching only a small number of people and simultaneously producing social, economic and environmental externalities depleting the world resources (Sumner 2011).

Current ethical consumption attitude–behaviour ‘gap’ (Carrington et al. 2016).

11.2. Technological Aspects of an Aquaponic System

The Aquaponics is an environmentally-friendly technology, where renewable and non-renewable resources are used efficiently, therefore waste is reduced (Sommerville et al. 2014). The design and application of the Aquaponics is multidisciplinary (Godek 2017). In an Aquaponic system, the living organisms are interconnected in a highly complex manner (Tyson et al. 2011). There is a circulating ichthyotoxic substance ammonia excreted by the fish in the system. The management of ammonia transforming into nutrients for plants, such as nitrogen and phosphorus, connected to a suitable pH level of water is crucial to the survival of the living organisms and their quality of life (Zou et al. 2016). This goes concurrently with the effort to achieve maximum yield potentials (Nichols & Savidov 2011) while decoupling the process from further material use. In the next section, the components and demands of an Aquaponic system are presented.

11.2.1. Components

Technology and equipment producers of Aquaponics have noticed an increased interest in Aquaponics in recent years. The focus has moved from elementary inexpensive kits and homemade DYI backyard units to more sophisticated industrial equipment combining traditional aquaculture and horticulture gear aspiring for more commercial scale production (Þórarinsdóttir et al. 2015).

The following are some of the typical material components and their functions in a Aquaponic installation:

- Tanks for the fish.
- Trays for placing the vegetables. Various kinds of plant trays can be utilised, such as floating rafts or flood and drain systems.

- A water pump which cares for recycled water recirculation. Water moves through plant mediums and then back into the fish tank.
- Plants are rooted in mediums. These support their roots.
- Water is aired with oxygen by an air pump with an automated timer for an on/off switch.
- Tubing and Air stones bring water in.
- Water is filtered by utilising various kinds of bio-filters.
- Undigested fodder, biofilm and other fine particles floating in the water are collected into a settling sink
- Sump basin to collect runoff water (Danner 2016).

There are fish, plants and ubiquitous bacteria as the main biological components in an Aquaponic system as described in Figure 11.1. The actions of each biological component in relation to the Aquaponic system is crucial for the circulation of nutrients and water in the system. Air and water pumps ensure that circulation continues. Fish are fed, the ammonia in their excrement gets transformed by bacteria and provides nutrients for the plants (Somerville et al. 2014).

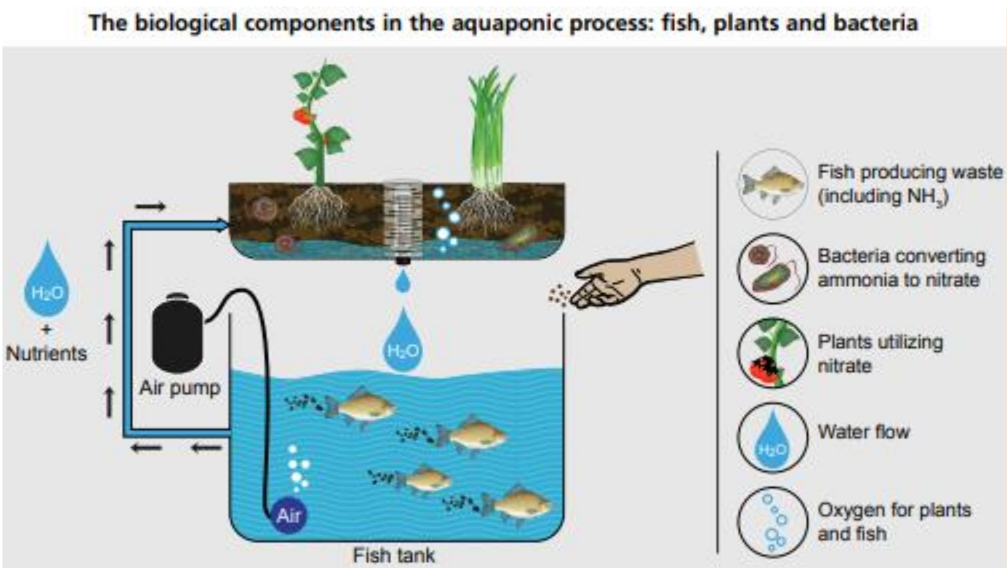

Figure 11.1 The biological components of an Aquaponic system and their performed actions (Somerville et al. 2014). The actions of each one in relation to the Aquaponic system are labelled, showing the cycle of nutrients and water circulating in the system. Air and water pumps ensure that circulation continues. Fish are fed, the ammonia in their excrement gets transformed by bacteria and provides nutrients for the plants.

The nitrogen cycle in the Aquaponics is crucial. In Figure 11.2, a simplified representation of the nitrogen cycle is illustrated. Via nitrogen fixing, the elemental nitrogen becomes available for uptake by living organisms in a closed loop. It happens in the form of ammonia or nitrate. Nitrogen circulates within the food chains. Every Aquaponic organism: the fish, ammonia-breaking bacteria, and plants has its function in this cycle (Somerville et al. 2014).

Nitrogen flow chart in an aquaponic system

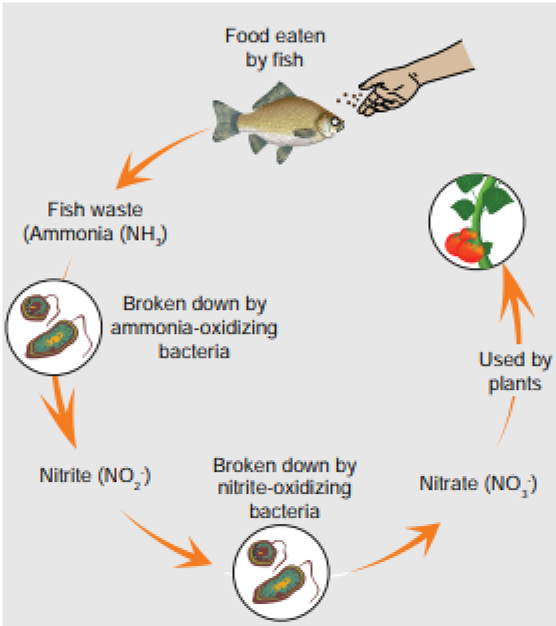

Figure 11.2 The nitrogen cycle present in an Aquaponic system (Somerville et al. 2014).The process of nitrogen fixing causes that the elemental nitrogen can be up taken by living organisms in a closed loop manner. It happens in the form of ammonia or nitrate. Nitrogen circulates within the food chains. Every Aquaponic organism: the fish, ammonia-breaking bacteria, and plants has its function in this cycle.

