INTER - ORGANIZATIONAL COLLABORATION IN BIO - BASED BUSINESS

SUSTAINABILITY - ORIENTED NETWORKS IN AGRO - INDUSTRIAL PARKS

GOHAR NUHOFF-ISAKHANYAN

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This research was conducted under the auspices of the
Wageningen School of Social Sciences (WASS)

Inter-organizational collaboration in bio-based business

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Gohar Nuhoff-Isakhanyan

Thesis
submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. Dr A.P.J. Mol,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Wednesday 15 June 2016
at 11 a.m. in the Aula.

Gohar Nuhoff-Isakhanyan

Inter-organizational collaboration in bio-based business: Sustainability-oriented networks in agro-industrial parks,

194 pages.

PhD thesis, Wageningen University, Wageningen, NL (2016)

With references, with summary in English

ISBN 978-94-6257-769-5

DOI: 10.18174/377689

PREFACE AND ACKNOWLEDGEMENTS

I undertook this PhD research as I was inspired by the need for sustainability–oriented actions, by the recent developments in bio-based business, as well as by the enhancement of organizational networks in agro-industrial parks launched and developed in the Netherlands. The accomplishment of the PhD proved to be a long journey, which was not always smooth. This journey led me through circuitous paths, bumpy roads with detours and sometimes even with dead ends. To accomplish my journey and arrive at the final destination, I needed people around me to give me a hand, to switch the lights on when it was dark, and to provide fresh impetus. We all believed that this journey was temporary, but the PhD thesis was forever. Here, I want to acknowledge the efforts these people invested in accompanying me through the journey during the past years of doing PhD research.

First and foremost, I want to thank the promoter Prof. Dr Onno Omta and co-promoter/supervisor Dr Emiel Wubben. What an incredible honor it was to work with you two!

Onno, thank you for allowing me be part of the academic group at Management Studies. Thank you for supporting and encouraging me in this journey. Your leadership, your vision, and your patience were priceless. Your critical, but constructive feedback helped to continuously improve the thesis. Finally, I thank you for giving me some extra time and believing in my capacities to reach the final destination of this journey.

Emiel, I am grateful to you for bringing your intellect into this journey. Your mentorship, your acute attention and detailed feedback to every piece of text I produced were unfathomable. Standing shoulder-to-shoulder in this journey through daily discussions, you encouraged me to go through difficult times and cherish the small achievements in-between. I am grateful for your patience, critical approach, and empathy. Thank you for teaching me so much and for encouraging me to take risks to reach my goal.

Next, my gratefulness goes to Dr Stefano Pascucci. Stefano, I appreciate your expertise, your experience, your positive approach, your enthusiasm and inspiring attitude. Thank you for being such a great collaborator.

I also would like to thank the student assistants Anne, Elene, Helena, Jasper, and Roy for their tremendous job in data collection and transcription. Additionally, I want to send my gratefulness to all the respondents, managers and CEOs of organizations within the studied agro-industrial parks. I thank them for their invested time and trust while providing me with typically confidential information.

I would also like to acknowledge the scholars whose advice had impact on my decision-making throughout this journey. Many thanks goes to Peter Tamas, lecturer and researcher in research methods at Wageningen University, for his methodological advise; to Edward Freeman, Professor of Business Administration at the Darden School of the University of Virginia, for his recommendations in theoretical choices; to Thomas Schøtt, Professor of Entrepreneurship and Relationship Management at the University of Southern Denmark, for his guidance in network analysis; to Jan de Wilt, program manager at the InnovationNetwork/Innovation Agro&Nature, for moderating focus group discussions and for frequently giving recommendations from a practical perspective; to Frank Boons, Professor of Innovation and Sustainability at the University of Manchester, for engaging me in different discussions around the topic; and to Wouter Spekkink, postdoctoral researcher at the Faculty of Technology, Policy and Management of the Delft University of Technology, for exchanging knowledge and for intellectual discussions.

This research has been a part of the EU-Interreg IV-B NWE ARBOR project financed by the European Union. The financial support of which is gratefully acknowledged. Additionally, I would like to acknowledge the project partners from six European countries for their constructive collaboration. I enjoyed the time I spent attending steering group meetings in different cities around North West Europe. It was always a pleasure to see the project partners, have formal discussions, enjoy social activities, but also write reports with the group. I learnt a lot from our visits to production sites: especially, I will never forget the impressive renewable energy installations, and the smell of household bio-waste incineration plants.

I highly appreciate the efforts of the dissertation committee, Prof. Dr C.J.A.M. Termeer, Prof. Dr A.P. de Man, Prof. Dr F.A. Boons, and Dr L.W.A. Klerkx in reviewing and evaluating the thesis. My special thanks go to Dr. Rodrigo Lozano for reviewing the thesis and representing Dr Frank Boons during the public defense of this thesis.

Then, my appreciation goes to all my colleagues from Management Studies. For administrative support, I want to especially thank Ina, Anne, Liesbeth, and Johnnatan. Special thanks to my office-mates Franco, Herman, and Annemarie. We really had fun and laughed together. For interesting chats about cultures around the world and social interactions, I want to thank all my friends and (former) colleagues from Management Studies and from other teams at Social Sciences.

I also want to thank the ex-fellow PhD candidates from the WASS PhD Council: Geralda, Iulian, Jannette, Jeroen, Kleoniki, Muriel, Susan, and William, as well as colleagues from WASS graduate school: Esther, Evelien, and Stefan. Working with you, having social drinks, and organizing various events for PhD candidates were a great pleasure for me.

I am also grateful to a colleague from LEI, a great friend of mine, Lusine, for her support in getting contacts with important people, and for sharing her experience in doing a PhD.

Finally, my greatest gratitude goes to my family that I love dearly. I want to thank my parents; without the education-orientated upbringing they gave me, I would not be doing academic work. I did not grow up in a life of privilege; I grew up in a small village at the border of Armenia, under the circumstances of war, and had to study mainly at home because the schools were unsafe and often shut. Both of my parents, being teachers at school, persuaded me to study hard. My Mother especially took the lead to teach me all the necessary subjects, encouraged me to continue studying at university, and showed her happiness every time I achieved a new milestone. Mom, I hope to bring a small happiness in your difficult life, full of worries, with this milestone. Next, I highly appreciate the efforts of my family-in-law, who understood my needs of additional time and supported me by taking over my parental obligations. Thanks for being such amazing parents.

My wonderful husband, you made it all possible. Thank you for always being up for adventure, for believing in me, for being patient, for energizing me by always celebrating the small milestones achieved, and just for being next to me whenever needed.

This book contributes to sustainability – oriented actions that may help protecting the planet for future generations. Therefore, I would like to devote this book to my daughter **Amélie Lucie Nuhoff.**

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Collaboration is one of the keys for unlocking sustainability.
No single organization or sector has the knowledge or resources to "go it alone."

Prof. Dr Tima Bansal ,
Executive Director, Network for Business Sustainability and Professor at Ivey Business School
(Gray and Stites, 2013)

CHAPTER 1: INTRODUCTION

1. INTRODUCTION

1.1. Bio-based economy and bio-based business

In recent decades a remarkable increase in scientific knowledge and commercial innovations has been carried out, leading to the development of the so-called "bio-based economy" (Pellerin and Taylor, 2008; Pfau *et al.*, 2014; Vandermeulen *et al.*, 2011). The bio-based economy is a part of the economy driven by the transition from fossil-based to bio-based production and consumption patterns (Langeveld *et al*., 2010). The bio-based economy can be understood as the biomass-driven alternative to the fossil-based economy (Slegers, 2014). The bio-based economy integrates natural and renewable biological sources and materials as biomass for processing, production, and consumption (EC, 2011). Biomass is mainly sourced from forestry, agriculture, industry, and households (Halford, 2015). Biomass is largely used to produce bio-based products and materials (for example, bioenergy, biodegradable products, bio-fertilizers, animal feed, and biofuel) for industrial, residential, and transportation use (Dahiya, 2014; Halford, 2015; Pfau *et al.,* 2014). Relying on the existing knowledge of current applications of biomass, this thesis focuses on organizational activities in the bio-based economy specified as bio-based business.

Globally, bio-based business is often perceived as sustainable, because its renewable production can potentially lower carbon and greenhouse emissions by substituting fossil-fuel-based production (Kline *et al.,* 2009; Pfau *et al.,* 2014), reduce environmental sourcing problems, and create turnover and jobs (Anbumozhi *et al.*, 2010; Mangoyana and Smith, 2011; Schmidt *et al.*, 2012). However, bio-based business can also bring sustainability challenges, such as land use conflict, deforestation of tropical areas, decrease in biodiversity, and soil erosion (Kline *et al.*, 2009; Lemus and Lal, 2005; Mangoyana and Smith, 2011). The sustainability benefits of bio-based business should not therefore be considered as self-evident (Pfau *et al.*, 2014). Tackling the sustainability challenges of bio-based business has received priority in the agendas of various stakeholders. Accordingly, collaboration that addresses sustainability challenges in bio-based business has been promoted and collaborative practices have been increased around the globe (Albino *et al.*, 2012). Collaboration allows the accumulation of diverse competences of organizations, enabling the tackling of challenges that individual

organizations are not capable of solving independently (Austin, 2010; Lozano, 2007). Inter-organizational collaboration is defined as collaboration between two or more legally separate organizations (Bergenholtz and Waldstrøm, 2011), in contrast to collaborations among entities within one organization. In this thesis, inter-organizational collaboration in bio-based business is studied as mechanism to enhance sustainability. The following section provides details on inter-organizational collaboration in bio-based business.

1.2. Inter-organizational collaboration in bio-based business

Urged to exploit innovative solutions and further enhance their sustainability performance, organizations engaged in bio-based activities extensively search for collaboration possibilities with new partners (Pfau *et al*., 2014; Posch, 2010). Inter-organizational collaboration has taken various forms, such as joint ventures, alliances, public-private partnerships, clusters, (eco-)industrial parks, integrated supply chains and closed loop supply chains (Bagchi-Sen *et al.*, 2011; Bergenholtz and Waldstrøm, 2011; Jensen *et al.*, 2013; Suarez-Villa and Walrod, 2003). The enhancement of sustainability performance in such collaborations relies heavily on common sustainability goals, such as to use/reuse of industrial waste, including carbon and greenhouse gas emissions, to increase resource use efficiency by sharing available utilities, exchanging knowledge and innovative ideas. The most common form of inter-organizational collaboration in bio-based business is that among co-located organizations in waste streams exchanges and utility sharing, often discussed in industrial ecology and agricultural systems (Elkington, 1998; Gray and Stites, 2013; Posch, 2010; Smeets, 2011).

Playing an important role in sustainability improvement trajectories, such collaboration may create added value for engaged heterogeneous stakeholders (Smeets, 2011). For instance, companies may enhance their reputation through increased Corporate Social Responsibility, reduce their environmental footprint, reduce their costs via higher resource efficiencies, and realize new business development, via innovative solutions (Hoes *et al*., 2012; Smeets, 2011; Wubben and Isakhanyan, 2011). Governmental organizations may achieve renewable energy goals and strengthen their social mandate. The surrounding community may enhance their welfare, receiving enhanced energy security, and employment, meanwhile sustaining natural resource use and escaping threatening poverty (Mangoyana and Smith, 2011; Smeets, 2011).

Although inter-organizational collaboration suggests a promising potential to enhance sustainability (Pfau *et al.*, 2014; Posch, 2010; Smeets, 2011), often the achieved sustainability performance remains ambiguous (Elghali *et al.*, 2007; Santoyo-Castelazo and Azapagic, 2014). Collaborating in inter-organizational networks does not imply that the organizations achieve merely sustainability benefits, especially when all the aspects of sustainability are considered (Fadeeva, 2005; Lozano, 2007; Lozano 2008b, Van Hoof and Thiell, 2014). A benefit in one aspect of sustainability may come at the cost of other sustainability aspects (Mangoyana and Smith, 2011). Moreover, the full realization of inter-organizational collaboration towards more sustainable production is a long-term and challenging path that requires intensive, continuous interactions, and high investments (Suarez-Villa and Walrod, 2003). The challenge that heterogeneous stakeholders experience along the long-term realization of inter-organizational collaboration goes beyond the control of an individual stakeholder and becomes a network level challenge. Many questions arise around the ways the co-located companies collaborate and around their perceptions on sustainability outcomes.

This thesis initially takes the broader view of inter-organizational collaboration in bio-based business across industrialized and emerging economies, and discusses the effects on sustainability. Then, the focus is shift to sustainability-oriented inter-organizational network structures and sustainability performance in agro-industrial park developed in the Netherlands. The following section introduces agro-industrial parks and provides examples from the Netherlands.

1.2.1. Agro-industrial park

An agro-industrial park is a form of inter-organizational collaboration among geographically co-located heterogeneous organizations (De Wilt and Dobbelaar, 2005; Hoes *et al.*, 2012; Smeets, 2011; Veldkamp, 2009). Through collaboration, organizations in an agro-industrial park form an inter-organizational network to jointly address sustainability issues and society's increasing demand for renewable (bio-)energy (Beers *et al.*, 2014; Breeman *et al.*, 2013; Hermans *et al.*, 2013b; Hoes *et al.*, 2012; Koerkamp and Bos, 2008; Termeer *et al.*, 2009). Similar to eco-industrial parks, such as Kalundborg in Denmark (Domenech and Davies, 2011;

Jacobsen, 2006) and Landskrona industrial symbiosis in Sweden (Baas, 2011; Mirata and Emtairah, 2005), agro-industrial parks connect co-located organizations to increase their resource use efficiency, reduce production wastes and emissions, meanwhile decreasing environmental foot prints and increasing reputation. Therefore, agro-industrial parks can be seen as an application of industrial ecology (Section 1.3.1) in agriculture (Smeets, 2011). Classical industrial parks usually engage industrial manufacturers, chemical companies, energy power plants and waste processing organizations (Ehrenfeld, 1997). Whereas, agro-industrial parks engage more heterogeneous organizations, such as horticultural, livestock, agri-food processing, chemical and logistics companies (Lambert and Boons, 2002). Additionally, agro-industrial parks focus on collaborations among co-located heterogeneous organizations in bio-based business, such as bio-energy production and biomass valorization, and by doing so support the growth of the bio-based economy. Agro-industrial parks, thus, connect co-located heterogeneous organizations to address sustainability issues and society's increasing demand for renewable (bio-)energy (Beers *et al.*, 2014; Breeman *et al.*, 2013; Hermans *et al.*, 2013b; Hoes *et al.*, 2012; Koerkamp and Bos, 2008; Termeer *et al.*, 2009).

This thesis considers agro-industrial parks from the Netherlands for two main reasons: (1) quite recently many agro-industrial parks have been set-up and developed in the Netherlands, and (2) the Netherlands is a leading country regarding agricultural innovations with highly advanced agri-food and horticultural sector (9% of the GDP), and a frontrunner with techno-managerial innovations in this industry. Agro-industrial parks set-up and developed in the Netherlands target more sustainable agri-food and (bio-)energy production, active bio-based business, enhanced socio-economic performance, and decreased pollution via waste, by-product exchange and via utility sharing (Hoes, 2011; Smeets, 2011). Considering the mentioned arguments, the examples of agro-industrial parks in the Netherlands can therefore be used as an archetype in realizing agro-industrial parks in other countries. Box 1.1 briefly describes agro-industrial parks included in the research sample. As Box 1.1 shows, the agro-industrial parks are spread over the country, being located in three different provinces of the Netherlands. Organizations in these three agro-industrial parks are expected to improve their environmental performance, such as reduced greenhouse gas emission, and to provide opportunities for biomass use and bioenergy production.

Considering the novelty of collaborations in agro-industrial parks, as well as recognizing differences between agro-industrial and industrial parks, this thesis brings the concept of waste streams exchanges and utility sharing among co-located heterogeneous organizations in agro-industrial parks to a new field of analysis, and by doing so expands the views in the industrial ecology domain. In developing this new field of analysis on inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular, this thesis focuses on network structures and network governance forms, using various theoretical perspectives.

BOX 1.1. Agro-Industrial Parks

Agriport A7 is an agro-industrial park located in the municipality of Hollands Kroon, to the north of Amsterdam, in the province of Noord-Holland, the Netherlands. Launched by the municipality in 2003 and developed by entrepreneurs in 2005, Agriport A7 became a progressive park with active business developments, expansions and acquisitions. Many companies in Agriport A7 are horticultural companies, who mostly originated from the Westland, a large horticultural region in the Netherlands overloaded with glasshouses with limited expansion opportunities. Agriport A7 connects large scale horticultural, logistic, agri-food, energy, IT and other industrial companies. The spatial concentration enables the exchanges of waste streams, such as waste heat, and sharing utilities, such as logistics, processing, energy, road, and water infrastructure. By collaborating, heterogeneous companies create closed material cycles, reducing traffic, creating economies of scale, reducing costs and improving efficiency. Moreover, the organizations increase opportunities to exchange information and share knowledge to enhance their innovation performance. Agriport A7 represents an interesting social structure among co-located heterogeneous organizations that collaborate to achieve both individual commercial and common sustainability goals set by individual companies.

Biopark Terneuzen is an agro-industrial park located in the Canal Zone area in the province of Zeeland, the Netherlands. The location is a harbor area with heavy industrial companies, such as Dow Chemicals and Yara. Launched in 1997 by Zeeland Seaports and developed in 2005 by Dow, Delta and the Province of Zeeland, Biopark Terneuzen aims to connect the existing industrial companies with newly established horticultural companies mainly for waste heat and CO_2 use. In 2014,

three horticultural companies have been established in around 300 hectares in Biopark Terneuzen. Biopark Terneuzen targets a strong regional economy to attract new companies, create new business and employment opportunities. Additionally, Biopark Terneuzen targets reducing the environmental burden, increasing economic performance of local companies, and developing bio-based business in the region. Organizations in Biopark Terneuzen are heterogeneous, such as energy generators and distributors, chemical companies, food and feed producers, horticultural growers, and waste/recycling companies. Biopark Terneuzen represents an interesting social structure among co-located heterogeneous organization, most of which are local industrial production and processing companies that collaborate with horticultural companies to achieve common sustainability goal set by the Zeeland Seaports and by the province of Zeeland.