11.2.2. Demands

The nitrogen cycle present in an Aquaponic system (Somerville et al. 2014).The process of nitrogen fixing causes that the elemental nitrogen can be up taken by living organisms in a closed loop manner. It happens

In order for an Aquaponic system to be functioning well, it must fulfil certain criteria. For maintaining a healthy bacterial colony, it is important to check:

Living area for the fish and plant species

PH and temperature

Oxygen balance

Ultraviolet light levels

Fine-tuning of the ecosystem

Levels of nitrates

Feed rate ratio for fish and plants

Fish and plants health and wellbeing

Nitrogen amount per water amount (Godek 2017)

There needs to be a certain balance in the system. In Figure 11.3 and Figure 11.4 the main feed, water, fish ratio demands and other important variables are shown. The knowledge of these ratios is crucial for the survival of the Aquaponic system. When calibrating the system, as shown in Figure 11.3 the system capacity, means of production, type and mix of used organisms, environmental conditions and filtration techniques need to be checked. There is 40-50 grams of fish fodder per square meter daily needed when growing leafy vegetables and 50-80 grams of fish fodder per square meter daily needed when producing fruiting ones (Somerville et al. 2014).

The main variables to consider when balancing a unit

- At what capacity will the system function.
- Method of aquaponic production.
- Type of fish (carnivorous vs. omnivorous, activity level).
- Type of fish feed (protein level).
- Type of plants (leafy greens, tubers or fruits).
- Type of plant production (single or multiple species).
- Environmental and water quality conditions.
- Method of filtration.

Recommended daily fish feed rates are:

- for leafy green vegetables: **40–50 grams of feed per square metre per day**
- for fruiting vegetables: **50–80 grams of feed per square metre per day**

Figure 11.3 The variable and ratios in a healthy Aquaponic system (Somerville et al. 2014). Calibration of the system requires checking its capacity, means of production, type and mix of used organisms, environmental conditions and filtration style. There is 40-50 grams of fish fodder per square meter daily needed when growing leafy vegetables and 50-80 grams of fish fodder per square meter daily needed when producing fruiting ones.

In Figure 11.4 it is illustrated that if one wants to harvest 25-30 grams of fish and 35-40 grams of veggies per day, the system requires 500 litres of water, can contain 50 kilograms of tilapia or 30 kilograms of koi or 60 kilograms of goldfish which produces nutrients for 120 pieces of lettuce or 280 tomato plants or 330 pieces of basil herbs. Fish need to be fed 3 times a day each time with 200-280 grams of fodder (Ros 2015).

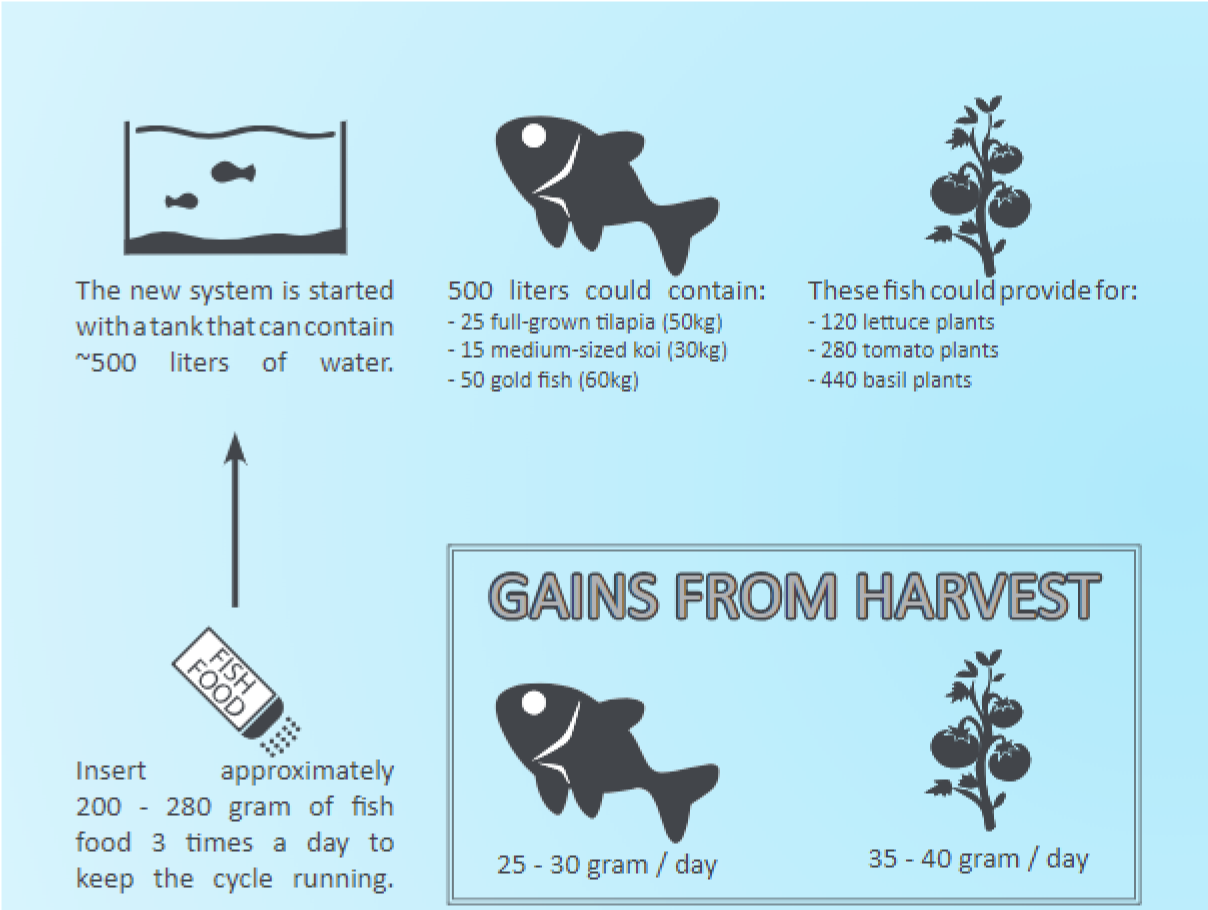

Figure 11.4 Summary of demands calculations in a healthy Aquaponic system (Ros 2015). In order to harvest 25-30 grams of fish and 35-40 grams of veggies per day, the system requires 500 litres of water, can contain 50 kilograms of tilapia or 30 kilograms of koi or 60 kilograms of goldfish which produces nutrients for 120 pieces of lettuce or 280 tomato plants or 330 pieces of basil herbs. Fish need to be fed 3 times a day each time with 200-280 grams of fodder.

In Figure 11.5 a DIY Aquaponic system that does not function well is presented. The fish tank is murky and overcrowded, with the algae growth potentially due to the bacteria not converting the ammonia efficiently and the plants being unable to access the nutrients from the fish waste. In order to avoid this, the system needs to be all the time observed, controlled and balanced.