Bergerden is an agro-industrial park located between Arnhem and Nijmegen in the province of Gelderland, the Netherlands. Launched by the province in 1990 and developed by the surrounding municipalities in 2003, Bergerden became an active developing park with new business developments specifically attracting horticultural companies. Bergerden targets more sustainable production with lower CO_2 emission, less use of energy and water, as well as with biomass valorization through the application of innovative technologies. The co-location of about twenty organizations, the majority of which are horticultural growers, would not be different from a classical cluster, where companies share utilities for resource efficiency, if bio-based, logistics, auction and other service providing companies are not engaged in the network. Additionally, vegetable and decoration plant growers, although from one sector, have different production systems and operate in different markets, which make these companies quite different. Co-located organizations are also connected via joint irrigation water system and via two auctions. Additionally, a bio-waste digester is expected to deliver heat and CO_2 to the horticultural companies. Bergerden represents an interesting social structure among co-located organizations that aim to achieve both individual commercial and common sustainability goal set by both the entrepreneurs and the province of Gelderland.

1.3. Theoretical perspectives

A challenging task when studying the social and management aspects of a novel phenomenon is to position it in existing domains in literature. The positioning of this thesis has been particularly challenging because agro-industrial parks are recently developed inter-organizational collaborations and are therefore, not extensively studied yet (Hoes, 2011). Although the benefits and difficulties of collaboration among multi-stakeholders or heterogeneous organizations have been intensively discussed in the literature (e.g., Fadeeva, 2005; Lozano, 2007; Van Hoof and Thiell, 2014), the conclusions remain context and situation dependent (Fadeeva, 2005). Therefore, in exploring the ways the inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular can enhance sustainability, this thesis uses different theoretical lenses based on industrial ecology, network theory, stakeholder theory, and event system theory. Specifically, the Chapters 2 through Chapter 5 are grounded in industrial ecology. The network theory is used in Chapters 3, 4 and 5; the stakeholder theory is used primarily in Chapter 3, and the event system theory is used in Chapter 5.

1.3.1. Industrial ecology

Industrial ecology has emerged from preventive environmental management to integrate environmental and economic systems with sustainability (Ehrenfeld and Gertler, 1997). Since the beginning of 1990s, awareness has increased at industrial companies that the traditional models of isolated industrial activities are not sustainable, leading to a transition into more integrated models (Lowe, 1997; Posch *et al.*, 2011). Industrial ecosystems or eco-industrial parks (also known as industrial symbiosis) as key strategies of industrial ecology shifted the production system from a linear input-output model to a closed-loop model (Jensen *et al.*, 2013; Lowe, 1997; Posch *et al.*, 2011). Eco-industrial parks represent inter-organizational networks, where individual organizations collaborate to achieve individual and common goals (Posch *et al.*, 2011). These goals are to lower the resource use, the impact on the natural environment, and increase their competitiveness through reusing waste and by-products

(Chertow, 1998). In sum, inter-organizational networks among co-located companies and symbiotic exchanges can lead to broader collaborations that aim at enhanced sustainability performance (Lambert and Boons, 2002; Posch, 2010).

Researchers of industrial ecology have increasingly been aware that inter-organizational exchanges of materials and energy cannot be merely treated as technical issues, but also as management, organizational, and cultural issues (Boons and Roome, 2000). This growing awareness has gradually attracted more scholars of different disciplines, such as engineering, environmental science, economics, ecology, business and management studies, producing a growing body of literature referring to technological, social, and managerial issues (Cohen-Rosenthal, 2000; Posch *et al.*, 2011; Roberts, 2004; Tudor *et al.*, 2007; van Beers *et al.*, 2007). For example, studies refer to the organization of eco-industrial parks (Ashton, 2008), the importance of informal ties in establishing social-material networks (Ashton and Bain, 2012; Schiller *et al.*, 2014), institutional capacity building (Spekkink, 2015), and evolution of inter-organizational networks (Boons *et al.*, 2011; Doménech and Davies, 2011).

The growing awareness of social and managerial aspects of eco-industrial parks has directed research towards sociology and management theories, next to the development of appropriate methods, in studying the complex inter-organizational networks. Particularly, network theory has been introduced to understand sustainability-oriented inter-organizational network structures (Ashton, 2008; Ashton and Bain, 2012; Schiller *et al.*, 2014). Network theory can help to improve the understanding of social/informal connectedness, next to technical/formal connectedness, within the sustainability-oriented networks (Ashton and Bain, 2012; Paquin and Howard-Grenville, 2013; Pina-Stranger and Lazega, 2011). In this thesis, network theory has been used and inter-organizational network aspects, raised in industrial ecology literature, have been applied to sustainability-oriented networks in agro-industrial parks.

However, as described in Section 1.2.1, agro-industrial parks can be distinguished from other types of eco-industrial parks, such as Kalundborg eco-industrial park, Landskrona industrial symbiosis, and Rotterdam Harbor industry complex, since they include more heterogeneous organizations from agricultural and other industrial sectors. In this research, heterogeneity refers especially to the core organizational activities, such as producing and processing agricultural food, manufacturing chemicals, providing transportation and construction services,

and producing bio-based products (Hoes, 2012; Smeets, 2011). The industrial ecology focuses primarily on technical aspects of physical exchanges, often ignoring the business strategies of heterogeneous organizations that shape the decision-making on collaborations in agro-industrial parks. Therefore, other theoretical perspectives have been taken up to complement existing knowledge of industrial ecology.

1.3.2. Stakeholder theory

Stakeholders are any groups or individuals who can impact and who are affected by a business (Freeman and Reed, 1983; Freeman *et al.*, 2004). Stakeholder theory assumes that interests drive the stakeholders behavior (Freeman *et al.*, 2004). Stakeholder theory claims that the consideration of (key) stakeholder interests in strategies raises the chances of resolving business related challenges (Parmar *et al.*, 2010). Moreover, through investigating the specific interests of stakeholders, the future directions of the business can be examined (Freeman *et al.*, 2007).

Stakeholders included in agro-industrial parks come from different sectors with a low level of similarities in activities, attributes, capabilities, expectations, and so can be described as heterogeneous. Heterogeneity may provide opportunities to combine diverse but complementary resources (Beckman and Haunschild, 2002; Corsaro *et al.*, 2012). However, the interests of heterogeneous stakeholders do not always align and may even arouse conflicts (Fadeeva, 2005). Heterogeneity can increase the risk of conflicts and opportunistic behavior creating less trustworthy relations (Gulati, 1995; Powell *et al.*, 1996). Reaching an alignment of stakes among heterogeneous stakeholders and tackling potential or actual conflicts in agro-industrial parks requires additional resources (Fadeeva, 2005; Freeman *et al.*, 2007; Lozano, 2007). It is the task of management to rethink and mitigate conflicting interests and create added value for all stakeholders (Parmar *et al.*, 2010).

The application of stakeholder theory to agro-industrial parks can provide insights into available opportunities and critical barriers created by key heterogeneous stakeholders towards the realization of inter-organizational collaboration in agro-industrial parks (Wubben and Isakhanyan, 2011). Not only the interests, but also the network position of the stakeholders

and network structures can influence the network outcomes (Ahuja, 2000). Therefore, the network position of the stakeholders and network structures should also be considered when advancing knowledge of sustainability-oriented inter-organizational networks.

1.3.3. Network theory

The network position of stakeholders and network structures of inter-organizational collaboration are studied by the means of organizational network theory. In general, network theory proposes that ties in a network can shape the network structures and enable/disable the establishment of new ties to achieve individual and/or common interests (Borgatti *et al.*, 2009; Salancik, 1995). Embedded in social network theory (Borgatti and Foster, 2003; Freeman, 1978), organizational network theory refers to ties among organizations and the complex structures of organizational ties (Albino *et al.*, 2012; Bergenholtz and Waldstrøm, 2011; Provan *et al.*, 2007; Schiller *et al.*, 2014). Specifically, organizational network theory explains the ties among organizations, and their social and behavioral phenomena at network level (Ahuja, 2000; Ahuja *et al.*, 2009; Borgatti and Foster, 2003; Burt, 1995; Gulati, 2007). Understanding inter-organizational ties and network structural properties at network level is considered important, because the network perspective can provide insight into network level dynamics not particularly observable at dyadic level (Cots, 2011; Rowley, 1997).

Recent research in inter-organizational networks shows that successful networks rely on reciprocity, collaboration, reputation, and communication with the aim of creating synergetic effects (Ahuja *et al.*, 2009; Borgatti *et al.*, 2009; Burt, 1995; Provan *et al.*, 2007; Tichy *et al.*, 1979). Additionally, a growing body of literature recognizes the importance of inter-organizational network ties in improving sustainable performance through physical and social exchanges (e.g., Schiller *et al.* (2014), Paquin (2013), Pina-Stranger (2011), Bergenholtz and Waldstrøm (2011).

In agro-industrial parks, the application of network theory proposes that the formal and informal ties among co-located organizations are directly or indirectly focused on sustainability related activities, such as reduced emissions, renewable energy production, or bio-waste valorization (Anbumozhi *et al.*, 2010; Mirata and Emtairah, 2005; Spekkink, 2013).

Although the body of literature on sustainability-oriented inter-organizational networks is growing, the relations between network structural properties and sustainability effects have not been explicitly studied yet. Therefore, the studies presented in Chapters 3 through Chapter 5 of this thesis use network theory to advance knowledge of sustainability effects of network structural properties of inter-organizational ties and network governance in agro-industrial parks.

1.3.4. Event system theory

Event system theory is an evolutionary approach to organization sciences (Morgeson *et al.*, 2015). Event system theory "focuses on how events command attention and impact organization behaviors, features, and subsequent events across levels and times" (Morgeson, 2015, page 517). Referring to the levels, the theory considers individual, team, organization, and network levels. Referring to the times, theory considers the long term developments of businesses. Accordingly, the event system theory takes an evolutionary perspective and apprehends the dynamic processes of inter-organizational networks that involves many subsequent actions of individual organizations within the networks (Boons and Howard-Grenville, 2009; Boons *et al.*, 2011; Morgeson *et al.*, 2015). Subsequent actions represent interactions among different organizations and constitute events bounded in space and time (Morgeson *et al.*, 2015). By means of events, organizations establish, strengthen or loosen relationships. Moreover, events influence the opportunities that organizations perceive as window for engaging in further actions together (Boons *et al.*, 2011; Morgeson *et al.*, 2015; Spekkink, 2015). Consequently, social learning can occur in the long run, as engaged organizations may find new ways of dealing with common problems and may encounter their interests and problems in networks (Innes and Booher, 1999). The evolutionary perspective suggests a systematic longitudinal analysis of events influencing network evolution (Boons *et al.*, 2014; Spekkink, 2013; Spekkink, 2015). Event sequences uncover temporal patterns, such as the order and the duration of the events.

The evolutionary perspective of event system theory helps understanding the development of collaboration over time among geographically co-located organizations (Boons *et al.*,

2014; Morgeson *et al.*, 2015). Therefore, this thesis applies event system theory in Chapter 5 to provide insights in network evolution of inter-organizational ties in agro-industrial parks through the multitude of actions that constitute events.

1.4. Research aim

As mentioned in the previous sections, this thesis focuses on inter-organizational collaboration among co-located organizations and studies the sustainability related questions. This thesis first takes the broader view of inter-organizational collaboration in bio-based business across industrialized and emerging economies. Then the focus is placed on inter-organizational collaboration in agro-industrial parks set-up and developed in the Netherlands. As a research strategy, first the general research aim and main research question are formulated followed by the four research objectives. To address the research problems described in Sections 1.2 and 1.3, the following research aim is formulated:

RESEARCH AIM

To advance knowledge of how inter-organizational collaboration in bio-based business in general and in agro-industrial park in particular can enhance sustainability.

To achieve the research aim, this thesis investigates the empirical evidence of sustainability in inter-organizational collaboration. In doing so, the thesis answers the following main research question.

MAIN RESEARCH QUESTION

In what way inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular enhance sustainability?

To answer this research question, the research aim was translated into four research objectives that are presented in the Chapters 2 through Chapter 5.

1.5. Research objectives

1.5.1. Research objective 1 (Chapter 2)

Inter-organizational collaboration in bio-based business is first of all challenged by disputed use of bio-based resources. On the one hand, bio-based business is often considered sustainable because it brings environmental benefits, such as lower carbon and greenhouse gas emissions by substituting fossil fuel based production (Nguyen *et al.*, 2010). On the other hand, bio-based business is linked to sustainability challenges, such as reduced biodiversity, deforestation and higher food prices. Inter-organizational collaboration among co-located organizations is claimed to increase the sustainability of bio-based business through the re-use of waste streams, such as CO_2, heat waste and bio-waste, and through minimizing solid waste release (Albino *et al.*, 2012; Anbumozhi *et al.*, 2010). In addition, through collaboration organizations can meet the demand for more sustainable sourcing and better waste-management (Albino *et al.*, 2012; Seitanidi and Crane, 2013) to achieve common sustainability goals (Lozano, 2008a). A wide variety of knowledge is available on bio-based business in general. This knowledge has an interdisciplinary background, such as biochemistry, biology, agricultural engineering, and environmental management (Mattsson, 2009; Mielenz *et al.*, 2007; Powell *et al.*, 1996; Schmidt *et al.*, 2012). However, the available knowledge is scattered and not systematically integrated for providing empirical evidence on sustainability outcomes achieved through inter-organizational collaboration in bio-based business. The Chapter 2 of this thesis takes a broader view of inter-organizational collaboration across industrialized and emerging economies, and discusses effects on sustainability considering the three aspects: environmental, economic, and social. Since the demand to integrate available knowledge and to complete the entire puzzle of effects on sustainability through collaborations has been growing, the following research objective has been formulated.

RESEARCH OBJECTIVE 1. *To systematically integrate the scientific knowledge on sustainability benefits and challenges of inter-organizational collaboration in bio-based business.*

1.5.2. Research objective 2 (Chapter 3)

Realization of inter-organizational collaboration among co-located organizations requires long-term and systematic interactions among local organizations, and can be described as system innovations. The challenges in realizing system innovations are widely discussed amongst scholars, in particular, in innovation management, industrial ecology, and transition literature (e.g., Baas, 2011; Klerkx and Leeuwis, 2009; Elzen and Wieczorek, 2005). As a type of system innovation, agro-industrial park realization requires involvement of heterogeneous stakeholders that rely on trust and shared vision to build networks and achieve common sustainability goals (Breeman *et al.*, 2013; Termeer *et al.*, 2009). The available literature often discusses collaborations either across supply chain partners or among relatively homogeneous organizations. Agro-industrial park realization in the Netherlands engages many heterogeneous organizations, the interactions of which create inter-organizational networks not particularly discussed in the literature before. Being aware of the potential and realized sustainability benefits an agro-industrial park can provide, there is a need for an improved understanding of the opportunities for and barriers to agro-industrial park realization. The need to adapt available theories and gain new insights in current agro-industrial park realization led to the following research objective.

RESEARCH OBJECTIVE 2. *To explore the opportunities for and barriers to agro-industrial park realization focusing on network structures and governance forms.*

1.5.3. Research objective 3 (Chapter 4)

Next, this thesis zooms in on the internal environment of agro-industrial parks, considering inter-organizational ties among collaborating organizations. Realization of inter-organizational collaboration among co-located organizations, such as in agro-industrial parks developed in the Netherlands, is related to the sustainability performance of engaged organizations. Through collaborations in agro-industrial parks, organizations construct inter-organizational networks and occupy a certain position within such networks. However, organizations in agro-industrial parks are often unaware of their network position and possible effects of network behavior on sustainability performance.

Inter-organizational collaboration for sustainable production has been intensely discussed in the field of industrial ecology and agricultural systems (Albino *et al.*, 2012; Ehrenfeld and Gertler, 1997; Gibbs and Deutz, 2005; Lozano, 2008a, Smeets, 2011). A comprehensive approach to study the structure of inter-organizational networks is via the application of social network analysis (Bergenholtz and Waldstrøm, 2011). The structural properties of networks with more heterogeneous organizations, such as an agro-industrial park, rely more on exchange relations (Ashton, 2008), whereas networks with homogeneous organizations rely more on utility sharing relations (Chertow *et al.*, 2008).

The sustainability performance of (organizations in) agro-industrial parks may be associated with the structural properties of inter-organizational networks (Ahuja *et al.*, 2009; Baum *et al.*, 2000), because organizations collaborate to enhance their sustainability. In general, sustainability performance refers to the three dimensions: environmentally friendly, economically beneficial, and socially supportive (Elkington, 1998; Jung *et al.*, 2013; Santoyo-Castelazo and Azapagic, 2014). In this study, the available indicators of the three sustainability dimensions are tailored to organizations in agro-industrial parks. Considering the importance of decision making in establishing network ties, the perceptions of managers on sustainability performance as a desired outcome is prioritized. Although inter-organizational network structures and the sustainability performance of organizations in agro-industrial parks are frequently discussed in the literature (Ashton, 2008; Santoyo-Castelazo and Azapagic, 2014; Schiller *et al.*, 2014), the relations between these two concepts have not so far been studied empirically. The need to understand the inter-organizational network structures and the plausible affiliations to sustainability performance led to the following objective:

RESEARCH OBJECTIVE 3. *To explore the inter-organizational network structures in agro-industrial parks that can enhance sustainability performance.*

1.5.4. Research objective 4 (Chapter 5)

The first three objectives of this thesis are related to the cross-sectional study design that considers agro-industrial park realization at one specific point in time. However, agro-industrial park realization is also related to the evolution of inter-organizational collabora-

tion that shapes the network structure over time. Inter-organizational network structures are not developed in a vacuum; they result from earlier events (Morgeson *et al.*, 2015) and eventually impact the network evolution. The understanding of network structure is incomplete without referring to the events that shaped the networks. Thus, a better understanding of the evolution of inter-organizational collaboration is needed to explain network structures at a given point in time (Boons *et al.*, 2011; Spekkink, 2013).