Figure 11.5 A "DIY" unhealthy Aquaponic system with a potential build-up of algae and fish waste (Know Stuff 2018).

11.3. Stakeholders Contact Data

In this section the stakeholders data according to their role in Aquaponics development are provided.

Current Aquaponic producers

Name of stakeholder: Duurzame Kost

Type of stakeholder: Current Aquaponic producers

Description: Foundation Duurzame Kost and Duurzame Kost City Farm work together with Futuris Zorg & Werk employing autistic youngsters.

Website: http://www.duurzamekost.nl/

Email: info@duurzamekost.nl

Contact person: Jos Hakkennes

Address: Torenallee 96-02, 5th floor of 't Veem warehouse in Eindhoven, before De Steeg 8b in Vortum Mullem.

Phone: 06 51 83 17 39

Notes: university.upstartfarmers.com/blog/aquaponics-autism-netherlands

https://www.circulairondernemen.nl/cirkel/voedselverspilling-in-de-circulaire-economie/oplossingen/duurzame-voedselproductie-door-hergebruik-voedingstoffen https://www.ad.nl/eindhoven/vissen-en-groenten-kweken-in-het-veemgebouw-op-strijp-s-in-eindhoven~a009cae8/

Name of stakeholder: Blue Acres

Type of stakeholder: Current Aquaponic producers

Description: Blueacres joined CrossRoads2 stimulation program together with Smart Farmers BVBA (founders of bankrupted Urban Farmers Den Haag) with Subsidy amount:

€ 135,000 from EU and Interreg Vlaaanderen-Nederland (CrossRoads2, n.d.) .Blue Acres works together with Vasch Aquaponics from Belgium selling Aquaponics material in Aquaponics Webshop (Blueacres.nl, 2018).

Website: http://www.blueacres.nl/

Email: jos@blueacres.nl

Contact person: Jos Hakennes

Address: De Steeg 8, 5827 AE Vortum-Mullem

Phone: 06 51831739

Notes: Jos Hakennes is active in Blue Acres, Duurzame kost and Agrofoodpluim. Blue Acres works together with Vasch Aquaponics from Belgium.
https://www.brabant.nl/actueel/nieuws/2017/mei/agrofoodpluim-voor-blue-acres

https://www.crossroads2.eu/projectresultaten/gecombineerde-teelt-van-vissen-en-planten-optimaliseren

Name of stakeholder: Metabolic Lab @ De Ceuvel

Type of stakeholder: Current Aquaponic producers

Description: Urban regeneration project, using aquaponics to grow vegetables and herbs for a small cafe. Described as a "cleantech" playground, with a focus on building a community whilst also regenerating the heavily polluted land they occupy. Solar panels, heat exchanges, and phytoremediation are all used to create a more sustainable and "circular" community,

Website: http://deceuvel.nl/en/boats/metabolic-lab/

https://www.metabolic.nl/advancing-aquaponics-metabolic-greenhouse/

Email:tycho@deceuvel.nl

Contact person: Saro Van Cleynenbreugel

Address: Association De Ceuvel, Korte Papaverweg 2, 1032 KB Amsterdam

Phone: +31 (0) 202296210

Notes: Partner with a variety of organizations : Metabolic, Urgenda , WaterNet, Gemeente Amsterdam, Advantage Metropolitan Solutions, Space & Matter , Amsterdam university and Stichting Doen.

Name of stakeholder: Mediamatic Fabriek

Type of stakeholder: Current Aquaponic producers.

Description: Aquaponics greenhouse, offering tours, workshops, and consultancy, as well as internship opportunities. The group focuses heavily on sustainability and the 'beauty' of reconnecting with food production. They post regular blogs to boost community engagement and make aquaponics more accessible, relying heavily on visuals.

Website: https://www.mediamatic.net/en/page/74034/aquaponics

Email: mail@mediamatic.nl

Contact person: Emma van Wolferen (Communications and press manager)

Address: Mediamatic Dijkspark. Dijksgracht 6, 1019 BS Amsterdam

Phone:+31(0) 20 638 9901

Notes: Mediamatic is a cultural institution dedicated to new developments in the arts since 1983. They provide lectures, workshops and art projects, focusing on nature, biotechnology and art+science within a strong multicultural network. Mediamatic is sponsored by Mondriaan Fonds, Stimuleringsfonds voor de Creatieve Industrie and Amsterdams Fonds voor de Kunst but due to the fact that there was no information found about the connection of these organizations to Aquaponic installation of Mediamatic, these connections are not presented in Figure 5.1.

Name of stakeholder: TGS Business & Development Initiatives TGS Aquaponics

Type of stakeholder: Current Aquaponic producers. Also researcher. Model farm.

Description: Aquaponics model farm researching cultivation processes in Driel, accompanied by an Aquaponic system set up in Awassa, Ethiopia. The parent company (TGS) focuses supporting small-scale social-entrepreneurship, offering support and assistance in finding finance. The Aquaponics unit belongs to their research and development arm and is hoping to fine tune the Aquaponic system through small scale experimentation, before scaling it up.

Website: http://tgsbusiness.com/tgs-aquaponics-netherlands/

https://www.nwo.nl/en/research-and-results/research-projects/i/45/12845.html

https://www.wur.nl/en/newsarticle/aquaponics_systems_in_urban_backyards.htm

Email: TGS: Info@tgsbusiness.com

WUR: Maja.Slingerland@wur.nl

Contact person: dr.ir. MA (Maja) Slingerland (WUR). +31 (0) 317483512

Location: TGS, Dreijenlaan 2, 6703 HA Wageningen. The Netherlands

Phone: +31 (0) 317311212

Notes: The aquaponics model farm is in Driel, the Netherlands. This small aquaponics unit has allowed us to fine-tune our designs in cooperation with students and researchers from Wageningen University & Research.

Name of stakeholder: NoordOogst Aquaponics

Type of stakeholder: Aquaponic producer

Description: Aquaponic producing focusing on Marine aquaponics and the development of salt water systems with an interest in social sustainability. Collaborating with other researchers and disciplines to make systems more accessible and sustainable. They work towards principles of circularity, sustainability, short-chain, and nature exclusivity. Their primary aim is towards social impact, namely reducing world hunger and malnutrition.

Website: https://noordoogst.nl/

Email: info@NoordOogst.nl

Contact person: Erik Moesker

Location: Visiting address: Suikerlaan 43/9743 AD Groningen

Postal address: Hoornsediep 89B / 9727 GG Groningen

Phone: 06 55 77 28 55

Notes: Partnered with ID3AS, Hanze Institute of Technology in Assen, Alex van Spyk (Partner in Synr3), Jan Veenstra (Architect), and in discussion with the Alfred Wegener Institute from Bremerhaven.

Former Aquaponic producers

Name of Stakeholder: Uit je eigen stad

Type of stakeholder: Former Aquaponic producers, urban farmer, and cafe/restaurants

Description: Aquaponic and urban farming organisation - city farm, facing financial difficulties, mentions to aquaponics on their website are now absent. At the beginning of 2016, Aquaponic UJES unit was declared bankrupt (Mulders, 2017). The farm runs community BBQs, farm tours and volunteer workshops, as well as running an onsite cafe and produce shop. The focus is one reconnecting people with food production in the city.

Website: http://www.uitjeeigenstad.nl/

Email: restaurant@uitjeeigenstad.nl, productie@uitjeeigenstad.nl

Contact person: Huibert de Leede

Address: Marconistraat 39, 3029 AG Rotterdam

Phone: +31 (0) 10 8208909

Notes: With the used fields covered with greenhouses, food production is returned to the city. The harvest from the land goes straight to the restaurant. http://www.urbangreentrain.eu/inventory/pdf/UIT%20JE%20EIGEN%20STAD_full%20case.pdf

Name of stakeholder: Urban Farmers Den Haag

Type of stakeholder: Former Aquaponic producers.

Description: It used to be the largest city farm in Europe. Two newly designed floors in a older Philips factory in the Hague, with one dedicated to fish (Tilapia) and the other to vegetables, altogether producing 32 products. These were sold in a farmers market held on the ground floor of the market. Declared bankrupt in July 2018 (Ketelaar, 2018), they are now searching for new investors. This was till now the second largest Aquaponic producer in Europe. Swiss Smart Farmers BVBA founded it.

In May 2018 Europe's Largest City Aquaponics Farm "Ferme Abattoir" opened built on rooftop of Foodmet Arable in Anderlecht, Brussels. It was partially funded by BIGH's equity financing which raised €4.3m, and partly in a debt facility from BNP Paribas Fortis bank (Burwood-Taylor, 2018). Website: N/A due to bankruptcy, information found on

https://www.facebook.com/UFDeSchilde/

https://www.instagram.com/urbanfarmersnl/,

https://www.ad.nl/den-haag/europaenrsquo-s-grootste-stadsboerderij-urban-farmers-in-den-haag-is-failliet~af7227c2/

Email: ufdeschilde@urbanfarmers.com

Contact person: Andreas Graber en Roman Gaus

Address: Televiestraat 2, 2525KD The Hague

Phone: +31 (0) 70 4492815

Notes: Urban Farmers was a rooftop farm in The Hague. The visit to the Farm was free and was possible to enjoy a fresh coffee, shop your ultra-fresh veggies and fish or simply enjoy the breathtaking view. https://www.nrc.nl/nieuws/2018/08/09/dakboeren-is-sexy-acht-euro-voor-een-kilo-tomaten-niet-a16https://www.nrc.nl/nieuws/2011/03/19/lof-van-het-dak-12006228-a17592212629

https://www.nrc.nl/nieuws/2011/03/19/lof-van-het-dak-12006228-a175922

There used to be the following Aquaponics bodies in the Netherlands which are non-active:

Uit je eigen stad Aquaponic unit in Rotterdam active 2014 - 2016 (Mulders, 2017).

Urban Farmers in Den Haag active 2016- 2018 (Ketelaar, 2018).

De Groene Liefde in Boskoop (Fresta, n.d.). Information N/A

Trial project Eco Futura project by Priva (process automation and control), GreenQ (horticultural technology), Groen Agro Control (chemical and microbiological strategies - lab research) and Aqua-Terra Nova (water and land use management) (Cyclifier, n.d.). Information N/A

Aquaponics installation in cooperation with Greenhouse Improvement Centre in Bleiswijk (Mediamatic, n.d.).

Aquaponicslab de Mengfabriek in Den Bosch. Information N/A

Iforesee in Den Haag active 2014- 2016 (Fresta, n.d.). Information N/A

AOC Almelo Aquaponics system by TGS active 2016 - 2017 (Tgsbusiness.com, n.d.).

Not active Aquaponics businesses:

Aquaponics Europe B.V. inj Goutum selling Aquaponics equipment in 2014.

Not active Aquaponics organizations and websites:

Facebook Aquaponics Nederland https://www.facebook.com/AquaponicsNederland not active since 2017

The EU Aquaponics Hub was a four year (2014-2018) project supported by the EU COST Action (FA1305). During its final conference in London in April 2017 a new organization called EU Aquaponics Association (EUAA) was founded.

In 2014 was active a “table project” De Transitietafel Aquaponics Noord- Nederland by Peter van Vliet, TT Aquaponics Noord-Nederland, TT Stadslandbouw Noord-Nederland to popularize Aquaponics as an efficient and cost-effective food production technique (Noordenduurzaam.nl, 2014).

National and transnational governmental organizations

Name of stakeholder: Municipality Amsterdam

Type of stakeholder: National and transnational governmental organizations

Description: City of Amsterdam

Website: https://www.amsterdam.nl/

Email: (Email form: https://formulieren.amsterdam.nl/TripleForms/DirectRegelen/formulier/nl-NL/evAmsterdam/scKlachtenformulier.aspx/fKlachtenformulierIntro)

Contact person: N/A

Address: Am-stel 1, Amsterdam

Phone: 14 020

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: The EU Aquaponics Association (EUAA)

Type of stakeholder: National and transnational governmental organizations

Description: It was created in April 2017, during the final conference of the EU Aquaponics Hub in London in order to foster the dialogue about Aquaponics, consumer education, food safety and used technology in the EU and globally (Milliken, 2018).

Website: https://euaquaponicshub.com/eu-aquaponics-association/ Separate actual The EU Aquaponics Association (EUAA) website N/A yet.

Email: b.kotzen@gre.ac.uk or Contact form:

https://euaquaponicshub.com/contact/

Contact person: Dr Benz Kotzen - Action Chair

Address: N/A

Phone: N/A

Notes: Cooperates with COST Horizon 2020 (biggest EU Research and Innovation programme ever with €80 budget for seven years from 2014 till 2020 (Horizon 2020, n.d.).

Name of stakeholder: The EU Aquaponics Hub

Type of stakeholder: Former National and transnational governmental organizations

Description: The EU Aquaponics Hub was a four year COST Action (FA1305) project, which ran from 2014-2018. During the final conference, the EU Aquaponics Association (EUAA) was created to continue with the hubs aims. The Hub was initiated to promote innovation and network building by a group of researchers and commercial Aquaponic companies.