Studies on inter-organizational collaboration often refer to the structural perspective or to the evolutionary perspective (for example, Boons *et al.* (2011), Spekkink (2013), Spekkink (2015), Ashton and Bain (2012), Gibbs and Deutz (2005), Boons *et al.* (2014), and Schiller *et al.* (2014). However, the literature fails to explain how the evolution of inter-organizational collaboration can shape the network structure. This knowledge is relevant for understanding what effects certain events can have on network structural properties and how the desired network structure can be achieved over time. The need to understand how event developments over time impact inter-organizational network structures at a given of point in time led to the following objective:

RESEARCH OBJECTIVE 4. *To investigate if the combined use of the structural and the evolutionary perspective can enrich the understanding of inter-organizational network structures in agro-industrial parks.*

1.6. Thesis structure

Investigating the empirical evidence, this thesis initially takes a broader view of inter-organizational collaboration, and then focuses on agro-industrial parks set-up in the Netherlands. Accordingly, the thesis is structured as follows.

Chapter 2 explores sustainability benefits and challenges of inter-organizational collaboration in bio-based business considering the three aspects of sustainability: environmental, economic and social. A systematic literature review was conducted to find and integrate the existing knowledge of inter-organizational collaboration in a systematic, explicit, transparent, and accountable manner. Twenty-four of the most relevant peer-review articles were selected from a large set of articles for context analysis. As a result, a framework is devel-

oped that illustrates the differences of sustainability benefits and challenges in industrialized and emerging economies, as investigated by scholars.

Chapter 3 identifies the opportunities for and barriers to agro-industrial park realization in the Netherlands focusing on network structures and network governance forms. An extensive literature study on agro-industrial park developments and two focus group discussions with stakeholders engaged in agro-industrial parks in the Netherlands were conducted. As a result, a conceptual framework for agro-industrial park realization is built that shows insights in opportunities for and barriers to agro-industrial park realization based on the literature and empirical data.

Chapter 4 investigates in what way the network structure of inter-organizational ties is associated with sustainability performance. In this Chapter, qualitative and quantitative methods are combined. Through qualitative methods, the general characteristics of agro-industrial parks were studied. Through quantitative methods, the bilateral ties among collaborating organizations and managers' perceptions of sustainability performance were studied. The study was conducted in three agro-industrial parks in the Netherlands, including 64 organizations in total. Analysis was run both at network and at organizational level. The perceptions of managers on economic, social and environmental performance of organizations in agro-industrial park were used as proxy for sustainability performance. A statistical test was carried out to find if network structural properties can predict perceived sustainability performance. Thus, Chapter 4 discusses how the sustainability performance of organizations relates to the specific position of an organization within a network.

Chapter 5 explains the added value of the combined use of structural and evolutionary perspective in understanding inter-organizational networks in agro-industrial parks. In this chapter, cross-sectional and longitudinal study designs are combined. Cross-sectional study design is used for a structural perspective and longitudinal design for an evolutionary perspective. Two illustrative cases of agro-industrial parks in the Netherlands are analyzed to demonstrate the complementarity of the evolutionary and structural perspectives. For the cross-sectional design, 34 organization managers of organizations from two agro-industrial parks were interviewed. Data were analyzed by using inter-organizational network analysis methods. For the longitudinal design, media documents from secondary sources were collected, and analyzed by using event sequence analysis. Chapter 5 provides methodological

contribution to the studies that focus on inter-organizational networks among co-located organizations.

Finally, **Chapter 6** concludes the thesis and reflects on the main findings and answers the main research question. Additionally, Chapter 6 provides the theoretical contribution of the thesis, the recommendations to future research, and policy and management implications.

This thesis expands the knowledge of sustainability-oriented inter-organizational collaboration by exploring network structure and network governance aspects and the effects on sustainability performance. The structure of the thesis is visualized in Figure 1.1.

CHAPTER 1	General Introduction		
CHAPTER 2	Literature study: Global inter-organizational collaboration in bio-based business	Systematic literature review	Sustainability benefits and challenges of inter-organizational collaboration in bio-based business
CHAPTER 3	Explorative study: Agro-industrial parks developed in the Netherlands	Desk research and two focus group discussions	Opportunities for and barriers to agro-industrial park realization
CHAPTER 4	Cross-sectional study: case studies in Agriport A7, Biopark Terneuzen, and Bergerden	Desk research and interviews with 64 managers	Network structure in sustainable agro-industrial parks
CHAPTER 5	Longitudinal and cross-sectional study: case studies in Agriport A7 and Biopark Terneuzen	News archives and interviews with 34 managers	An evolutionary and structural perspective on inter-organizational networks in agro-industrial parks
CHAPTER 6	Discussion and Conclusions		

Figure 1.1. Thesis structure

CHAPTER 2: SUSTAINABILITY BENEFITS AND CHALLENGES OF INTER-ORGANIZATIONAL COLLABORATION IN BIO-BASED BUSINESS: A SYSTEMATIC LITERATURE REVIEW

This chapter is based on:

Nuhoff-Isakhanyan, G., Wubben, E., Omta, S.W.F., 2016. Sustainability benefits and challenges of inter-organizational collaboration in bio-based business: A systematic literature review. Sustainability 8 (4), 307-324.

2. SUSTAINABILITY BENEFITS AND CHALLENGES OF INTER-ORGANIZATIONAL COLLABORATION IN BIO-BASED BUSINESS: A SYSTEMATIC LITERATURE REVIEW

2.1. Introduction

The societal demand to address increasing scarcity of natural resources and climate change has resulted in the expansion of renewable activities such as bio-based business. In this study, we refer to bio-based business as commercial activities that use renewable biological resources and related technologies to produce food, feed, energy, chemicals, pharmaceuticals and other products and materials (Pellerin and Taylor, 2008; Pfau *et al.*, 2014; Schmidt *et al.*, 2012). Bio-based business is often considered to be sustainable because the renewable products of bio-based bring environmental benefits such as lower carbon and greenhouse gas (GHG) emissions by substituting fossil-fuel-based products (Pfau *et al.*, 2014). Additionally, bio-based business creates economic and social activities (Gold, 2011). However, bio-based business is also associated with sustainability challenges, such as conflicts in land-use (Gold, 2011), deforestation, decrease in biodiversity, and soil erosion due to long-term mono-crop production (Dauvergne and Neville, 2010; Hall *et al.*, 2012; Kline *et al.*, 2009; Lemus and Lal, 2005; Mangoyana and Smith, 2011). Encouraged to exploit innovative solutions and enhance sustainability, organizations engaged in bio-based activities extensively explore collaboration possibilities with external partners (Anbumozhi *et al.*, 2010; Bergenholtz and Waldstrøm, 2011). Many organizations have already established inter-organizational collaboration with external partners through joint ventures, strategic alliances, and public-private partnerships (Anbumozhi *et al.*, 2010). These inter-organizational collaborations are often claimed to increase the sustainability of bio-based business through providing technological solutions for cleaner production, such as reuse of waste streams, reduction of solid wastes, and optimization of energy use (Albino *et al.*, 2012; Mangoyana and Smith, 2011; Pellerin and Taylor, 2008). The aim of this study is to show the added value (if any) of such inter-organizational collaboration in terms of sustainability.

A wide variety of knowledge is available on bio-based business in general, as well as on inter-organizational collaboration in bio-based business specifically. This knowledge has an inter-

disciplinary background in, among others, biochemistry, agricultural engineering, environmental management, and industrial ecology (Pfau *et al.*, 2014; Vandermeulen *et al.*, 2011). However, the available knowledge is scattered and not systematically integrated, which hampers the formulation of a clear statement about whether inter-organizational collaboration in bio-based business can indeed improve the sustainability of bio-based business. The objective of this paper is therefore to find and integrate the available knowledge of sustainability of inter-organizational collaboration in bio-based business, while considering the three aspects of sustainability: environmental, economic, and social. We conducted a systematic literature review, which allowed us to find, gather, and integrate the existing knowledge of inter-organizational collaboration in bio-based business in a systematic, explicit, transparent, and accountable manner. We developed a framework showing sustainability benefits and challenges as investigated by scholars (Gough *et al.*, 2012; Pittaway *et al.*, 2004).

In the following section we outline the data and methods used to conduct the systematic review. In the Section 2.3 we present the main results and develop the framework, and in the Section 2.4 we discuss the results and draw conclusions.

2.2. Data and methods

To conduct the systematic literature review, a group of academics with a multidisciplinary background developed a review protocol as the main guideline (Gough *et al.*, 2012; Pittaway *et al.*, 2004). According to this review protocol, the following steps were followed: operationalization of the main concepts; identification of keywords and search strings; identification of inclusion criteria; identification of exclusion criteria; operation of the final search; screening the references based on titles and abstracts, and running the synthesis. Afterwards, we focused on the most relevant articles and conducted a context analysis. Below, we detail the steps from the protocol and provide the methodological considerations.

Main concepts. The two concepts “bio-based” and “sustainability” are studied by various sciences, such as chemistry, biochemistry, agricultural engineering, environmental management, and environmental ecology (Brundtland *et al.*, 1987; Elkington, 1998; Pfau *et al.*,

2014). For the sake of clarity and precision, the authors define "bio-based business" as commercial activities that use renewable biological resources and technologies to replace fossil fuels (Pellerin and Taylor, 2008; Pfau *et al.*, 2014; Schmidt *et al.*, 2012). "Sustainability outcome" is defined as any benefit or challenge in any of the three aspects of sustainability: environmental, economic, and social (Brundtland *et al.*, 1987; Elkington, 1998; Santiago-Brown *et al.*, 2015). Thus, sustainability benefits refer to environmentally friendly, economically beneficial, and socially supportive production (Elkington, 1998). Finally, "Inter-organizational collaboration" is defined as collaborations between two or more companies (Bergenholtz and Waldstrøm, 2011), in contrast to collaboration among entities within one organization.

Keywords and search strings. We performed a preliminary literature study to refine the keywords and construct search strings. In total, we identified three keywords and, due to similarity between terms in use, about 90 search strings (Appendix A). We conducted the prime search operation using the databases ISI Web of Science (WoS), Scopus, and EconLit. This resulted in a few hundred thousand citations (n=364 387).

Inclusion criteria. The study team identified six inclusion criteria referring to the science discipline, language, year, and type of articles (Appendix B).

Exclusion criteria. The study team identified three exclusion criteria to reduce the data in such a way that only relevant articles remained in the final set. Due to a lack of precision in use, the authors operationalized the exclusion criteria by forty-seven terms, sixteen categories, and seven themes (Appendix C).

Final search. To get rid of irrelevant articles (e.g., due to key terms pointing at alternative meanings, such as the term "network" referring to computer networks instead of inter-organizational networks) we applied the inclusion and exclusion criteria to filter the titles and abstracts (Appendix C). The results of these advanced search operations have been exported to EndNote: 148 articles from WoS, 1560 from Scopus, and 272 from EconLit, that sum up to 1980 articles. The removal of duplicates resulted in a total set of 1867 articles. The authors observed that sometimes different search engines recorded the same reference differently, causing malfunctioning of the Endnote "remove duplicates" command. Therefore the authors manually re-examined the set and removed another 40 duplicates, resulting in a set of 1827 non-identical articles (Table 2.1).

Table 2.1. Data reduction process of final set selection

Processes		In	Out	Reason
Merging, among which		**1980**	**362 451**	Irrelevant
	WoS	*148*	*34 163*	
	Scopus	*1560*	*68 390*	
	EconLit	*272*	*259 898*	
Cleaning for duplicates – automatic function		**1867**	**113**	Duplicates
Cleaning for duplicates – manually		**1827**	**40**	Duplicates
Screening titles and abstracts		**99**	**1728**	Irrelevant + one duplicate*
Synthesis		**24**	**75**	Quality

* Note: while reading articles in detail, the authors found that one article was still present twice in the set because the same article was registered under different names in different search engines.

Screening the titles and the abstracts. Two academics from the study team separately evaluated the relevancy of the articles by judging the titles and abstracts. In this evaluation, they excluded the articles that 1) referred to intra-organizational collaboration instead of inter-organizational collaboration, 2) focused on developing models, and/or 3) discussed inter-organizational collaboration normatively without providing empirical evidence. Afterwards, they discussed the disagreements and achieved essential agreement on including 99 articles in the set for content analysis (Cohen's kappa = 0.65). These 99 articles were published primarily in dedicated journals, such as Energy Policy, International Journal of Biotechnology, Organization Science, Journal of Industrial Ecology, Biomass & Bioenergy, Business Strategy and the Environment, Journal of Cleaner Production, and Waste and Biomass Valorization. About 81% of these articles were found in WoS, 95% in Scopus, and only 31% in EconLit. WoS provided two unique articles, Scopus seventeen, and EconLit two, which indicates a substantial overlap among the databases.

The number of articles per year (1993-2013) has increased notably, with more than 80 % of the articles published after 2007 (Figure 2.1).

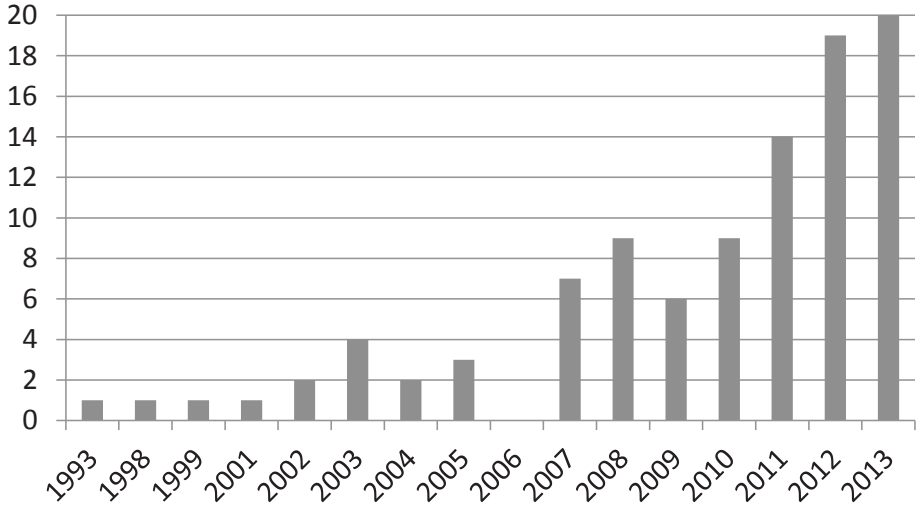

Figure 2.1. Number of articles on inter-organizational collaboration in bio-based business by year of publication

Running synthesis. The selected 99 articles were judged based on the combination of the following three selection criteria: inter-organizational collaboration; bio-based business; and, benefits or challenges to any of the three aspects of sustainability. Articles were considered relevant if they satisfied all three criteria. Two academics from the study team independently synthesized the data by reading the articles in more detail, and systematically discussing the articles that one of them thought deficient of the criteria. They achieved a substantial inter-rater agreement of Kappa 0.63 (Table 2.2).

Table 2.2. Inter-rater agreement on data synthesis

				Rater 2
		Include	Exclude	Total
	Include	**24**	12	36
	Exclude	3	60	63
Rater 1	Total	27	72	99
			Kappa	**0.63**

In total, the entire data-reduction process ran from a few hundred thousand citations (n=364387) via 1827 and 99 towards the 24 most relevant ones (Table 2.2). The core set of 24 articles was examined and selected for content analysis.

Finally, the authors conducted content analysis using Atlas.ti software (Friese, 1997), thereby systematically categorizing, coding and examining the 24 core articles. The authors integrated the results from the individual studies that addressed similar topics (Malterud, 2001). Out of the 24 articles in the dataset sixteen used case studies, six used surveys, and two used literature reviews as the main method of studying inter-organizational collaboration in bio-based business. Although all articles were designed as a cross-sectional study, the methodological variety of datasets helped to capture the different dimensions of inter-organizational collaboration in bio-based business.

Finding a focus regarding the three main concepts (inter-organizational collaboration, sustainability outcomes, and bio-based business) was a major challenge for this literature study because each of these three domains was ambiguous, complex, and multidimensional. Therefore, studying interrelations between these concepts required extra efforts to find a balance between precision and comprehensiveness. The authors discussed the issue within the study team and, as a result of several brainstorming sessions, jointly arrived at more specific key words and search string (Appendix A). Additionally, the inclusion–exclusion criteria were strengthened (Appendices B and C) following an iterative process by executing the search function several times.

2.3. Results

The results of this paper are presented in three subsections. First an overview of inter-organizational collaboration in bio-based business is given, such as the types, means, and characteristics. Second, the sustainability benefits are presented, followed by the third subsection where the sustainability challenges are shown.

2.3.1. Overview of inter-organizational collaboration

Table 2.3 presents an overview of the 24 articles by discussed type and means of collaboration.

Table 2.3. Overview of the final set of articles

Reference	Types of collaboration	Means of collaboration
Industrialized		
Anbumozhi *et al.*, 2010	Wood biomass industrial cluster in Japan	Exchange material and energy, waste heat, knowledge. Sharing resources, personnel, facilities and infrastructure. Integration of production system, integration of bio-based with other industries.
Baas, 2011	Industrial symbioses in the Netherlands and in Sweden	Exchange material and energy, waste heat, CO_2, knowledge, bio-waste, waste water. Sharing buildings, facilities, resources, personnel, social network, and other utilities. Integration of CHP with bio-gas/bio-fuel plant, of CHP with district heating system.
Bagchi-Sen *et al.*, 2011	Biotechnology clusters in the USA	Exchange knowledge. Share innovation and social network.
Dauvergne and Neville, 2010*	Bio-fuel alliances in the USA and Europe	Exchange (bio-)waste. Share property rights. Integration of production system.
Ferguson *et al.*, 2005	Biotechnology partnerships in Germany, Canada and France	Exchange knowledge and R&D. Share resources, physical goods and services, and social network.
Forbord *et al.*, 2012	Wood biomass cluster in Norway	Exchange material and energy, wood waste, waste heat, knowledge, resources. Share social network.
Gold 2012	Integrated supply chain biogas plants in Germany	Exchange (bio-)waste, energy, waste heat. Integration of supply chain.
Jensen *et al.*, 2013	Closed-loop supply chain in Denmark	Exchange material and energy, (bio-)waste, energy. Integration of processes, of CHP with district heating system, of supply chain.
Karlsson and Wolf, 2010	Wood biomass industrial symbiosis in Sweden	Exchange material and energy, waste heat, (bio-)waste. Integration of processes, of bio-fuel and sawdust plant productions, of CHP with district heating system.
Klugman *et al.*, 2009	Industrial symbiosis in Sweden	Exchange waste heat, steam. Integration of processes, of CHP with district heating system.
Mangoyana and Smith, 2011*	Bioenergy clusters in Australia, Sweden, Austria, Finland and Denmark	Exchange material and energy, (bio-)waste, waste heat. Integration of production systems, of bio-based with other industries.
Martin and Eklund, 2011	Industrial symbiosis in Sweden	Exchange material and energy, waste heat, industrial waste. Share utilities. Integration of bio-based with other industries, of CHP with bio-gas/bio-fuel plant, of CHP with district heating system.