Website: https://euaquaponicshub.com/

Email:b.kotzen@gre.ac.uk

Contact person: Dr Benz Kotzen

Address: N/A

Phone: N/A

Notes: Partnered or sponsored by COST (European Cooperation in Science and Technology), EU Framework Programme Horizon 2020 and The University of Greenwich

Name of stakeholder: Municipality Aalburg

Type of stakeholder: National and transnational governmental organizations

Notes: Connected with Blue Acres. https://kybys.nl/werkvelden/natuur-en-water/herbestemmen-zwembad-veldzicht-genderen

Contact: Via email form

Research and knowledge groups

Name of stakeholder: Wageningen University & Research

Type of stakeholder: Research and Knowledge groups

Description: University and research group working with an aim to accelerate the opportunities that nature provides in order to increase the quality of our life also through better food security. Participated in 3 accomplished projects:

Project Innovative Aquaponics for Professional Application (INAPRO) with Project leader dr.ir. HM (Henrice) Jansen in cooperation with the Ministry of Economic Affairs and Climate Change (WUR, 2017f). Start project: Jan 1, 2017 End project: Dec 31, 2017. It aimed at improving the integration of innovative technologies to save water, energy and nutrients (Inapro-project.eu, n.d.).

Aquaponics project in Awassa, Ethiopia by Bouke Kappers, a MSc-student and dr.ir. MA (Maja) Slingerland (WUR, 2015). Project partners were TGS Business & development initiatives, GCM and Addis Ababa Universty, funded by NWO-WOTRO.

Project of Dr.ir. RH (Roel) Bosma from the research group Aquaculture and Fisheries at Wageningen University & Research (leerstoelgroep Aquacultuur en Visserij van Wageningen Universiteit) (Bosma et al., 2017; Sikkema, 2017).

Opportunities and Challenges of Multi-Loop Aquaponic Systems. PH.D. (Godek 2017) were also published at Wageningen University.

Website: www.wur.nl

Contact person, email and phone:

dr.ir. MA (Maja) Slingerland

Maja.Slingerland@wur.nl

+31317483512

dr.ir. HM (Henrice) Jansen

https://www.wur.nl/en/contact_form.htm?contactpersonid=124067

+31317486168

dr.ir. RH (Roel) Bosma

https://www.wur.nl/en/contact_form.htm?contactpersonid=5531

+31317483861

Dr.ir. RH (Roel) Bosma who used to work for Wageningen University & Research and was a part of a research group Aquaculture and Fisheries at Wageningen University & Research (Leerstoelgroep Aquacultuur en Visserij van Wageningen Universiteit) (Bosma et al. 2017, Sikkema 2017).

Notes: Wageningen University & Research has cooperated also with TGS Business & development initiatives focusing on the integration of innovative technologies to save water, energy and nutrients, GCM and Addis Ababa Universty, Belgian INAPRO (Innovative Aquaponics for Professional Application) focusing on the integration of innovative technologies to save water, energy and nutrients.

Name of stakeholder: HAS Hogeschool Den Bosch

Type of stakeholder: Research and Knowledge groups

Description: School cooperating with Duurzame kost focusing on education and projects connected to city food, technology and regenerative agriculture

Website: https://www.hashogeschool.nl/

Email: N/A

Contact person: N/A

Address: Onderwijsboulevard 221, 5223 DE ’s-Hertogenbosch

Phone: 088 - 890 36 00

Notes: Partner of Duurzame kost.

Name of stakeholder: University of Amsterdam

Type of stakeholder: Research and Knowledge groups

Description: Co-ran a summer school focusing on the Circular Economy, using Amsterdam as a case study

Website: http://summerschool.uva.nl/content/summer-courses/the-circular-city-towards-a-sustainable-urban-ecosystem/the-circular-city-towards-a-sustainable-urban-ecosystem.html

Email: M.Giezen@uva.nl

Contact person: dhr. dr. M. (Mendel) Giezen

Address: Nieuwe Achtergracht 166

1018 WV Amsterdam

Phone: 0655406346

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: Hanze Institute of Technology in Assen or Groningen

Type of stakeholder: Research and Knowledge groups

Description: Institute focusing on Energy, entrepreneurship and healthy ageing. The first Fairtrade-certified university in the Netherlands (Hanze.nl 2017).

Website: www.hanze.nl/eng/education/engineering/school-of-engineering

Email: info@org.hanze.nl

Contact person: Alex van Spyk (Partner in Synr3 and member of Hanze Institute of Technology)

Address: Van OlstToren, Zernikeplein 7, 9747 AS Groningen

Phone: +31 (0) 50 595 55 55

Notes: Partner with NoordOogst Aquaponics

Address: Hanzehogeschool Groningen

Zernikeplein 11, B1.44

9747 AS Groningen

Phone: +31505957009

Email:a.p.d.van.spyk@pl.hanze.nl

Website: https://www.hanze.nl/nld/onderzoek/kenniscentra/kenniscentrum-noorderruimte/onderzoeksprojecten-uitgelicht/projecten-in-de-etalage/duurzame-dorpen/onderzoekers/onderzoekers/alexvanspijk

Name of stakeholder: Jan Veenstra (Architect)

Type of stakeholder: Research and Knowledge groups

Description: Architect who designed the set-up for a salt water Aquaponic system with fish, seaweed and sea vegetables

Website: http://www.veenstra-bna.nl/www.veenstra-bna.nl/contact_gegevens.html

Email:info@veenstra-bna.nl

Contact person: Jan Veenstra

Address: Korreweg 114-A

9715 AJ Groningen

Phone: 06 25 09 88 98

Notes: Partner with NoordOogst Aquaponics

Name of stakeholder: Alfred Wegener Institute (Bremerhaven)

Type of stakeholder: Research and Knowledge groups (in discussion)

Description: Centre for Polar and Marine research, focusing on understanding complexities of system Earth.

Website: https://www.awi.de/en.html

Email: Contact form: https://www.awi.de/en/about-us/service/contact.html

Contact person: N/A

Address: Alfred-Wegener-Institut (AWI), Am Handelshafen 12, 27570 Bremerhaven

Phone: N/A

Notes: Partner with NoordOogst Aquaponics

Name of stakeholder: Addis Ababa University

Type of stakeholder: Research and Knowledge groups

Description: Aims to improve conservation and biodiversity of Ethiopian fresh water fish, and improve dietary breadth and food security of lower income communities.

Website: http://www.aau.edu.et/

Email: abebeg@bio.aau.edu.et

Contact person: Dr Abebe Getahun

Address: College of Natural Sciences, Addis Ababa University, Ethiopia

Phone: 0118 95 92 17

Notes: Partner with TGS Aquaponics

For-profit firms and partners - supply side

Name of stakeholder: KYBYS engineers and consultants

Type of stakeholder: For-profit firm partners

Description: Consultancy and engineering firm. In 2017 operation of Marcel van Gendt with Blue Acres. Part of Kybys professionals and Kybys contracting.

Website: https://kybys.nl/

Email: info@kybys.nl

Contact person: N/A

Address: Herenweg 115 , 2105 MG Heemstede.

Phone: +31(0) 411678055

Notes: Partner of Blue Acres.

Name of stakeholder: Aquaponics Webshop

Type of stakeholder: For-profit partners

Description: Blue Acres (Jos Hakennes also active in Duurzame kost) works together with Vasch Aquaponics from Belgium selling Aquaponics material in Aquaponics Webshop (Blueacres.nl 2018). Offers Dutch and Belgian aquaponics systems: demo, design, construction, integration of social projects, sales of materials, fish and vegetables.

Website: https://www.aquaponicsshop.eu/

Email: jos@blueacres.nl

Contact person: Jos Hakennes

Address: De Steeg 8, 5827 AE Vortum-Mullem

Phone: 06 51831739

Notes: Jos Hakennes is active in Blue Acres, Duurzame kost and Agrofoodpluim. Blue Acres works together with Vasch Aquaponics from Belgium.
https://www.brabant.nl/actueel/nieuws/2017/mei/agrofoodpluim-voor-blue-acres

https://www.crossroads2.eu/projectresultaten/gecombineerde-teelt-van-vissen-en-planten-optimaliseren

Name of stakeholder: Futuris Zorg & Werk bv

Type of stakeholder: For-profit firm partners

Description: Partner of Duurzame kost Futuris Zorg & Werk supports vulnerable disadvantaged (including 0 (young) adults through integral guidance on the way to maximum self-reliance and self-efficacy in a respectful manner on their way to learn to make independent choices about living, self-care and working. Through an integrated approach they increase the social and economic self-reliance of the participants enrolled in their integration programmes, while reducing healthcare costs (Futuris Zorg & Werk, 2018). To participate in a Futuris work project, an assignment or decision for integration is required from the municipality or UWV. Futuris has various contracts with the municipality of Eindhoven and surrounding municipalities within the framework of Social Activation and WorkFit projects. They offer to their clients work placing at the Duurzame kost (urban agricultural project found on the 5th floor of the Veemgebouw, at the Torenallee on Strijp-S) in the following type of working activities:

“Process control by measuring all kinds of data on a daily basis

Sow, transfer and again transfer plants, always in larger containers

Harvesting and washing of vegetables

Daily control of the growth process

Distribution to the different restaurants and other customers

Maintenance of working space and materials

Financial administration

Sales of fish on Fridays" (Futuris Zorg & Werk, 2018).

Website: https://www.futuriszorgenwerk.nl/

Email: info@futuriszorgenwerk.nl, CR@futuriszorgenwerk.nl

Contact person:

Chairman:

Thursten van der Werff

Treasurer:

Tim Hustinx

Frank van Delden

Secretary:

Robby Kluitmans

Address: Raiffeisenstraat 3A, 5611 CH, Eindhoven

Phone: 040 251 90 35

Notes: Partner of Duurzame kost

Name of stakeholder: Philips Lighting

Type of stakeholder: For-profit firm partners

Description: Engineering firm. Company providing the special LED growth lighting system for Aquaponics installation of Duurzame kost in Eindhoven (Theeuwen, 2017).

Website: http://www.lighting.philips.nl/home

Email: N/A

Contact person: N/A

Address: Boschdijk 525, 5600 KA Eindhoven

Phone: +31 40 275 00 00

Notes: Partner of Duurzame kost

Name of stakeholder: Sint Trudo

Type of stakeholder: For-profit organization partners

Description: Partner of Duurzame kost with a mission 'Supporting People'. Real estate company that owns of the Veemgebouw where Duurzame kost has its Aquaponics installation (Ed.nl, 2016; Duurzame Kost, 2018). Together with the many parties in their network, Sint Trudo aims to facilitate social growth on four social scales: living, learning, working and leisure while providing good housing conditions.

Website: https://www.trudo.nl/

Email: trudo@corpsupport.nl

Contact person: Jack Hock - landlord on behalf of the Sint Trudo housing corporation (Theeuwen, 2017)

Address: Torenallee 34, 5617 BD Eindhoven

Phone: 0800 - 88 88 811

Notes: Partner of Duurzame kost.

Name of stakeholder: Space & Matter

Type of stakeholder: For-profit firm partners

Description: Architect with interest in sustainable design, also worked with Urban Farmers in Den Haag

Website: http://www.spaceandmatter.nl/home

Email: info@spaceandmatter.nl or marjolein@crowdbuilding.nl or marjolein@smeelearchitecture.com

Contact person: Marjolein Smeele

Address: Johan van Hasseltkade 306

1032 LP Amsterdam

Phone: +31 (0)20 630 6590

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: WaterNet

Type of stakeholder: For-profit firm partners

Description: Water company for Amsterdam and the surrounding area.

Website: https://www.waternet.nl/en

Email: simone.berkhout@waternet.nl

Contact person: Simone Berkhout

Address: Stichting Waternet

Korte Ouderkerkerdijk 7

1096 AC Amsterdam

Phone: 06 10 70 44 01

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: ID3AS

Type of stakeholder: For-profit firm partners

Description: Consultancy and engineering firm. ID3AS functions as a collaboration between the Hanzehogeschool and the Hochschule Osnabrück, with the aim of stimulating the economy in the German-Dutch border region, and the application of sensor technology

Website: http://www.id3as.org/

Email: id3as@org.hanze.nl

Contact person: Joke Bruining

Address: Hanze University of Applied Sciences

Zernikeplein 11, 9747 AS Groningen

Phone: +31 623 044 268

Notes: Partner with NoordOogst Aquaponics

Non-profit organization partners

Name of stakeholder: De Stuurgroep Landbouw Innovatie Noord – Brabant (Stuurgroep LIB)

Type of stakeholder: Non-profit organization partners

Description: In 2016 the Steering Group for Agriculture Innovation Brabant supported "the new farmers" Duurzame kost urban Aquaponics project in an old Philips production hall at StrijpS in Eindhoven with a financial contribution in 2016 (Ed.nl, 2016). It is a joint venture between the Province of North - Brabant and the Southern Agriculture and Horticulture Organisation (ZLTO) with the aim of working together on a sustainable and vital agriculture and horticulture that contributes to the quality of the countryside. Geert Wilms

Website: http://www.stuurgroeplib.net/

Email: geertwilms@stuurgroeplib.net, marjonkrol@stuurgroeplib.net

Contact person: Geert Wilms - Secretary Steering Group LIB, Marjon Roller - Project Manager

Address: Onderwijsboulevard 225, 5233 EB Den Bosch

Phone: Geert Wilms: 073 - 2173620,   Marjon Krol: 073 - 2173234

Notes: Supporter of Duurzame kost in 2016 with one time financial contribution.