Martin *et al.*, 2012	Bio-fuel clusters in Sweden	Exchange material and energy, by-product. Share utilities.
Suarez-Villa and Walrod, 2003	Biotechnology alliances in the USA	Exchange knowledge and R&D. Share personnel.
Van Moorsel *et al.*, 2007	Biotechnology cluster in Canada	Exchange knowledge and R&D. Share resources, personnel.
Vuylsteke and Van Gijseghem, 2012	Agricultural knowledge and innovation system in Belgium	Exchange knowledge and R&D. Share personnel.
Wubben *et al.*, 2012	Biomass collaboration in the Netherlands	Exchange (bio-)waste, knowledge. Share resources.
Zollo *et al.*, 2002	Biotechnology alliances in the USA	Exchange knowledge and innovation. Share partner-specific experience.
Emerging		
Dauvergne and Neville, 2010*	Bio-fuel alliances in Asian, South American and African countries	Exchange (bio-)waste. Share property rights. Integration of production system.
Mangoyana and Smith, 2011*	Bioenergy clusters in India and Uganda	Exchange material and energy, (bio-)waste, waste heat. Integration of production systems, of bio-based with other industries.
Hall *et al.*, 2012	Integrated biodiesel supply chain in Brazil	Exchange (bio-)waste, knowledge.
Hiete *et al.*, 2012	Industrial symbiosis in Chile	Exchange material and energy, waste heat, (bio-)waste. Integration of water system, of processes.
Kiraly *et. al.*, 2013	Integrated production system in Slovenia	Exchange material and energy, waste heat, (bio-)waste. Integration of processes, of CHP with bio-gas/bio-fuel plant, of CHP with district heating system.
Park *et al.*, 2011	Biotechnology cluster in South Korea	Exchange knowledge and learning. Share social network.
Shi *et al.*, 2010	Eco-industrial park in China	Exchange material and energy, waste heat, (bio-)waste. Share utilities. Integration of water system.
Yuan *et al.*, 2010	Industrial park in China	Share facilities and infrastructure. Integration of waste water system.

* Articles with * study cases from both industrialized and emerging economies.

Types of inter-organizational collaboration. As Table 2.3 shows, various types of inter-organizational collaborations in bio-based business have been studied, the most popular type of which are (eco-)industrial parks. More than 60% of the papers refer to and analyze (eco-)industrial parks. "(Eco-)industrial park" refers to industrial ecology and constitutes industrial clusters, energy clusters, eco-industrial clusters, and biotechnological clusters. The

next popular type of collaboration is the strategic alliance, which encompasses innovation alliances and public–private partnerships.

The results show that organizations aim to eliminate the negative effects of bio-based business to the environment and create sustainability benefits through collaboration. Moreover, it is believed that bio-based business can only be sustainable through collaborations, which attracts organizations from various industries such as agriculture, horticulture, aquaculture, fisheries, pharmaceuticals, chemicals, and energy. It is claimed that inter-organizational collaboration among these heterogeneous organizations can bring competitive advantages and synergetic opportunities along the chains of rest-stream processing and resource sharing (Martin and Eklund, 2011). Inter-organizational collaboration is not only promising for increasing the environmental performance and ensuring sustainability of bio-based business, but also for ensuring the intensive innovations (Suarez-Villa and Walrod, 2003; Van Moorsel *et al.*, 2007).

Means of inter-organizational collaboration. Table 2.3 presents the three means of inter-organizational collaboration in bio-based business that exchange waste streams, share utilities, and integrate systems.

First, exchanging waste streams refer to the flow of material and energy (for instance heat), steam, bio- and industrial waste, by-products, and information and knowledge, among collaborating organizations. For example, exchanges are conducted through delivery of electricity from a pulp mill to a sawmill, and dispatch of sawdust and wood chips from the sawmill to the pulp mill (Anbumozhi *et al.*, 2010; Baas, 2011). When it comes to heat exchanges, many authors refer to collaborations between industries and district heating companies as economically and environmentally beneficial. Authors also refer to the steam exchanges between, for example, a combined heat and power plant (CHP) and an ethanol plant, between a paper mill and a pulp mill (Baas, 2011; Klugman *et al.*, 2009; Martin and Eklund, 2011). Additionally, authors refer to carbon emission as industrial waste and emphasize the importance of CO_2 use in greenhouses (Baas, 2011; Martin and Eklund, 2011; Martin *et al.*, 2012). Another exchange is the flow of information, knowledge, and experience among local organizations and local research institutes and universities. The exchange of relevant information and knowledge brings a competitive advantage to collaborating organizations (Dyer and Singh, 1998; Ferguson *et al.*, 2005).

Second, sharing utilities refers to joint use of resources such as raw material, buildings, personnel, infrastructure, and information. Sharing resources decreases information asymmetry and breeds trust and commitments in collaborations (Ferguson *et al.*, 2005; Forbord *et al.*, 2012). In particular, sharing personal contacts in the form of social relations plays an essential role in inter-organizational collaboration being an important channel to transfer tacit knowledge, skills, and experiences necessary for innovation (Bagchi-Sen *et al.*, 2011; Suarez-Villa and Walrod, 2003; Zollo *et al.*, 2002).

Third, integrating systems refers to the integration of processes, production systems, water, and heat systems. For instance, integration of processes refer to joint bio-fuel combustion and bio-gas production (Klugman *et al.*, 2009), and integration of production systems refers to the closed-loop material flows where the waste and by-product from one production are used by another (Mangoyana and Smith, 2011; Martin and Eklund, 2011).

Characteristics of inter-organizational collaboration in bio-based business. The key characteristics of inter-organizational collaboration in bio-based business are heterogeneity, geographical proximity, technological proximity, cultural proximity, and complementarity.

Heterogeneity refers mainly to the differences in the industry in which the organizations operate. Many organizations attach a high importance to collaborations with organizations from other industries (such as agricultural centers), universities, and local scientists. Additionally, industries such as biotechnology, bio-fuel, forestry, agricultural biotechnology, agri-food, the chemical sector, and cosmetics provide potential partners for inter-organizational collaboration in bio-based business. Heterogeneity not only allows for exchanges of waste streams among different organizations, but also enables a wider access to local resources, such as information, knowledge, skilled labor, and finance (Bagchi-Sen *et al.*, 2011; Zollo *et al.*, 2002), eventually increasing innovations (Bagchi-Sen *et al.*, 2011).

Geographical proximity refers to the co-location of heterogeneous organizations, and offers opportunities for synergy for successful formation of inter-organizational collaboration in bio-based business (Chertow, 1998; Hiete *et al.*, 2012; Martin *et al.*, 2012). Synergy is created among co-located companies via exchange channels, shared services and logistics, and integration systems, such as water flow and heat integration systems (Martin *et al.*, 2012). Geographical proximity is especially important for heat integration systems, because its storage and/or transportation can be technically and economically impossible (Hiete *et al.*,

2012; Kiraly *et al.*, 2013). Regarding geographical proximity, a radius of 20 km or less is recommended (Gold, 2012; Mangoyana and Smith, 2011). Co-located companies usually develop social networks through which innovations, information, and knowledge are exchanged (Bagchi-Sen *et al.*, 2011). Additionally, geographical proximity reduces transportation costs and fuel use within collaborating organizations (Mangoyana and Smith, 2011). Available local resources and local markets provide an opportunity to close the supply chain with no or low transportation costs (Mangoyana and Smith, 2011).

Technological proximity refers to the ability of an organization to collaborate with other co-located organizations without needing to implement any radical changes (Anbumozhi *et al.*, 2010). Technological proximity exists if none of collaborating organizations have to shift their business. Organizations that are geographically co-located but are technologically incompatible need to implement radical changes because their absorptive capacities may lie beyond the capabilities of collaboration (Anbumozhi *et al.*, 2010; Vuylsteke and Van Gijseghem, 2012).

Cultural proximity refers to the non-tangible issues such as norms, values, trust, and understanding. Cultural experience is usually built in time while building common experiences (Zollo *et al.*, 2002). Organizations that are culturally far apart will prefer formal governance despite high transaction costs (Zollo *et al.*, 2002).

Complementarity refers to the equilibrium of supply and demand (Dyer and Singh, 1998; Jensen et al., 2013; Suarez-Villa and Walrod, 2003; Wubben *et al.*, 2012). The complementarity of supply and demand shows that the availability of required biological resources and the demand for bio-based products in local markets are essential. For example, a bio-gas plant needs a certain quantity of biomass (e.g., manure) to operate and meet the local demand for bio-gas (Jensen *et al.*, 2013). Supply and demand complementarity is difficult to fulfil because of uncertainties in biomass supply such as unpredictable yields and fluctuating prices of biomass (Gold, 2012; Jensen *et al.*, 2013).

In summary, the predominant type of inter-organizational collaboration in bio-based business is in the form of (eco-)industrial parks, where organizations collaborate by exchanging waste streams, sharing utilities, and integrating systems. Inter-organizational collaboration in bio-based business is characterized by the involvement of heterogeneous organizations

that have a certain degree of geographical, technological, and cultural proximity and complementarity.

2.3.2. Sustainability benefits

In this subsection, the environmental, economic, and social benefits of inter-organizational collaboration in bio-based business are presented.

Environmental benefits. The most important environmental benefit is the substantial reduction of carbon emission. The distribution and use of CO_2 emission of bio-based and industrial production in agricultural production, such as in greenhouses, may result in the reduction of substantial amounts of CO_2. The CO_2 savings here are twofold: (1) CO_2 emission from bio-based and industrial companies is used rather than expelled into the atmosphere, and (2) avoiding costs of burning natural gas in greenhouses (Baas, 2011; Martin and Eklund, 2011).

> *"A new private company ... captures CO_2 emissions from the Shell plant, and distributes the waste emissions to 500 greenhouse companies to the North of Rotterdam. ... In 2007, the greenhouse companies achieved a reduction of 170 000 tones CO_2 emissions by avoiding the burning of 95 million m^3 natural gas" (Baas, 2011; p. 432-3).*

Besides greenhouses, other local companies can also capture CO_2 for carbon use in, for example, soft drinks, cooling applications, and algae production (Martin and Eklund, 2011). Studies show an extensive potential to reduce CO_2 emission (more than 500 000 tones CO_2 per year) through energy cooperation among local integrated paper and pulp mills, district heating systems, and bio-fuel production (Klugman *et al.*, 2009). Anbumozhi *et al.* (2010) found that the collaborations among local companies in Maniwa, Japan, can turn the cluster into a zero-emission zone:

> *"The energy generated from the system not only meets the company's own demand but is also sold to other companies. This green energy is estimated to be an equivalent of 58 000 tons of CO_2, an environmental benefit." (Anbumozhi et al., 2010; p. 368)*

Additionally, CO_2 reduction can also be achieved through reduced transportation offered by geographical proximity. Use of local raw materials, as well as local production and supply to local markets reduce the need for transportation within the entire supply chain, and through

this reduce fossil fuels use (Mangoyana and Smith, 2011; Shi *et al.*, 2010). In addition, the reuse of waste heat of local companies as substitutes for fossil fuel for heating (Klugman *et al.*, 2009; Mangoyana and Smith, 2011), eventually reduces carbon emission even further. For example, in Sweden the combustion of biomass and the production of ethanol in combination with CHP plants reduced GHG emissions by about 80% as compared to plants that were based on fossil fuel (Martin and Eklund, 2011).

Another environmental benefit is waste reduction. The valorization of (bio-)waste from agro-food, forestry, and other industries in closed-loop models, minimizes solid waste and reduces environmental pollution (Mangoyana and Smith, 2011). For instance, manure from livestock production is degassed in bio-gas installations, which produce bio-gas and replace the mineral fertilizers with organic compost. Degassing of manure reduces methane and nitrous oxide emissions and provides green energy for local industries or local residences (Jensen *et al.*, 2013; Mangoyana and Smith, 2011). It is apparent that the whole process of using agricultural waste for bio-based purposes provides value to the waste and produces organic fertilizers (Jensen *et al.*, 2013):

> *"... the biogas technology facilitates ... an improvement of the residual product's fertilizer value, which leads to an increased uptake by plants, reduced runoff of nutrients to surface water, and reduced leaching to groundwater as well as reduced costs for purchase of mineral fertilizers." (Jensen et al., 2013; p. 139)*

Waste reduction is also achieved by the use of oil and fat waste, organic household waste, and organic waste from food industries, such as vegetable oil waste from fast-food industries, all in biodiesel, bio-gas, bio-fuel, biodegradables, and other bio-based productions (Martin and Eklund, 2011; Martin *et al.*, 2012). Other environmental benefits of inter-organizational collaboration are evident in the use, reuse, and recycling of waste water and waste heat (Karlsson and Wolf, 2008; Martin and Eklund, 2011):

> *"Greenhouses in particular can also use waste heat from the ethanol and biogas industry." (Martin and Eklund 2011; p. 1751).*

> *"Waste heat from the pulp mill, the sawmill and the biofuel upgrading plant is used as a resource base to cover the base load of the heat demand in the district heating system." (Karlsson and Wolf 2008; p. 1541)*

In general, the integration of renewables to a company system (such as bio-energy production and use, and integration of CHPs with district heating systems) is an alternative solution to improve companies' environmental performance (Kiraly *et al.*, 2013). Inter-organizational collaboration in bio-based business brings substantial environmental benefits and tackles the more alarming sustainability issues such as increasing carbon and GHG emissions, and increasing waste.

Economic benefits. First, inter-organizational collaboration in bio-based business create various economic synergies (Anbumozhi *et al.*, 2010; Hiete *et al.*, 2012; Klugman *et al.*, 2009). Synergy in the implementation of new technologies, improvement of material use and energy handling, such as water, utility, services, logistics, and renewable solutions (Gold, 2012; Hiete *et al.*, 2012; Martin and Eklund, 2011; Martin *et al.*, 2012), create economies of scope that can be decisive for sustainability performance (Forbord *et al.*, 2012; Shi *et al.*, 2010; Suarez-Villa and Walrod, 2003). Another important synergy is the joint discovery of new knowledge, knowledge generation and transfer, and uncovering tacit knowledge, ultimately leading to improved trust and supportive relationships (Suarez-Villa and Walrod, 2003; Vuylsteke and Van Gijseghem, 2012).

> *"Synergies between the biofuel industry and food industry are primarily of two different types: using biofuel by-products for human and animal food and feed; and using food industry by-products for biofuel production." (Martin et al., 2012; p. 549)*

Second, inter-organizational collaboration in bio-based business can result in cost reduction in, for instance, waste disposal, waste incineration, and waste taxation (Jensen *et al.*, 2013). Referring to cost reduction, Yuan at al. (2010) show that the shared systems (e.g., of waste water treatment) are more than 150 times more cost-efficient than single uses. Karlsson and Wolf (2008) show that the integration of chemical pulp mills, sawmills, bio-fuel plants, and district heating systems, can bring about 18% cost efficiency for the companies involved in the system. Inter-organizational collaboration effects on cost can also be visible in the reduction of transportation and fuel costs (Mangoyana and Smith, 2011), and overhead costs related to R&D, production, and distribution (Suarez-Villa and Walrod, 2003).

> *"Slaughterhouse wastes in the city of Linköping are sent to the local biogas facilities as a method for disposal. This greatly benefits the meat processing industry, with reduced*

waste handling costs and produces biogas used for vehicle fuel in the community" (Martin and Eklund 2011; p. 1753)

Additionally, collaborations enable the shared use of techniques and technologies. This reduces start-up costs and enables investments that are often not affordable by stand-alone companies (Forbord *et al.*, 2012). Inter-organizational collaboration opens new opportunities, especially for small and medium-sized enterprises (SMEs) (Hiete *et al.*, 2012; Wubben *et al.*, 2012). SMEs can benefit from using the resources and technologies of large companies that they would not be able to afford on their own (Bagchi-Sen *et al.*, 2011). Inter-organizational collaboration can provide new business-development and business-expansion opportunities (Anbumozhi *et al.*, 2010). Especially in emerging economies, new business developments and economic opportunities are of high importance (Abraham *et al.*, 2007; Dauvergne and Neville, 2010; Forbord *et al.*, 2012).

Third, inter-organizational collaboration can result in enhanced innovation performance and competitive advantages through the exchange of resources, materials, energy, water, by-products, and so forth (Martin *et al.*, 2012; Shi *et al.*, 2010), and through the exchange of relevant knowledge, technical knowhow, and innovative ideas (Dyer and Singh, 1998). Companies that collaborate intensively are stronger competitors regarding biomass utilization (Anbumozhi *et al.*, 2010).

"Given the growing interest in the valorization of bio-waste it is posited that entrepreneurial firms develop inter-organizational relationships to generate competitive advantages." (Wubben et al., 2012; p. 261)

Geographical proximity of collaborating organizations (e.g., companies, research organizations, industry organizations, venture capitalists and universities) effectively allows access to knowledge and skilled labor, and promotes knowledge-sharing essential for innovation (Bagchi-Sen *et al.*, 2011; Bagchi-Sen and Scully, 2004). Collaborating organizations are on average more innovative than stand-alone ones (Bagchi-Sen *et al.*, 2011). The diversity of information and capabilities has a positive influence on a company's innovation performance (Park *et al.*, 2011; Suarez-Villa and Walrod, 2003; Van Moorsel *et al.*, 2007). Collaborations enable not only exchange of knowledge that enhances innovation, but also exchange of existing techniques and shared use of technologies (Forbord *et al.*, 2012), and through that

provides benefits of innovation availability (Suarez-Villa and Walrod, 2003) and supports SMEs to sustain innovations in bio-based production.

Fourth, inter-organizational collaboration in bio-based business can result in improved reputation of the involved organizations. The involvement in green supply chains, the use of renewable technologies, and the implementation of sustainable innovations are branding opportunities for collaborating companies (Jensen *et al.*, 2013). On top of improving their reputation, inter-organizational collaboration enables companies to actually invest in reducing their carbon footprint (Hall *et al.*, 2012). Through this, companies capture not only financial benefits but also goodwill that enhances the investment climate and gives a green image regarding cleaner production (Jensen *et al.*, 2013; Shi *et al.*, 2010).

Finally, inter-organizational collaboration in bio-based business brings not only economic benefits for the engaged companies but also benefits for local, regional, and national economies, which is especially important in emerging economies (Anbumozhi *et al.*, 2010):

> *"Many of the new alliances reveal the growing economic and political strength of some developing countries, such as Brazil and Indonesia" (Dauvergne and Neville, 2010; p. 639).*

In general, inter-organizational collaboration in bio-based business is discussed to bring substantial economic benefits. This is demonstrable especially in cases from emerging economies, where bio-based business is of essential importance to national economic growth and poverty reduction (Dauvergne and Neville, 2010; Mangoyana and Smith, 2011).

Social benefits. Inter-organizational collaboration in bio-based business has potential ability to support socio-economic activities and to create employment (Anbumozhi *et al.*, 2010; Mangoyana and Smith, 2011), to improve living conditions (Anbumozhi *et al.*, 2010), and to provide higher-paid jobs (Hall *et al.*, 2012). Collaboration attracts competent human capital, such as multidisciplinary researchers (Bagchi-Sen and Scully, 2004; Suarez-Villa and Walrod, 2003):

> *"Bio-energy production company in Maniwa cluster has created employment opportunities of 110 man/months." (Anbumozhi et al., 2010; p. 369)*

The social benefits of inter-organizational collaboration in bio-based business are especially significant in emerging economies (Gold, 2012). These benefits usually appear in different forms, such as availability of energy, electricity, heat, and irrigation water in previously remote areas, and economic development opportunities in marginalized areas (Mangoyana and Smith, 2011). Local companies often implement social-responsibility programs by investing in health and education for the employees and their families, and for people living in the vicinity (Hall *et al.,* 2012). Moreover, inter-organizational collaboration in bio-based business often includes SMEs that expand employment opportunities, generate income, advance economies, and reduce poverty in the long term (Hall *et al.*, 2012). Arndt *et al.* (2010) found that, in a period of 12 years, the expectation of poverty reduction because of bio-based business is 6% in Mozambique (Arndt *et al.*, 2010; Dauvergne and Neville, 2010).

> *"Hosahalli village biomass gasifier in an agricultural community provided 20 kW electricity in 1997. The benefits of the project included cutting the walking distance of women to fetch water as water would be pumped to households whilst farmers were able to get irrigation water. A total of 20.2 acres was irrigated in 2002 enabling production of a variety of crops benefiting 17 farmers. Availability of evening lighting was also reported to benefit studying school children and the elimination of kerosene use" (Mangoyana and Smith, 2011; p. 1288)*

In summary, inter-organizational collaboration in bio-based business is found to create wealth and social benefits for local populations, empower local communities, bring new employment opportunities, create social wealth, develop economies, and reduce poverty. As a result, inter-organizational collaboration in bio-based business is found to have higher value in emerging economies than in industrialized economies.

2.3.3. Sustainability challenges

Despite several benefits, inter-organizational collaboration in bio-based business has been criticized for increasing risk and uncertainties.

The environmental challenges are the following. First, inter-organizational collaboration in bio-based business is criticized for aggravating land-use conflicts. The concentration of vari-

ous industries needs large-scale use of local land, including land for energy-crop production (Mangoyana and Smith, 2011), which escalates local land use conflicts (Gold, 2012). Bio-based business has been strongly criticized for their intensive land use (i.e. for energy crop production) (Mangoyana and Smith, 2011). Similarly, inter-organizational collaboration in bio-based business is criticized for the use of even more land. Large-scale production of energy crops may have a negative impact on water resources, cause soil erosion, and eventually require additional chemical fertilizers (Dauvergne and Neville, 2010; Hall *et al.*, 2012; Mangoyana and Smith, 2011). Second, inter-organizational collaboration in bio-based business is criticized for concentrating industrial activities at one geographical location. Concentration increases the pressure on the local ecology, and increases the risks of the ecological capacity being unable to deal with local pollution.

Economic challenges are related to capital intensity because of, for instance, huge investments required to start inter-organizational collaboration, costs for waste quality standards, and costs for operation and maintenance of huge installations (e.g., a biomass gasifier). Capital intensity may cause financial difficulties (Baas, 2011; Forbord *et al.*, 2012; Jensen *et al.*, 2013; Mangoyana and Smith, 2011). These costs (e.g., high costs of the required infrastructure) are not always affordable for commercial companies without, for example, governmental support (Anbumozhi *et al.*, 2010; Baas, 2011; Shi *et al.*, 2010):

> *"It was calculated that such a pipeline system would cost € 112 700 000 and would require government funding for new infrastructure." (Baas, 2011; p. 431).*

Substantial capital is always needed to establish inter-organizational collaboration and often the large-scale approach has been economically unsuccessful (Baas, 2011). For instance, Norwegian bio-energy companies made a loss in 2007, which was the result of high investment costs, lack of suitable techniques and technologies, and low electricity prices that decreased the competitiveness of bio-energy (Forbord *et al.*, 2012). Additionally, inter-organizational collaboration in bio-based business can cause interdependency issues among collaborating organizations. Interdependency may lead to path dependencies and technological lock-in situations if the organizations link their businesses with other local companies for a long period (Baas, 2011; Shi *et al.*, 2010). Interdependencies in inter-organizational collaboration raise the risk of failure of the entire system if one collaborating company fails to fulfil its commitments (Yuan *et al.*, 2010). Finally, inter-organizational collaboration in bio-based

business is linked to transactional uncertainties, fluctuating prices of agricultural products, unstable quantities of yields, and unpredictable markets for waste and by-products leading to the risk of failure (Gold, 2012).

Social challenges are related to traffic congestion, odor nuisance, adverse visual appearance, and diminished recreational value due to the concentration and expansion of bio-based business at one location increasing social discomfort (Gold, 2012; Mielenz *et al.*, 2007; Shi *et al.*, 2010; Yuan *et al.*, 2010). However, these critiques are raised in industrialized countries, such as the Netherlands, Norway, Sweden, and Germany, where the population density is relatively high (Gold, 2012).

In summary, inter-organizational collaboration in bio-based business is discussed to bring sustainability risks and uncertainties, such as increasing land-use conflict, and to increase pressure on the local ecology. Additionally, the operation and maintenance of inter-organizational collaboration in bio-based business is indicated to be capital-intensive, with increased interdependencies and transactional uncertainties. However, these challenges have been much less discussed in relation to emerging economies as compared to industrialized economies.

To integrate the findings in a transferable manner we developed a conceptual overview (presented in Table 2.4). Presently not yet recognized in the core articles, we present the sustainability benefits and challenges by distinguishing between industrialized and emerging economies. This conceptual overview indicates that the environmental benefits and challenges seem not to be geographically dependent. For instance, CO_2, greenhouse gas and waste reduction, and less use of mineral fertilizers are discussed as being similarly beneficial for emerging and industrialized economies. Likewise, the increasing pressure on local ecology and human health risks are discussed as challenging for emerging and industrialized economies. However, the patterns change if we consider the social aspect of sustainability. It turns out that scholars emphasize social benefits in emerging economies, such as poverty reduction and energy availability as typical social benefits. In contrast, scholars seem to emphasize more the social challenges, next to the social benefits in industrialized economies. The challenges of social aspect, such as traffic congestion, visual appearance, and decreasing recreational value, are typical in economically wealthy countries and are not perceived as challenges in emerging economies.

Table 2.4. Sustainability of inter-organizational collaboration in bio-based business in industrialized and emerging economies*

Industrialized economies (31 cases)		
	Benefit	**Challenge**
Environmental	CO_2 and GHG reduction	Ecological and human health risks
	Waste reduction	
	Less mineral fertilizer use	
Economic	Synergies	Capital intensive
	Cost reduction	Interdependency
	Competitive advantage	Transactional uncertainty
	Enhanced innovation	
	Enhanced reputation	
Social	Enhances socio-economic life	Aggregated conflict of land-use
	Local employment	*Traffic congestion*
	Generate income	*Odor*
	Social-responsibility programs	*Adverse visual appearance*
	Secure energy supply	*Decreasing recreational value*
	Supports small-scale farmers	*Exceeding local ecological capacity*
Emerging economies (14 cases)		
	Benefit	**Challenge**
Environmental	CO_2 and GHG reduction	Ecological and human health risks
	Waste reduction	
	Less mineral fertilizer use	
Economic	Synergies	Capital intensive
	Cost reduction	Interdependency
	Competitive advantage	Transactional uncertainty
	Enhanced innovation	
	Enhanced reputation	
	Enhancement of local economy	
Social	Enhances socio-economic life	Aggregated conflict of land-use
	Generate jobs and income	
	Social-responsibility programs	
	Secure energy supply	
	Supports small-scale farmers	
	Poverty reduction	
	Energy availability	

* Concepts that are different across the blocks are presented in *italic.*

In summary, the results suggest a clear distinction between the individual cases from emerging and industrialized economies. Inter-organizational collaboration in bio-based business are discussed as bringing more sustainability benefits in cases from emerging economies mainly due to the social aspect of sustainability.

2.4. Discussion and conclusions

The objective of this paper was to find and integrate the available knowledge of sustainability of inter-organizational collaboration in bio-based business, while considering the three aspects of sustainability: environmental, economic, and social. In this section, we discuss the results and present the main conclusions.

Bio-based business is recognized in the literature as playing an important role in sustainability enhancement, such as improved environmental performance of companies, developed socio-economic life (Dauvergne and Neville, 2010), increased income for developing communities (Forbord *et al.*, 2012), and secured energy availability in a carbon-neutral way (Dauvergne and Neville, 2010; Forbord *et al.*, 2012; Hall *et al.*, 2012; Mangoyana and Smith, 2011). Meanwhile, bio-based business has been criticized for creating ecological and human health risks (Mangoyana and Smith, 2011), for reducing biodiversity and for causing deforestation, soil erosion, and land-use conflicts (Dauvergne and Neville, 2010; Kline *et al.*, 2009; Lemus and Lal, 2005; Mangoyana and Smith, 2011).

By establishing inter-organizational collaboration in bio-based business, organizations are presumed to respond to sustainability challenges of bio-based business through exchanging waste streams, sharing utilities, and integrating production systems (Anbumozhi *et al.*, 2010; Hall *et al.*, 2012; Jensen *et al.*, 2013). The core studies often investigate (eco-)industrial parks as a typical type of inter-organizational collaboration in bio-based business. (Eco-)industrial parks are characterized by heterogeneity of collaborating organizations, and geographical, technological, and cultural proximity and complementarity among the collaborating organizations (Table 2.3).

From our systematic literature review, we found empirical evidence for both sustainability benefits and challenges studied by authors (Table 2.4). However, the authors of core 24 articles have not investigated if the collaborations can mitigate all sustainability challenges of bio-based business, such as land use conflicts and soil erosion. As for the environmental aspect of sustainability, evidence has been found for reduced carbon and greenhouse gas emissions, reduced waste disposal, and reduced use of mineral fertilizers. As for the economic aspect, evidence has been found for synergy, cost reduction (e.g., of waste disposal), competitive advantage, enhanced innovative performance, and enhanced reputation. As for

the social aspect, evidence has been found for increased energy availability and energy-supply security, new employment opportunities, and improved living conditions. The latter of these is especially evident in individual cases from emerging economies. However, evidence has also been found for sustainability challenges, such as increased risk for the local ecology, the capacity of which might not be able to carry the concentrated production activities. Other challenges concern the capital intensity and high operational and maintenance costs. Finally, inter-organizational collaboration in bio-based business seems to raise social discomfort due to traffic congestion, odor nuisance and diminished recreational value, which is especially evident in individual cases from industrialized economies.

Having explored the sustainability benefits and challenges, the authors discovered that scholars discuss different sustainability effects while studying cases from emerging and industrialized economies (Table 2.4). In particular, the social benefits of inter-organizational collaboration in bio-based business are more emphasized in cases from emerging economies, while they are challenged in cases from industrialized economies. In emerging economies, inter-organizational collaboration in bio-based business is argued to contribute to rural empowerment by generating jobs and income, eventually leading to the reduction of poverty. In industrialized economies, the scholars' emphasis is more on the negative social aspects, such as traffic congestion and decreasing recreational value. Therefore, sustainability outcomes seem to be more positively presented in cases from emerging economies than from industrialized economies.

Although our study is preliminary in uncovering the sustainability effects of inter-organizational collaboration in bio-based business, the conclusion that inter-organizational collaboration provides a variety of sustainability benefits next to (region-)specific challenges strengthens pleas to pursue sustainability studies and develop political agendas on inter-organizational collaboration in bio-based business. We recognize the lower number of empirical studies on inter-organizational collaboration in bio-based business in emerging economies compared to industrialized economies (Table 2.4). Nevertheless, the substantial presence of individual case studies (within the articles) from two in many respects opposite extremes (six case studies from Sweden and four case studies from United States) strengthens the representativeness of the conclusions.

Finally, the systematic literature review provided the surprising insight that, while the popularity of the topic of inter-organizational collaboration in bio-based business is growing (Figure 2.1), only a modest number of studies (24 articles) empirically investigated sustainability effects of inter-organizational collaboration in bio-based business, which may lower the reliability of the conclusions. Additionally, note that the studied articles were built on cross-sectional design. Hence, the long-term perspective of sustainability and the interaction between its three aspects could not be found. Finally, the literature failed to give substantial quantitative evidence for the benefits and challenges of all three aspects of sustainability, making it impossible to assess the trade-offs between sustainability benefits and challenges. Articles typically focus on only one out of three sustainability aspects. Therefore, future research is recommended to consider more quantitative measures of all three aspects of sustainability when studying inter-organizational collaboration in bio-based business.

CHAPTER 3: OPPORTUNITIES FOR AND BARRIERS TO AGRO-INDUSTRIAL PARK REALIZATION

This chapter is based on:

G. Nuhoff-Isakhanyan, E.F.M. Wubben, S.W.F. Omta. Opportunities for and barriers to agro-industrial park realization (submitted).

3. OPPORTUNITIES FOR AND BARRIERS TO AGRO-INDUSTRIAL PARK REALIZATION

3.1. Introduction

Agro-industrial parks are inter-organizational networks among geographically co-located organizations, that aim at more sustainable agri-food and renewable energy production, improved bio-mass utilization, enhanced socio-economic performance, and decreased pollution via waste streams exchanges and shared utilities (Beers *et al.*, 2014; Breeman *et al.*, 2013; Hermans *et al.*, 2013b; Hoes *et al.*, 2012; Koerkamp and Bos, 2008; Termeer *et al.*, 2009).

Recently, several agro-industrial parks have been set up and developed in the Netherlands (Hoes, 2012; Smeets, 2011). The Netherlands is a densely populated and highly industrialized country that is a world leader in agricultural innovations (Lambert and Boons, 2002). Examples of currently set-up agro-industrial parks spread throughout the Netherlands are Agriport A7, Bergerden, Biopark Terneuzen, New Mixed Farm, and New Prinsenland (Smeets, 2011). Box 3.1 provides more details about these agro-industrial parks.

In spite of the opportunities provided by the government and invested efforts by project developers, most of these agro-industrial parks have encountered serious barriers in terms of realization (Beers *et al.*, 2014; Breeman *et al.*, 2013; Smeets, 2011). For instance, the government provided several subsidies to establish an innovative collaboration among horticultural, livestock, and biomass production in the New Mixed Farm. Then, in 2013 following strong criticism from local inhabitants, the local authorities cancelled the permissions for the New Mixed Farm (Breeman *et al.*, 2013). However, after a long-lasting legal procedure, the permission was justified by the judge and construction of the New Mixed Farm could restart in 2014 (Limburg, 2014).

BOX 3.1. Examples of agro-industrial parks in the Netherlands

Name	Year start	Occupied areas	Purpose	No. org.	Partners
Agriport A7	2005	930 ha	Connect horticultural, production, logistics, knowledge-intensive business, and leisure	24	Horticultural entrepreneurs, retail companies, agribusiness, construction companies, local and regional authorities, biomass processors, bio-energy producers
Bergerden	2003	320 ha	Connect horticultural, energy, irrigation water production and use	17	Horticultural entrepreneurs, decoration plant producers, energy companies, biomass processors
Biopark Terneuzen	2005	445 ha	Connect horticultural production with existing local industrial production	23	Chemical companies, horticultural entrepreneurs, energy companies, knowledge institutions, development agencies, local and regional authorities, waste processor companies.
New Mixed Farm	2004	36 ha	Connect intensive life husbandry, horticultural, and bio-energy production	5	Animal farming entrepreneurs, horticultural entrepreneurs, local authorities, biomass processors
New Prinsenland	2009	310 ha	Connect horticultural production, logistics, and the local sugar company	4	Horticultural entrepreneurs, energy companies, development agencies, local and regional authorities, the sugar company

Agro-industrial parks represent systematic interactions among local agricultural and industrial companies, and can be described as system innovations. The challenges in realizing system innovations are widely discussed amongst scholars, especially in innovation management, industrial ecology, and transition literature, e.g., Albino *et al.* (2012), Atkinson *et al.* (1997), Boons and Howard-Grenville (2009), Elzen and Wieczorek (2005), Heeres *et al.* (2000), Lambert and Boons (2002), Loorbach (2007). As a type of system innovation, agro-

industrial park realization typically involves heterogeneous stakeholders that rely on trust and shared vision to build networks and to achieve sustainability goals.