Name of stakeholder: Urgenda

Type of stakeholder: Non-profit organization partners

Description: Partnering with Metabolic to analyse potential for the Circular economy and raw material flows in Friesland

Website: https://www.urgenda.nl/themas/produceren/circulair-fryslan/

Email: info@urgenda.nl

Contact person: Christiaan Kuipers

Address: New Energy Docks Foundation

Distelweg 451 (previously 113)

1031 HD Amsterdam

Phone: 020 - 33 00 566

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: Foundation Doen

Type of stakeholder: Non-profit organization partners

Description: Financier focused on green, social and creative enterprises, with support from loans, subsidies, and charity lottery, supporting people from entrepreneurship actively working on innovative solutions for a better world.

Website: https://www.doen.nl/home.htm

Email: doen@doen.nl

Contact person: N/A

Address: Van Eeghenstraat 70

1071 GK Amsterdam

Phone: 020 - 573 7333

Notes: Partner with Metabolic @ De Ceuvel

Name of stakeholder: Zeewierplatform (Noordzee Boerderij)

Type of stakeholder: Non-profit organization partners

Description: Working to develop the sustainable seaweed sector and platform to share knowledge.

Website: https://www.noordzeeboerderij.nl/

Email: koenvanswam@noordzeeboerderij.nl

Contact person: Koen van Swam

Address: Zeestraat 84

2518 AD The Hague

Phone: +31 (0) 6 53 52 60 89

Notes: Partner with NoordOogst Aquaponics

Name of stakeholder: Toentje

Type of stakeholder: Non-profit organization partners

Description: A social enterprise working to grow fresh produce for the Groningen food bank in a sustainable and professional way, with the aim to alleviate poverty. Initiative of Jos Meijers, municipality Groningen and the City foodbank.

Website: http://www.toentje.nl/

Email: Contact form: http://www.toentje.nl/stuur-ons-een-berichthttp://www.toentje.nl/stuur-ons-een-bericht

Contact person: Jos Meijers

Address: Paradijsvogelstraat 10, 9713 BV Groningen

Phone: N/A

Notes: Partner with NoordOogst Aquaponics

Name of stakeholder: Graanrepubliek

Type of stakeholder: Non-profit organization partners

Description: Cooperation between farmers and grain processing companies to encourage and support a local economy and the growth of a variety of grains.

Website: https://www.graanrepubliek.nl/

Email: info@graanrepubliek.nl

Contact person: N/A

Address: Oudezijl 1

9693 PA Bad Nieuweschans

Phone: +31 599 312 611

Notes: Partner with NoordOogst Aquaponics

For profit firms and partners - demand side - Shops and restaurants

Name of stakeholder: Cucina Italiana

Type of stakeholder: Shops and restaurants

Description:

Website: http://www.cucina-italiana.eu

https://www.instagram.com/p/BnDp8rnDGTY/?taken-by=cucinare_italia

Eindhoven, Noord-Brabant

https://www.instagram.com/explore/locations/222130485/eindhoven-noord-brabant/

Email:info@cucina-italiana.eu

Address: Torenallee 86-02, 5617 BD Eindhoven.

Phone: 06 24217102

Notes: Sells Duurzame kost products

Name of stakeholder: ’t Genot in Vierlingsbeek

Type of stakeholder: Shops and restaurants

Description: Restaurant providing selling fish & veggies by Duurzame kost, former Blue Acres, owner of a Blue Acres aquaponics system on its terrace since September 2015.

Website: https://www.t-genot.nl/

Contact person: Anja Goossens – Nillesen

Phone:

Address: Spoorstraat 49, 5821BC Vierlingsbeek.

Phone: +31 (0)478631669

Notes: Selling products by Duurzame kost, former Blue Acres.

https://www.eet.nu/oosterwijtwerd/veldzicht

http://www.venrayboeit.nl/index.php/zakelijk/item/1343-pannenkoekenrestaurant-t-genot-ambachtelijk-puur-natuur-en-innovatief-een-van-de-mooiste-plekjes-van-noord-brabant

Name of stakeholder: Vershal het Veem shop and restaurant

Type of stakeholder: Restaurants and shops

Description: Daily indoor market on Strip-S offering Aquaponics products from Duurzame kost "less than twenty metres between catching and selling" (Vershalhetveem.nl, 2018).

Website: http://www.vershalhetveem.nl/nl/home

Email: ondernemen@vershalhetveem.nl

Contact person:

Address: Torenallee 86-02, 5617 BE Eindhoven, Nederland

Phone: +31 6 15362164

Notes: Sells Aquaponic trout from Duurzame kost.

Product users/public

The current product users and the public or the potential product users.

Name of stakeholder: Dan Engevik

Address: Amsterdam

Phone: 0646996311

Name of stakeholder: Merel van der Weyde

Address: Leiden

Phone: 0643000325

Name of stakeholder: Francesca Reichert

Address: Medemblik

Phone: 0627882836

Plant and animal wellbeing organizations

Name of stakeholder: Partij voor de Dieren Party for the Animals

Type of stakeholder: Plant and animal wellbeing organizations

Description: The Party for the Animals is a political party in the Netherlands. Among its main goals are animal rights and animal welfare, though it claims not to be a single-issue party. Founders are Marianne Thieme, Lieke Keller, Ton Dekker (Partij voor de Dieren 2019).

Website: https://www.partijvoordedieren.nl/

Email: l.dgroot@tweedekamer.nl, pers.partijvoordedieren@tweedekamer.nl, partijvoordedieren@eerstekamer.nl

Contact person: Laurens de Groot - Press & Media Officer, Tweede Kamerfractie Partij voor de Dieren, Christine Teunissen: https://www.partijvoordedieren.nl/organisatie

Address: Den Haag

Phone: 020-5203870, +31 (0)70 31 83 471, +31 (0)6 269 459 00

Notes: https://www.partijvoordedieren.nl/organisatie

Non-human stakeholders

Name of stakeholder: Fish

Name of stakeholder: Plants

Non-human stakeholders inside/outside of the Aquaponic system

Incumbent farmers

Description: Description: Farmers engaged in traditional farming.

Name of stakeholder: Landzicht BiologischOrganic farm Familie Visser

Type of stakeholder: Incumbent farmers

Description: A farm to be included in the research interviews. It was found by search in google for the following term in Dutch language: farmer AND nl AND direct. Website https://www.hofweb.nl/groenteboer was found. This farm was found in the category Salad, tomatoes, herbs; growing and selling vegetables similar to the ones grown in Aquaponics.

Website: https://www.groentenabonnement.nl/boerderij-landzicht

Email: info@landzichtbiologisch.nl

Contact person: Floor Visser - the owner (floor@landzichtbiologisch.nl, Tel. 06-34742709)

Address: Broekseweg 2A, 3291 LA Strijen

Phone: 06 14110152

Notes: Floor Visser, the owner, said that they have no opinion about Aquaponics and not know what it is. Afterwards he said that he is googling it and that he indeed does not know it. He also said that they grow organically, using the ground and not just water.

Name of stakeholder: De kwekerij - Kwekerij Sjerps

Type of stakeholder: Incumbent farmers

Description: A farm to be included in the research interviews. It was found by search in google for the following term in dutch language: farmer AND nl AND direct. Website https://www.hofweb.nl/groenteboer was found. This farm was found in the category Salad, tomatoes, herbs; growing and selling vegetables similar to the ones grown in Aquaponics.

Website: http://www.kwekerijsjerps.nl/de-kwekerij

Email: richard.sjerps@quicknet.nl

Contact person: Richard Sjerps - the owner

Address: Molenweg 81, 1608 ED Wijdenes

Phone: 06 12931807

Notes: Richard Sjerps, the owner, said that they do not know Aquaponics and have nothing to say about it.

Name of stakeholder:Bonaventura

Type of stakeholder: Incumbent farmers

Description: A farm to be included in the research interviews. It was found by search in google for the following term in Dutch language: farmer AND nl AND direct. Website hakkenhttps://www.hofweb.nl/groenteboer was found. This farm was found in the category Salad, tomatoes, herbs; growing and selling vegetables similar to the ones grown in Aquaponics.

Website: http://www.bio-bonaventura.nl

Email: engelsriethenk@gmail.com

Contact person: Riet Engels - the owner

Address: Het Skoar 8, 9145 CD Ternaard

Phone: 0519 321 422

Notes: Riet Engels, the owner, said that they do not know Aquaponics and have nothing to say about it.

11.4. Contacted Stakeholders not Participating in the Interviews

The following organizations were contacted and asked to provide more information in an interview, however, they have decided not to participate in the research for various reasons. Ines Kostic and Natascha Spitsbaard from Partij voor de Dieren apologized for not being able to participate in the research due to the high amount of requests and high workload. Sjoerd Houben the Office / Venue Manager of Mediamatic has not received any response from Saro van Cleynenbreugel who set up their Aquaponics system and said that he could not provide any more information. The founder Willem Velthoven has not responded. Alien from Cucina Italiana where they sell Aquaponics products and Alex van Spyk from Hanzehogeschool University of Applied Sciences have not replied to the emails about the current research anymore. The DOEN Foundation and Urgenda represented by Christiaan Kuipers said that he is not a right person to talk to and recommended to speak to Jos Hakkennes who already agreed to be interviewed. Hero Havenga de Poel, the project coordinator from Graanrepubliek, and Jos Meijers from Foundation Toentje also said that they do not know much about Aquaponics and recommended to talk straight to Erik Moesker from NoordOogst Aquaponics. The author has not been able to reach Andreas Graber and Roman Gaus from the Urban farmers Den Haag who have gone bankrupt due to the fact that their email addresses do not work and the author has not received any answer through different channels. The email addresses of Uit je eigen stad from Rotterdam who also has gone bankrupt also do not work. The author has contacted via a different email address Huibert de Leede from former Uit je eigen stad who shortly replied he had nothing to do with Aquaponics and after the author has asked him if he could put the author in touch with somebody who had been involved with Aquaponics and would be willing to be interviewed, has not replied anymore. An email with Anja Goossens – Nillesen from Pannenkoekenrestaurant ’t Genot Vierlingsbeek was also exchanged. Restaurant Vershal het veem, foundation Space matters, Futuris zorg en werk and engineering company Kybys have not responded to the inquiry. Municipality Amsterdam and Aaalburg have not responded to the inquiry via sent Email form. Dan Engevik in Amsterdam, Merel van der Weyde in Leiden and Francesca Reichert in Medemblik were asked to be interviewed in order to participate in the research as the Product users, however, they said that they do not know what Aquaponics and barriers hindering it are. The Incumbent farmers stakeholders were also contacted. They were found by search in google for the following term in dutch language: farmer AND nl AND direct. Website https://www.hofweb.nl/groenteboer was found and farmers in the category Salad, tomatoes, herbs; growing and selling vegetables similar to the ones grown in Aquaponics; were selected. Landzicht Biologisch Organic farm was contacted via phone in order to participate in the interview. Floor Visser, the owner, said that they have no opinion about Aquaponics and not know what it is. Afterwards he said that he is googling it and that he indeed does not know it. He also said that they grow organically, using the ground and not just water. De kwekerij - Kwekerij Sjerps was also contacted via phone in order to participate in the interview. Richard Sjerps, the owner, said that they do not know Aquaponics and have nothing to say about it. Bonaventura farm was also contacted via phone in order to participate in the interview. Riet Engels, the owner, said that they do not know Aquaponics and have nothing to say about it.

Short email conversations were exchanged with Anja Goossens – Nillesen from ’t Genot Vierlingsbeek restaurant who has said that she has nothing to say about Aquaponics except that first the Aquaponics was a nice eye-catcher for the terrace, where they grew mint and when guests ordered a fresh mint tea that added to the experience. However, in 2020 they removed it because the maintenance costs were starting to rise. The waiting staff in the restaurant of Metabolic was also questioned about what prevents Aquaponics from being successful in the Netherlands. They stated that the customers so far like the idea of products being grown in an Aquaponic system and that the person to ask about it more is the Aquaponics Manager Andrei Radu Beca who had already been interviewed. Phillips has not replied to the interview inquiry.

11.5. Interview Protocol

In-depth interviews were performed at a location or by telephone, recorded for the purpose of analysing the interviews later. In order to elicit further information, heuristics for Interviewing Stakeholders by Friedman et al. (2002) were used in the form of probing stakeholders with questions, such as Why? Can you give me an example? What did you do when you encountered this situation?

Interview protocol

I introduce myself, my thesis and studies at my university. I inform the interviewee that the interview questions refer to the current situation of Aquaponics development in the Netherlands.

I ask for their permission about the current interview to be:

Recorded

Transcribed

Used in my thesis.

I present the possibility of thesis view embargo for a certain amount of years in case the interviewee wishes this.

In the first part of an interview a question 'What prevents Aquaponics from being successful in the Netherlands?' is asked. In the second part of the interview, additional questions about each of the specific institutional, technical, economic, infrastructural, knowledge, socio-cultural and ethical dimensions were asked in case the interviewee did not mention them. Open question is asked: "Would you like to add something or are you aware of any other barriers which we have not mentioned yet?" in order to explore barriers which were not mentioned in the literature or in the primary theoretical Piptová 1 (2018) framework.

The interviewees were additionally asked via email to confirm that they agree that their names and the institution they work for will be explicitly provided in the thesis as interviewees for the current research and their answers will be provided anonymously.