Being aware of the potential and realized sustainability benefits an agro-industrial park can provide, there is a need for an improved understanding of the opportunities for and barriers to agro-industrial park realization. Agro-industrial park realization in the Netherlands includes many heterogeneous stakeholders, the interactions of which create stakeholder networks. The objective of this paper is to explore the opportunities for and barriers to agro-industrial park realization from stakeholder network structure and network governance perspectives.

Grounded in social network theory, the paper first draws upon an extensive literature review on agro-industrial park developments. Secondly, it identifies new insights into the opportunities for and barriers to agro-industrial part realization based on two focus group discussions with representatives of stakeholders that are included in several agro-industrial parks in the Netherlands. In doing so, this paper contributes to the scientific knowledge regarding realization of sustainability-oriented inter-organizational collaboration by drawing upon empirical work conducted in the Netherlands.

In the following section, we introduce the data and methods used. In Section 3.3 the results of literature review and in Section 3.4 the results of the focus group discussions are presented. Finally, in Section 3.5 we discuss the results and draw main conclusions.

3.2. Data and methods

To accommodate the exploratory nature of the study we combined two methods: extensive literature review and two focus group discussions with representatives of various stakeholders that are involved in several agro-industrial parks in the Netherlands (Krueger and Casey, 2000; Morgan, 1996; Seal *et al.*, 1998; Wilson, 1997).

First, by use of a literature review we explored the existing academic literature and practitioners' materials. The main sources of data were Web of Science, Scopus, EconLit, Google Scholars, official websites of companies, and media items. Because the focus was put on Dutch cases, the search was conducted in two languages: English and Dutch. We used the

following terms: agropark, agro-industrial park, bio-based, innovation implementation, intensive farming, livestock, mega farm, network governance, social network analysis, sustainable agriculture, system innovation, and transition. Next, we screened a few hundred sources including books, book sections, journal articles, news items, practitioners' and company reports. Two authors of this paper synthesized and filtered the available literature and practitioners' materials that reflect various concepts related to the opportunities for and barriers to agro-industrial park realization from network structure and network governance perspectives. These concepts were used in coding and analyzing the results of focus group discussions (Section 3.4).

Second, to explore factors influenced by opinions focus group discussions were organized (Krueger and Casey, 2000; Morgan, 1996; Seal *et al.*, 1998; Wilson, 1997). About one-hundred potential representatives of stakeholders were listed. These people were company managers, policy makers, entrepreneurs, scholars, and consultants, who had experience with agro-industrial park realization and could be knowledgeable enough to provide the information on agro-industrial park realization. We e-mailed invitations to participate in one of the focus group discussions. In total, twenty-four experts accepted the invitation, amongst which eight consultants, five entrepreneurs, four academics, three managers from large industrial companies, two officials from provinces, one politician, and one official from a regional development agency. The number of twelve participants per focus group ascertained the availability of time to express opinion and discuss relevant items per participant (Krueger and Casey, 2000). The participants were involved in several agro-industrial parks spread throughout the Netherlands, such as Agriport A7, Bergerden, Biopark Terneuzen, New Mixed Farm, and New Prinsenland. Moreover, the participants had a broad range of expertise and reliable insights into agro-industrial park realization.

We invited an external moderator from InnovationNetwork institution. The moderator had experience in the design, development, and implementation of agro-industrial parks in the Netherlands. He provoked and led the discussions and established an atmosphere of trust by promoting free expression of opinions. Additionally, the moderator prompted questions, kept the conversations on track, and provided every participant a fair chance to speak (Krueger and Casey, 2000; Morgan, 1996; Wilson, 1997).

The focus group discussions were semi-structured with the dual purpose to provoke and simultaneously steer the discussions. The protocol for the discussion was as follows:

I. *Opening and short introduction of participants.*
II. *Questions:*
    - *What is the first thing that comes to your mind when you hear "agro-industrial park"? What is your experience in agro-industrial parks?*
    - *What is your attitude towards, and what do you (dis)like about agro-industrial parks?*
    - *How are agro-industrial parks set-up and developed?*

    Coffee break

    - *What are positive, negative, and interesting aspects of agro-industrial parks?*
    - *Which aspects do you consider the most important ones?*
    - *Do you recognize the positive and negative aspects mentioned by other participants?*
    - *If you had full power to decide the future of agro-industrial parks, what would you prioritize first?*
III. *Closing: presenting the summary of the discussion and providing opportunity for additional comments.*

Additionally, during the coffee break we invited the participants to write down the opportunities for and barriers to agro-industrial park realization they considered important.

We conducted the discussions in Dutch to stimulate participation and to prevent reticence abstention by participants not fluent in English (Krueger and Casey, 2000). Focus group discussions (about three hours each) were recorded, transcribed, and translated into English by a native Dutch speaker. Two authors examined, coded, categorized, and synthesized the transcripts of about 51 single-spaced pages (including participants' notes) per focus group discussion by using a top-down coding technique (Krueger and Casey, 2000). According to top-down coding technique, we used the theoretical concepts relevant to our study objective to code the transcripts while keeping those constructs in mind (Saldaña, 2009).

3.3. Literature review

In this section we discuss the general characteristics of agro-industrial parks, provide an overview of possible waste streams exchanges, explore engaged stakeholders and their network structure, and typical network governance forms.

3.3.1. Agro-industrial park

As mentioned in Section 3.1, an agro-industrial park is an inter-organizational network among geographically co-located organizations targeting sustainable production. An agro-industrial park applies the main principles of industrial ecology to agriculture (Hoes *et al.*, 2012; Smeets, 2011) and refers to collaboration among heterogeneous stakeholders. Figure 3.1 provides an illustrated overview of a possible waste streams exchanges in an agro-industrial park.

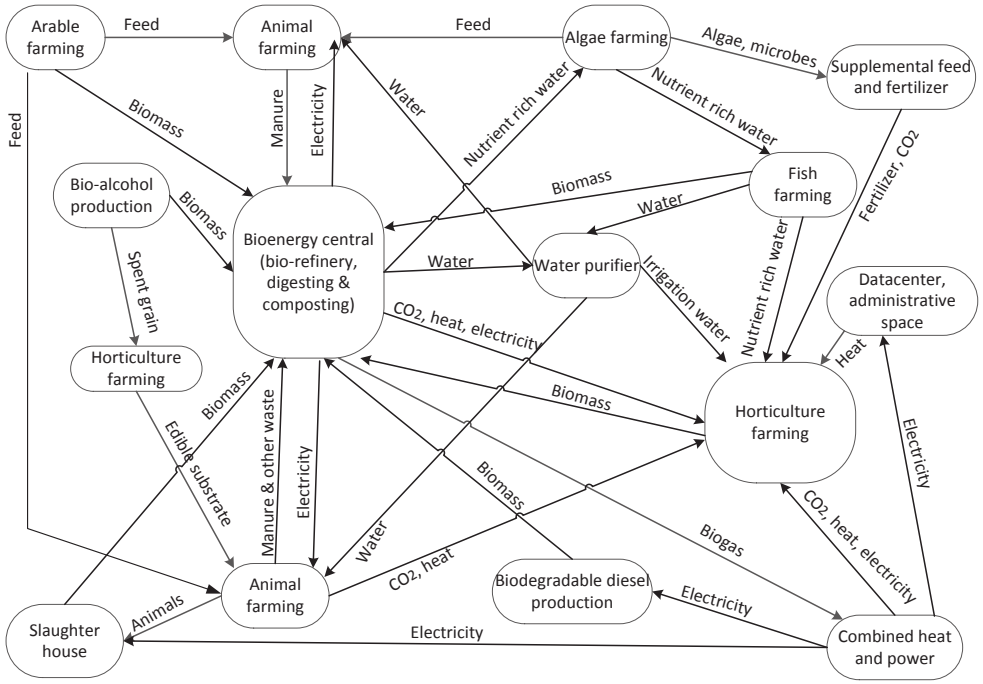

Figure 3.1. Overview of possible waste streams exchanges in an agro-industrial park

The literature uncovers the following main characteristics of an agro-industrial park:

- An agro-industrial park is a system innovation that brings new technical and technological solutions for more sustainable agro-food production *(Ge et al., 2011; Klerkx et al.*, 2010; Smeets, 2011; Wubben and Isakhanyan, 2011);
- Agro-industrial park realization requires large investments and long-term commitments to identifiable, interrelated, and at the same time interdependent stakeholders (Boons and Howard-Grenville, 2009; Ge *et al.*, 2011; Klerkx *et al.*, 2010; Smeets, 2011; Wubben and Isakhanyan, 2011);
- An agro-industrial park connects various organizations and by doing so forms an inter-organizational network (Martin *et al.*, 2012; Smeets, 2011; Wubben and Isakhanyan, 2011);
- Geographical proximity of co-located organizations enables collaborations for enhanced sustainable production through processing and utilizing biomass, waste water, CO_2, and waste heat (Anbumozhi *et al.*, 2010; Lambert and Boons, 2002; Smeets, 2011); and
- Heterogeneous stakeholders with diverse activities, such as agricultural (horticultural and livestock) farming, logistics, processing, bio-based, chemical, energy production, and distributors are engaged in agro-industrial parks (Breeman *et al.*, 2013; Hoes *et al.*, 2012; Smeets, 2011). These stakeholders have to rely on their partners to be able to realize the park (Rooks *et al.*, 2011).

In sum, agro-industrial parks aim at enhanced economic and environmental performance, more sustainable agri-food, and renewable energy production through collaborations among co-located heterogeneous companies and engaged stakeholders.

3.3.2. Stakeholders and their networks

As mentioned, an agro-industrial park as a typical system innovation engages numerous heterogeneous companies and stakeholders (Boons and Berends, 2001; Freeman *et al.*, 2007; Freeman and Reed, 1983; Geels, 2005; O'Connor, 2008), such as organizations and groups of

individuals with their own interests. Stakeholder theory differentiates internal and external stakeholders from internal and task environment respectively (Figure 3.2).

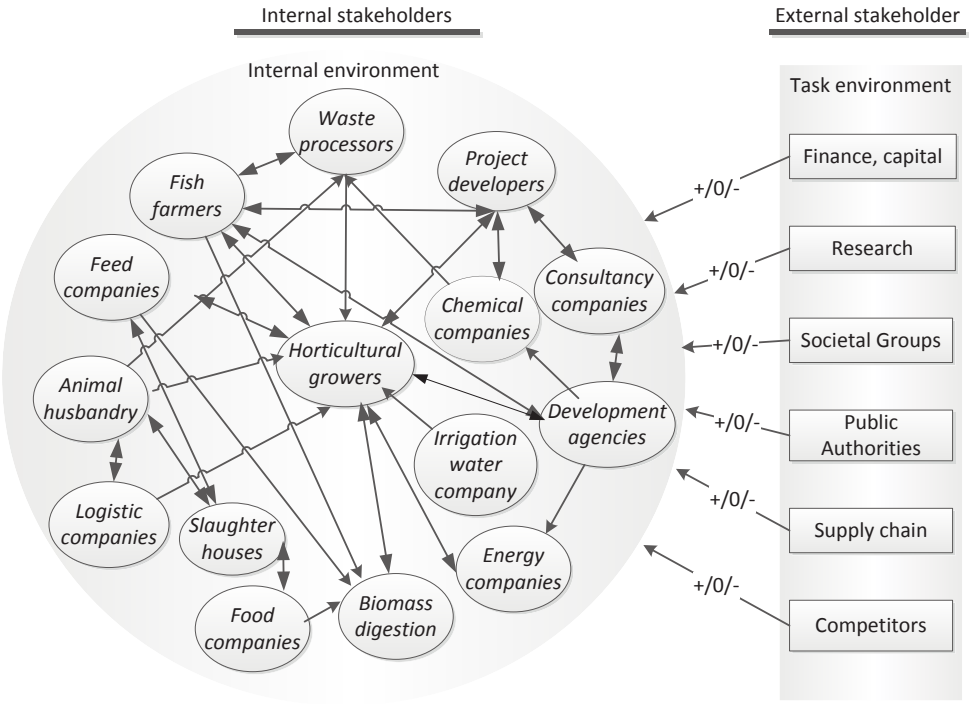

Figure 3.2. Overview of stakeholder groups, adapted from Freeman & Reed (1983) and Geels (2005)

As Figure 3.2 shows, external stakeholders are situated in the task environment, such as financial institutes, research organizations, societal groups, local inhabitants, public authorities, political parties, supply chain partners, and competitors (Omta, 1995; Smeets, 2011). Internal stakeholders are situated in the internal environment, such as project developers and companies involved in waste streams exchanges (Hoes *et al.*, 2012; Smeets, 2011). Recently set-up and developed Dutch agro-industrial parks vary in number of engaged stakeholders, and accordingly in available opportunities and critical barriers. For instance, besides commercial organizations, the provincial and municipal authorities and universities and re-

search organizations, and local societal groups and different NGOs, have an interest in the realization of agro-industrial parks, and can therefore be recognized as stakeholders.

Stakeholders are characterized as key because of their interests and power (Greenwood and Van Buren, 2010). It is important to understand that stakeholders may change their interests and power over a long period, may consequently become key, and thus have influencing power by changing their strategies towards agro-industrial park realization (Berkers and Geels, 2011; Korhonen *et al.*, 2004). Previous studies showed that steady support of key stakeholders (both internal and external) is required for a successful system innovation (Elzen and Wieczorek, 2005; Freeman *et al.*, 2007; Freeman and Reed, 1983; Friedman and Miles, 2006; Wubben and Isakhanyan, 2011). Steady support of engaged stakeholders may decrease the uncertainty and through that attract new companies to collaborate in agro-industrial parks. On the contrary, ongoing volatile strategies may create barriers by creating investment risks, perceptions of uncertainty, and potential for a mismatch of interests.

The engagement of heterogeneous stakeholders is needed to establish exchanges and to realize an agro-industrial park. Heterogeneous stakeholders enable greater access to necessary resources and attract external businesses (Anbumozhi *et al.*, 2010; Freeman *et al.*, 2007). Moreover, a higher number of heterogeneous stakeholders may raise the potential for synergy. However, increasing numbers of stakeholders may also increase the risk of having to deal with conflicting interests (Hermans *et al.*, 2013a; Hermans *et al.*, 2013b; Korhonen *et al.*, 2004; Schiller *et al.*, 2014; Van de Ven and Fery, 1980). Conflicting interests of powerful stakeholders may create barriers and have negative effects on the behavior of other stakeholders engaged in agro-industrial park realization. The lower the engagements and/or stronger the conflicting interests, the more effort agro-industrial park realization may require.

Stakeholder interactions in agro-industrial parks create networks of formal and informal ties (Van de Ven *et al.*, 1999; Van de Ven and Fery, 1980; Wubben and Isakhanyan, 2011). Formal ties are contractual focusing on waste and by-product exchange, and utility sharing to enhance sustainability performance. Informal ties are non-contractual focusing on information and knowledge exchange, and joint innovation among co-located organizations. Formal ties are needed between heterogeneous stakeholders with low level of trust, although formal ties simultaneously increase the transaction costs. Informal ties are useful for tacit knowledge transfer and social control, which can increase the trust level between stake-

holders (Termeer *et al.*, 2009). The more formal and informal ties exist among stakeholders, the more successful agro-industrial park realization is expected to be (Ashton, 2008).

In the literature on network analysis, networks with large amount of ties are described as dense (Burt, 2000; Gilsing, 2005). In dense networks, ties among stakeholders overlap, facilitating a high level of trust (Burt, 2000) and encouraging further collaboration (Corsaro *et al.*, 2012; Gulati, 1998). However, high density may also restrict access to external knowledge (Gulati, 1998; Powell *et al.*, 1996). The optimal level of density is often linked to the network size, which is the number of engaged stakeholders (Gilsing, 2005; Mizruchi and Galaskiewicz, 1993; Rowley, 1997). In relatively small networks, high density of ties may facilitate success through establishing trust and increasing investments. In relatively large networks, high density may slow down information flows.

3.3.3. Network governance

A system innovation, such as an agro-industrial park, requires substantial changes in governance forms (Heeres *et al.*, 2000; O'Connor, 2008; Smits, 2008). A proper governance form is a critical determinant of network success (Grandori, 1997; Teng and Das, 2008). Three typical forms of network governance at network level are discussed in the literature: (a) shared, (b) lead, and (c) brokered (Arikan and Schilling, 2011; Hoetker and Mellewigt, 2009; Provan *et al.*, 2007; Provan and Kenis, 2008).

a. Shared governance is a suitable governance form in relatively small networks. Here, stakeholders are responsible for managing networks and for making decisions. Although shared governance might be desirable for stakeholders to remain in control, with network growth this governance form may cause inefficiencies, complications, and may demand extra time and financial resources at the network level (Grandori, 1997; Provan and Kenis, 2008). This governance form results in dense but highly decentralized networks. Shared governance form is therefore more effective in relatively small-sized agro-industrial parks (Venkatraman and Lee, 2004).

b. Lead governance is a suitable governance form in moderate-sized networks, where one (or a small group of) central stakeholder(s) governs the network. This governance form results in highly centralized network structure with asymmetric power distribution. The lead organization manages important issues for the whole network, such as maintenance and fa-

cilitation, communication, and decision-making (Grandori, 1997; Provan and Kenis, 2008). The lead organization may not only distribute and coordinate the network resources, but also control the access of other stakeholders to external resources, such as government grants and subsidies (Grandori, 1997), by having comparatively better opportunities to mobilize other stakeholders for collective action (Ackermann and Eden, 2011; Rowley *et al.*, 2000; Rowley, 1997).

Brokered governance is a suitable governance form in relatively large networks. This form suggests external governance by a voluntarily established or mandated organization. This organization is an "outsider" that holds a mandate to govern the network and the ties among all stakeholders. Similar to lead governance, brokered governance results in a centralized network with a relatively low density of ties, being efficient mainly in large sized networks (Provan and Kenis, 2008). However, the broker organization is usually professional in network governance by supervising the network ties and dealing with challenges, such as unpredictable behavior and distrust (Grandori, 1997; Human and Provan, 2000). Therefore, a brokered governance form enhances opportunities to realize highly innovative networks with uncertain environment, where mutual trust among stakeholders is not yet established (Rowley *et al.*, 2000). However, similar to the lead governance form, brokered governance restricts direct interaction among stakeholders and may weaken the commitment to achieve common network goals.

Table 3.1 shows the main predictors of three typical network governance forms. As can be seen in Table 3.1, the network size, centralization, density, decision making and power predict the network governance form.

Table 3.1. Main predictors of three typical network governance forms

Governance form	Network size	Centralization	Density	Decision making	Power
Shared	Small	Decentralized	High	Collective	Shared, symmetric
Lead	Moderate	Centralized	Low	Central by the lead organization	Asymmetric
Brokered	Moderate to large	Centralized	Moderate	Central by a network broker	Asymmetric

Source: Provan and Kenis (2008)

The authors defined an agro-industrial park as a system innovation that connects numerous heterogeneous stakeholders for a long period of time, and aims at enhanced sustainable production. To understand the opportunities and barriers created by stakeholder networks, we explored the agro-industrial parks from network structures and network governance perspectives. In general, high density of formal and informal ties creates opportunities for the realization of an agro-industrial park. However, high density may decrease the speed of information flow in large-sized networks. The network governance form of an agro-industrial park that creates opportunities for establishing collaborations is determined by several main predictors (Table 3.1).

3.4. Results

In this section the results of the two focus group discussions are presented. Although the participants of the focus group discussions had divergent opinions, the final summary of the two focus group discussions largely overlap. In the analysis we therefore combined the results of the two focus group discussions. Below the main opportunities for and barriers to agro-industrial park realization are presented according to stakeholder engagement, network structure, and network governance.

3.4.1. Stakeholder engagement

A wide range of stakeholders is engaged in agro-industrial park realization in the Netherlands. However, the participants of focus group discussions often referred to two groups of stakeholders: (1) co-located companies as internal stakeholders, and (2) public authorities as external stakeholders (Figure 3.2). Regarding co-located companies, the active engagement of horticultural entrepreneurs was emphasized. As mentioned by one of the academic participants, *"the pioneering spirit of Dutch entrepreneurship"* was an essential impetus to agro-industrial park realization. All participants of the focus group discussions perceived agro-industrial parks as innovative projects that could connect horticultural, food and livestock production, dairy farming, chemical production, logistics, biomass processors, and residential areas. These very different activities of companies (heterogeneity) in agro-industrial

parks increased the potential for waste streams exchanges. However, the heterogeneity also created barriers in collaborations. Heterogeneous companies with diverse backgrounds hardly communicated with one another and had different (sometimes even conflicting) interests. As mentioned by a project developer, *"usually, glasshouse farmers, livestock farmers, and chemical companies do not communicate with each other on issues like exchanging waste and heat.*"

The engagement of intensive livestock husbandry was discussed as the main barrier to agro-industrial park realization. The participants had contradictory opinions about this issue, which caused emotions to run high during the two discussions. The academics and consultants claimed that intensive livestock husbandry was essential for the successful realization of agro-industrial parks, *"... it is fantastic that animal farms can also be clustered."* Contrarily, the project developers and horticultural entrepreneurs looked critically on this issue, "*Nobody wants to have pigs and chicken in the parks." "... the successful parks have no animal husbandry in it." "The parks with animals are without a chance and parks without animals are full of opportunities."* Nevertheless, the participants recognized the importance of animal waste for bio-based production, *"We want to have the digester, and use manure for bio-based production, but we do not want livestock production at the location."* However, the participants also mentioned that they were mainly against livestock farming in a park because it mobilized opposing power of people concerned with animal welfare and other ethical issues, *"Bringing many animals together mobilizes an opposing power because of environmental concerns or people raising ethical issues." "Animal husbandry raises unnecessary discussions, such as animal welfare, odor nuisance, and evokes resistance."*

Regarding public authorities as key external stakeholders, the participants, especially the academics and consultants, mentioned that the Dutch government had high ambitions and provided subsidies to implement innovative sustainable projects, *"Two million governmental subsidies were used to connect two companies, one of which produced CO_2 and the other one consumed it." "The government has made guarantees, without which nothing would have happened."*

The participants emphasized not only the importance of supportive rules and regulations given by the national government, but also permissions and licenses given by the local and regional authorities, *"If there is no additional regulation, the idea of an agro-industrial park will stay nice, but not realistic."* Participants also mentioned that the government was able to

use other tools than subsidies to stimulate collaborations, such as stronger taxation for emission, *"Government should strengthen antipollution policy, and by doing that stimulate innovative solutions."* In contrast, project developers and entrepreneurs mentioned that the realization of agro-industrial parks was business driven, and the governmental interventions, such as subsidies and funds, could hinder the creativity of entrepreneurial activities, *"The ones that have realized something did not originate from the sciences, nor from the governments or from the consumers. These are just companies that see advantages, solve the problem, and to do so they seek and find partners."* Additionally, entrepreneurs were driven by economic benefits to collaborate in an agro-industrial park. An entrepreneur stated, *"Although governmental regulations force new solutions, we look purely at the economic benefits."* A project developer confirmed that entrepreneurs were motivated mainly to make profit and earn money in the parks.

In general, the focus group participants perceived the following opportunities for agro-industrial park realization: heterogeneity of organization, active entrepreneurship, and governmental support in providing licenses, permissions, and implementing antipollution policies. The barriers that focus group participants mentioned regarding agro-industrial park realization were conflicting interests, engagement of intensive livestock husbandry, and active intervention of public authorities.

3.4.2. Network structure

Network size: The focus group participants emphasized the difficulties and challenges in connecting many heterogeneous stakeholders. As a project developer mentioned, *"The collaboration with many partners is complex and it is very difficult to bring many different parties together and require them to collaborate for a long term."* However, the engagement of large amount stakeholders could expand collaboration opportunities in agro-industrial parks. Entrepreneurs mentioned that they would prefer to have ever growing amount of companies collaborating at the location. Moreover, project developers mentioned that a large amount of engaged partners guaranteed success, *"It should be on a big scale with many partners. Otherwise, success will not be achieved."*

However, the participants also mentioned that large scale agro-industrial parks often spark the opposing power to combine forces against agro-industrial park realization. Moreover, the involvement of many heterogeneous organizations increased interdependencies among each other and made the system vulnerable, especially in an economic downturn.

In general, a large agro-industrial park involving many organizations was needed to achieve the initial goals of agro-industrial park realization. However, organizations met difficulties in managing the multiple ties with all other network partners. In particular, small and medium-sized organizations, such as vegetable growers, perceived network administration as a barrier.

Network tie type: The participants emphasized formal and informal ties as main links among co-located companies. The formal ties seemed to create barriers to agro-industrial parks. Organizations preferred to have short-term contracts. However, the connected high investments with related long payback period require long-term formal contracts. These long term contracts carry a risk of opportunistic behavior as a manager of an industrial company mentioned, *"Long-term contracts, valid for more than 15 years, are necessary. However, we do not want to sign long-term contracts to deliver CO_2 and waste heat because we cannot guarantee the delivery for a long term."* Moreover, the companies did not want to sign long-term formal contracts because of the uncertainty in the biomass market. A project developer said, *"Assume biomass becomes golden. Therefore, no one wants to have a long term agreements."*

The informal ties served as important ways to transfer knowledge and to create trust, *"We have had informal meetings with other companies, for instance, at a bar, where we also exchanged knowledge."* A project leader mentioned that continuous communication and knowledge exchange have created trust. Many entrepreneurs confirmed that they were successful in establishing collaborations by exchanging knowledge and innovative ideas.

In general, the formal ties that connected organizations for a long period have often been perceived as barriers, whereas informal ties have been perceived as opportunities to transfer knowledge, information, and build trust.

Network density: Operationalized as a large number of ties among stakeholders, focus group participants associated density mainly with interdependencies. Entrepreneurs recognized that a large number of ties guaranteed success, *"The collaboration with many partners makes it easier to invest while in the meantime solving the issue of being dependent on one*

supplier." A consultant said, *"The collaboration with many companies is required for agro-industrial park success."* However, the connections brought new dependencies. A manager from an industrial company said, *"There is a big risk in availability of waste streams supplies. Therefore, the consumers and the suppliers of waste streams do not want to become dependent on one another."* En entrepreneur mentioned, *"I have to be honest, despite all successes, if one company goes bankrupt, we will all have big problems."* Moreover, academics emphasized that in an intensive collaboration, entrepreneurs might lose the advantages of being specialized and flexible, *"The more collaboration, and the less flexibility."*

In general, the participants agreed that intensive collaborations (dense network) with many partners were required for successful exchanges. However, intensive collaboration was not always desirable by entrepreneurs, who might lose the advantage of being specialized. Moreover, in a dense collaboration, companies could lose their flexibility and time in running extra administrative tasks.

3.4.3. Network governance

Shared governance: Shared governance, operationalized as shared responsibility of engaged stakeholders and joint decision making, was recognized by participants from small to medium sized agro-industrial parks (up to 15 engaged stakeholders). These participants mentioned that the partners made joint decisions and took responsibilities for park activities. An entrepreneur mentioned, *"In decision making we do not consider the size of the company but the turnover. In selling and buying heat, electricity, and CO_2, we have rules to ensure that the decision-making process is democratic and the actions are controlled by all partners."* Other entrepreneur agreed, "Because of interdependencies, we do it jointly. Preferably, all partners are involved in decision making." Another entrepreneur engaged in a small park mentioned, *"We are equal partners. We have made agreements and contracts with each other."* However, being involved in all activities related to park realization was recognized as barrier to many small horticultural companies. *"We have good agreements. We manage the collaborations internally without external people, which create extra administration. This administration is very difficult and time consuming for us as a vegetable grower."*

In general, the participants of the focus group discussions indicated that shared governance created opportunities, especially in small and medium sized parks. Collaborating organizations preferred to manage the networks together because of interdependencies. However, the administrative work in agro-industrial parks required substantial resources, which were not always affordable, for example, to horticultural companies.

Lead governance: Lead governance, operationalized as centralized power of one dominant organization, was recognized as a barrier to agro-industrial park realization. The participants mentioned difficulties and problems, rather than opportunities of lead governance. A project leader from an agro-industrial park, where one dominant organization took an initiative to realize a park, mentioned, *"We thought of a complete system. We should have started with implementation, but the entrepreneurs called and cancelled the agreements a day in advance. Another trial to restart the system implementation caused another withdrawal of horticultural entrepreneurs."* Apparently, small entrepreneurs often withdrew and avoided collaborations with one large company. Small companies avoided to be dependent on, and lose autonomy to a large organization as a result of asymmetric power distribution. Conversely, some entrepreneurs and academics mentioned that a lead partner was needed to develop the networks and to realize the available chances. In general, the lead partner might be able to develop the network and through this create opportunities for new collaborations. However, the involvement of a lead partner might also create barriers by decreasing the willingness of small companies to enter agro-industrial parks.

Brokered governance: Brokered governance, operationalized as the engagement of an external organization that holds a mandate to govern the networks, was perceived as positive by the participants. The project developers mentioned that an "outsider" was needed, who would take initiative and connect various organizations in an agro-industrial park. The academics emphasized that strong governance was important, which led to the choice of external governance. The entrepreneurs, project developers, and academics agreed that a third party was needed to connect stakeholders, which were unaware of collaboration possibilities. In general, the participants indicated that the collaborative activities in an agro-industrial park were not the core business of most stakeholders that had low incentive to invest resources in building intensive and enduring ties without substantial economic benefits. Therefore, the involvement of an external organization that could connect the compa-

nies and promote interactions between heterogeneous stakeholders (brokered governance) was important for agro-industrial park realization.

Table 3.2 summarizes the opportunities for and barriers to agro-industrial park realization identified from the literature and the focus group discussions according to the stakeholder heterogeneity and engagement, network size, tie type, density, and governance forms.

Table 3.2. Integrated conceptual framework of the opportunities for and barriers to agro-industrial park realization based on the literature review and the focus group discussions

	Opportunities	
	Literature	*Focus Groups*
Stakeholder heterogeneity	• Heterogeneity of stakeholders creates collaboration opportunities, e.g., for waste exchange, and attracts external businesses.	• Heterogeneity of stakeholders provides opportunities to establish exchanges.
Stakeholder engagement	• Engagement of key stakeholders and their steady support is required to realize a system innovation that requires high investments with long payback period.	• Active engagement of horticultural entrepreneurs that are open to innovate and collaborate for sustainability is needed. • Engagement of public authorities to provide permissions and licenses, and implement antipollution policy can enhance the collaborations in agro-industrial parks.
Network size	• Larger networks offer greater access to resources.	• Large networks expand collaboration opportunities.
Network tie type	• Informal ties are needed to discuss new ideas, and exchange information and advice. • Formal ties are needed among heterogeneous organizations with low levels of trust.	• Informal ties are an important means to transfer knowledge, information, and build trust.
Network density	• Density facilitates trust and advances collaborations.	• Density is a guarantee for success.
Shared governance	• Shared governance allows stakeholders to share the responsibilities and remain in control.	• Shared governance allows organizations to remain in control and take part in decision making, which they prefer because of interdependencies.
Lead governance	• A lead company can carry the responsibilities, such as maintenance and facilitation, and communication. • A lead company can attract ex-	• A lead partner can develop the networks and brings co-located companies together.

	ternal resources, such as grants and subsidies, and mobilize stakeholders.	
Brokered governance	• A broker organization can build and develop highly innovative networks within an uncertain environment.	• A broker organization is needed in parks to connect internal and external stakeholders.
	Barriers	
	Literature	*Focus Groups*
Stakeholder heterogeneity	• Increasing the number of heterogeneous stakeholders can increase the risk of conflicting interest.	• Heterogeneous stakeholders hardly communicate with one another. They do not know each other; they do not share the same knowledge. • Heterogeneous stakeholders sometimes have conflicting interest.
Stakeholder engagement	• Volatile strategies of engaged stakeholders for a long run can change their interests, making it conflicting.	• Intensive livestock husbandries mobilize negative perceptions and attitudes of external stakeholders. • Active intervention of public authorities can hinder the creativity of entrepreneurship.
Network size	• Large networks require extra resources for network administration and maintenance.	• Large networks mobilize opposing power and engage more stakeholders with conflicting interests.
Network tie type	• Formal ties can increase the transaction costs.	• Formal ties require long term commitments and high investments. • The market of biomass is too uncertain to build formal ties in the long run.
Network density	• High density can restrict access to external knowledge.	• High density can create strong interdependencies. • In dense networks, entrepreneurs may lose advantages connected to being specialized and flexible.
Shared governance	• Shared governance becomes inefficient with the growth of network size.	• Shared governance creates administrative burden especially for small companies.
Lead governance	• Direct interactions among stakeholders are restricted and power is unequally distributed.	• Small companies avoid collaboration with lead partner to avoid losing autonomy.
Brokered governance	• Direct interactions among stakeholders are restricting.	• No related barrier was identified.

Table 3.2 shows that the results of the two focus group discussions brought new insights in the opportunities for and barriers to agro-industrial park realization from both stakeholder network structure and network governance perspectives. For instance, while the literature highlights that the formal ties create opportunities for networks in an uncertain environment, the focus group discussion results highlight the barriers in formal ties because of high investments and long-term commitments, and advocate high density of informal ties. Regarding network governance forms, in contrast to literature, focus group results show the opportunities created by brokered and barriers created by shared or lead governance irrespective of the network size.

Agro-industrial parks are perceived as innovative projects in which the active engagement of small horticultural companies is vital. Realizing an agro-industrial park by connecting agriculture with the other industries for waste streams exchanges is a challenging task. It requires long-term commitments and high investments. Although all partners want to remain in control because of stakeholder heterogeneity, they avoid extra administrative burden, which can be even more difficult for small horticultural companies. Academics and consultants had similar opinions, which sometimes contrasted the opinions of project developers and entrepreneurs. The contrast in opinions specifically regards the engagement of intensive livestock husbandry, role of government, network size, and network density.

3.5. Discussion and conclusions

The objective of this paper was to explore the opportunities for and barriers to agro-industrial park realization from stakeholder network structure and network governance perspectives. Through a literature review, we explored the recent studies on design, set-up, and development of agro-industrial parks. Through two focus group discussions, we gained deeper insights into, and practical examples about critical barriers to and available opportunities for agro-industrial park realization perceived by stakeholders. As mentioned, an agro-industrial park connects heterogeneous stakeholders and through this creates an interdependent network. Therefore, agro-industrial park realization has been explored from stakeholder network structure and network governance perspectives by using network theory.

First, a dilemma of agro-industrial park realization is related to stakeholder heterogeneity. Stakeholder heterogeneity is essential to realize exchanges within agro-industrial parks.

However, an increasing number of heterogeneous stakeholders may lead to conflicting interests and hinder agro-industrial park realization. In line with the literature, the findings of the two focus group discussions confirmed that both a high number and heterogeneity of stakeholders are essential for agro-industrial park realization, but the increased risk of conflicting interests may be regarded as barrier.

Second, the literature emphasizes the requirements of contractual agreements and formal governance structures. Collaborations in agro-industrial parks are often long term. Therefore, formal collaborations are considered essential, especially under uncertain market conditions (Beers *et al.*, 2014; Breeman *et al.*, 2013; Hoes *et al.*, 2012). However, the results of focus group discussions emphasize that formal ties are regarded as barriers, because organizations avoid high investments and formal, long term commitments to previously unknown partners. Instead, the results from the focus group discussions emphasize the opportunities created through informal ties, such as knowledge transfer, open innovation, and information exchange. Consequently, a high density of informal ties is perceived as an opportunity for agro-industrial park realization by creating a high level of trust.

Third, the literature emphasizes that a lead organization can create network opportunities by taking over maintenance, facilitation and decision-making functions, and by mobilizing stakeholders for collective actions. The findings of the focus group discussions, however, reveal that lead governance encompasses a potential barrier for small companies that avoid collaborating with a dominant partner in an agro-industrial park. Findings of the focus group discussions confirmed that shared governance creates substantial administrative barriers for small companies.

In general, the exploitation of critical barriers to and available opportunities for agro-industrial park realization from stakeholder network structure and network governance perspectives leads us to the following conclusions. Regarding network structure, a large number of engaged heterogeneous stakeholders seems to be essential to create opportunities for agro-industrial park realization. Also, high density of informal ties is important for agro-industrial park realization. The density of formal ties, however, may create reluctance for new organizations to join the network if high investments and a long-term commitment to previously unknown partners are needed. Regarding network governance, small organizations generally meet difficulties with regards to network administration, and often do not prefer to collaborate with a lead organization to avoid dependency. Instead, small entrepre-

neurial companies often prefer to delegate network administrative responsibilities to professional organizations known as network brokers. Therefore, a brokered governance form is preferred for small organizations to avoid administrative burden and maintain independency.

This study contributes to the theoretical discussion on inter-organizational collaboration among co-located organizations focusing on network structures and network governance forms, and establishes a basis for further empirical work. To close, we recognize that the outcomes of only two focus group discussions represent the practices of agro-industrial park realization in the Netherlands. However, the Netherlands is a highly industrialized country with an advanced horticultural sector, allowing it to be a frontrunner in agricultural innovation and collaboration for sustainable production. The findings of our study can therefore be used as an archetype in realizing agro-industrial parks in other countries.

CHAPTER 4: NETWORK STRUCTURE IN SUSTAINABLE AGRO-INDUSTRIAL PARKS

This chapter is based on:

G. Nuhoff-Isakhanyan, E.F.M. Wubben, S.W.F. Omta. Network structure in sustainable agro-industrial parks. *Journal of Cleaner Production.* Submitted May 2015, 3rd round revision (revisions included in the Chapter).

4. INTER-ORGANIZATIONAL NETWORK FOR SUSTAINABILITY IN AGRO-INDUSTRIAL PARKS

4.1. Introduction

The growing societal demand for more sustainable sourcing, production and waste-management stimulates inter-organizational networks (Albino *et al.*, 2012; Seitanidi and Crane, 2013). Within this context, several sustainability-oriented inter-organizational networks have emerged, such as eco-industrial parks (Cohen-Rosenthal, 2000; Lambert and Boons, 2002). While eco-industrial park is already an established type of inter-organizational network (Jacobsen, 2006), other types of networks that connect heterogeneous organizations emerge, for example, in agro-industrial parks (Beers *et al.*, 2014; Smeets, 2011). Within the boundaries of agro-industrial parks, organizations are connected to exchange waste, by-product, and share resources and information (Corsaro *et al.*, 2012; Smeets, 2011; Spekkink, 2015). Heterogeneity refers to core organizational activities, such as horticulture, chemical, processing, logistics, food and bio-based production, and provides opportunities to combine diverse but complementary resources (Beckman and Haunschild, 2002; Corsaro *et al.*, 2012) and by that further enhances sustainability. Despite high expectations and major endeavors when realizing agro-industrial parks in the Netherlands, not all socio-economic and environmental opportunities have been exploited (Smeets, 2011; Spekkink, 2013).

Sustainability-oriented inter-organizational networks have been intensely discussed in the field of industrial ecology (e.g., Albino *et al.*, 2012; Ehrenfeld and Gertler, 1997; Gibbs and Deutz, 2005). Industrial ecology scholars increasingly pay attention to the network analysis of symbiotic ties (e.g., Ashton, 2008; Sydow *et al.*, 2011; Seitanidi and Crane, 2013), according to which inter-organizational networks in agro-industrial parks can be described as compositions of complex inter-organizational ties (Smeets, 2011). A comprehensive approach to study the structure of inter-organizational networks is via the application of social network analysis (Bergenholtz and Waldstrøm, 2011; Schiller *et al.*, 2014). Social network analysis focuses on ties (or lack thereof) and provides appropriate tools to analyze network structures (Borgatti and Foster, 2003; Freeman, 1978).

Inter-organizational networks among co-located heterogeneous organizations are focused on sustainability related activities, such as reduced emissions, renewable energy production, or bio-waste valorization through waste streams processing (Anbumozhi *et al.*, 2010; Mirata and Emtairah, 2005; Spekkink, 2013). Organizations often build network ties to enhance their sustainability performance (Friedkin, 1991; Lozano, 2007; Powell *et al.*, 1996). Decisions to build network ties are usually motivated by expected and perceived sustainable performances by organization managers (Székely and Knirsch, 2005). Managers' expectations and perceptions drive the network strategies that create networks structures. Thus, managers' perceptions regarding sustainability improvement can explain network formation (Kumar and van Dissel, 1996) and network strategies of different organizations (Boons and Roome, 2000).

The available literature often discusses inter-organizational networks either across supply chain partners or among homogeneous actors, although the sustainability performance is claimed to have association with the network structures and network strategies (Ahuja *et al.*, 2009; Baum *et al.*, 2000). Inter-organizational networks and sustainability performance of organizations are frequently discussed in the literature (Ashton 2008; Santoyo-Castelazo, 2014; Schiller *et al.*, 2014), but the relations between these two concepts have not so far been studied empirically. The objective of this study is, therefore, to explore network structures of inter-organizational ties that can enhance perceptions of sustainability performance in agro-industrial parks.

To meet the study objective, a multiple case study approach was used combining quantitative and qualitative methods (Morgan, 2013). Through quantitative methods, the network structures and managers' perceptions of sustainability performance, as well as the relation between these two were studied. Through qualitative methods, the findings were complemented with deeper insights to provide a better understanding (Eisenhardt, 1989). This study brings the concept of waste streams exchanges among co-located heterogeneous organizations to a new field of analysis by examining them as inter-organizational networks in agro-industrial parks.

Three agro-industrial parks in the Netherlands, including 64 organizations in total were included in the study sample. The Dutch cases were chosen because the Netherlands is active in initiating and developing agro-industrial parks. Moreover, the Netherlands is the world's

third largest exporter of agricultural products, and recognized for being a frontrunner with techno-managerial innovations in this industry (Ministry of Agriculture, NL, 2008).

The following section presents recent scholarly discussions on inter-organizational networks and effects on sustainability performance. Section 4.3 elaborates on the data and methods used for data collection and data analysis. Section 4.4 presents the results and Section 4.5 discusses the results followed by main conclusions in Section 4.6.

4.2. Social structure for inter-organizational networks

Agro-industrial parks encompass complex inter-organizational networks of heterogeneous organizations that are geographically proximate (Baas, 2011; Smeets, 2011). Inter-organizational networks are defined as collaborations between more than two separate organizations (Albino *et al.*, 2012; Bergenholtz and Waldstrøm, 2011), in contrast to collaborations among entities within a single organization. Due to the complexity of network structures in agro-industrial parks, two levels of network analysis are differentiated: network level (i.e. entire network level) and organization level (Albino *et al.*, 2012; Wasserman and Faust, 1994).

4.2.1. Network level

At the network level, agro-industrial parks are conceptualized as planned or self-organized networks, in which geographically co-located organizations create networks for waste streams exchanges (Baas, 2011; Smeets, 2011). While planned networks can be formed under certain institutional settings, self-organized networks often involve informal ties (Chertow and Ehrenfeld, 2012). In line with social network theory, the structure at network level can be described by the concepts centralization and density (Ahuja, 2000; Bergenholtz and Waldstrøm, 2011; Wasserman and Faust, 1994).

Centralization gives an indication of the power distribution among the collaborating organizations (Wasserman and Faust, 1994) and encompasses the degree to which networks are

managed by hierarchies (Ahuja, 2000). Decentralized structures indicate well-balanced power distribution among the collaborating organizations, may prevent conflicts and attain more agreements (Lawler and Yoon, 1993). Considering the heterogeneity of collaborating organizations in agro-industrial parks, it is expected that decentralized structures indicating similar embeddedness of organizations within the network, may further expand the networks. Decentralization, however, may cause inefficiencies and so requires extra resources for network maintenance, especially in large networks (Provan *et al.*, 2007).

Density indicates the proportion of actual to total potential ties (Burt, 2000; Rowley, 1997). High density may facilitate knowledge diffusion, stimulate imitative behavior, and shorten cognitive distance among heterogeneous organizations (Rowley, 1997). High density, however, can also create network inefficiencies, increasing network redundancies (Burt, 2000). Dense networks are considered to be beneficial, especially in heterogeneous networks such as agro-industrial parks, to overcome opportunism, to reduce large cognitive distance, to avoid opportunistic behavior, and to breed trust (Gilsing and Nooteboom, 2005). Therefore, dense networks are expected to suit to agro-industrial parks encouraging sustainability performance.

In sum, centralization and density of ties indicate the embeddedness of organizations within the networks and the degree to which the inter-organizational network structure can influence physical exchanges (Ashton, 2008).

4.2.2. Organization level

At the organizational level, the focus is on bilateral ties and centrality of individual organizations (Bergenholtz and Waldstrøm, 2011; Provan *et al*., 2007). Bilateral ties among heterogeneous organizations are differentiated as formal, informal, and interdependency (Ashton, 2008). The centrality of individual organizations is differentiated as degree, betweenness and closeness.

Formal ties are sustainability oriented contractual ties, such as exchanging waste and by-products, and sharing resources (Ackermann and Eden, 2011). Formal ties are core in agro-industrial parks, because these ties are instruments to advance sustainability performance.

Informal ties are non-contractual ties reflecting non-contractual agreements, exchanging information and advice (Ackermann and Eden, 2011; Kreiner and Schultz, 1993). Informal ties may be latent and not directly related to sustainability performance, but they may help in developing new businesses and thereby new formal ties. Informal ties, although subtle and pervasive, can help the development of formal ties (Pina-Stranger and Lazega, 2011) and, in reverse, formal ties can stimulate informal ties (Ashton, 2008). Informal ties connecting the representatives of individual organizations are always present in inter-organizational collaboration alongside the network of physical exchanges (Chertow and Ehrenfeld, 2012).

Interdependency ties reflect mutual dependencies of collaborating organizations that (to a certain extent) have to rely on collaborating partners for the achievement of common goals (Gulati, 2007; Tina Dacin *et al*., 2007). Interdependencies may indicate the strength of ties that influences managers' willingness to collaborate. Managers of autonomous organizations are often reluctant to collaborate in a highly interdependent network. Therefore, it is expected that a strong interdependency may discourage the establishment of additional formal ties. The operationalization of formal, informal and interdependency ties is presented in Appendix D, part 4.

Centrality of an individual organization indicates the organization's position in formal, informal and interdependency networks. In general, an organization with a central position has more opportunities than others to gather essential information and access to necessary resources (Ackermann and Eden, 2011; Powell *et al*., 1996). Literature suggests three main centrality measures for inter-organizational networks: degree, betweenness, and closeness centralities (Borgatti, 2005). **Degree centrality** indicates the number of direct ties that an organization has. Usually, an organization with a higher degree of centrality has more alternatives, more autonomy, and less dependency. **Betweenness centrality** indicates the extent to which an organization connects two other organizations (Borgatti, 2005). Betweenness centrality is often used to find the gatekeepers in a network (Sueur *et al*., 2012). **Closeness centrality** indicates the length of the shortest path between collaborating organizations (Freeman, 1978). An organization with a shorter distance to all other collaborating partners has a more central position than other collaborating partners (Friedkin, 1991). An organization with high closeness centrality is less dependent on others and can profit from the networks by being able to build ties with other organizations via a small number of intermediary

partners (Friedkin, 1991; Powell *et al*., 1996). Although organizations with high degree and betweenness centrality may have a greater influence on the network, it is expected that organizations with high closeness centrality may benefit the most from their central positioning.

4.2.3. Sustainability performance

As mentioned in the Section 4.1, organizations collaborate in agro-industrial parks to enhance their sustainability performance (Lozano, 2007; Smeets, 2011). Sustainability performance is a multifaceted concept as it encompasses various implications given by scientists of different backgrounds (Gerdessen and Pascucci, 2013). In general, sustainability performance refers to the three dimensions: environmentally friendly, economically beneficial, and socially supportive (Elkington, 1998; Jung *et al*., 2013; Lozano, 2008b; Santoyo-Castelazo and Azapagic, 2014). Although the separation of the three dimensions reduces the complexity of the concept, the underlying indicators in each dimension remain complex and unstandardized. The sustainability indicators developed by different scholars, for example by Elghali *et al*. (2007), Gerdessen and Pascucci (2013) and Santoyo-Castelazo and Azapagic (2014), are context-, space- and time-dependent. These indicators are not always directly applicable to agro-industrial parks as network of heterogeneous organizations. In this study, therefore, the available indicators for the three dimensions are integrated and tailored to sustainability in agro-industrial parks (Figure 4.1).

Another complexity of the sustainability concept is related to the measurement of the indicators (Lozano, 2008b). From management science perspective, expectations and motivations of organization managers are considered essential in decision-making processes. Dealing with perceptions is as relevant as dealing with objective measures (Kumar and van Dissel, 1996), since perceptions shape the decisions to build inter-organizational ties (Székely and Knirsch, 2005). Additionally, Boons and Roome (2000) claim that the perceptions of managers may influence the outcome of networks. These perceptions, via individual decision-making, can drive the networks towards desired outcomes (Boons and Roome, 2000). Although perceptions are subjective, they are claimed to uncover latent performance para-

digms (Richard *et al.*, 2009). Therefore, this study considers the perception of managers of organizations within agro-industrial parks as a valid measure of sustainability performance (Figure 4.1).

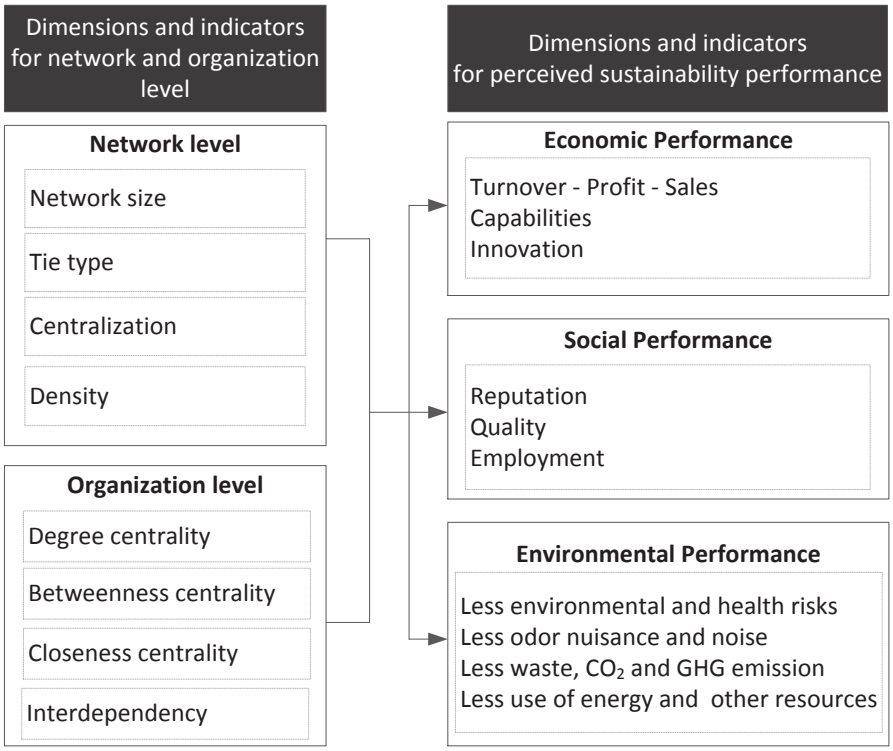

Figure 4.1. Conceptual framework relating inter-organizational network structure with perceived sustainability improvement performance

Figure 4.1 shows the conceptual framework that relates inter-organizational network structure with perceived sustainability improvement performance. The conceptual framework assumes that the dimensions and indicators of the network structural properties are connected with the dimensions and indicators of perceptive sustainability improvement performance. The sustainability performance indicators have been mainly derived from Smeets (2011). However, the literature is not clear regarding the significance of the linkages between these different dimensions and indicators. Therefore, this research presents an explorative multiple case studies to find empirical evidence of associations between dimen-

sions and indicators of the network structural properties and perceived sustainability performance.

First, a decentralized and a dense network structure of formal ties may enhance sustainability performance in agro-industrial parks. Second, a strong interdependency may discourage the establishment of additional formal ties. Third, organizations with high closeness centrality may benefit more from their central position than organizations with high degree and betweenness centrality.

4.3. Data and methods

Following the grounded theory-approach, inter-organizational networks in agro-industrial parks were studied by means of multiple case studies (Yin, 2009). The multiple case study approach was a necessary and sufficient method to explore the concepts given (Eisenhardt, 1989). In this study, agro-industrial parks that encompass inter-organizational networks towards enhanced sustainable production have been considered. The dimensions and indicators of network structural properties and perceived sustainability performance (Figure 4.1) required a convergence of findings using qualitative and quantitative methods (Flyvbjerg, 2006; Morgan, 2013). Quantitative methods were used to find general patterns in network structures, and to relate these with perceived sustainability performance. Qualitative methods were used to get insight in the background of the quantitative findings and to provide a better understanding of the different variables.

4.3.1. Case selection

The cases for this study have been strategically selected with the objective to collect the greatest amount of information on the network strategies and sustainability improvement perceptions (Flyvbjerg, 2006). The case selection criteria were (i) being an agro-industrial park operating in the Netherlands, (ii) being focused on agri-food activities and processes; (iii) having an explicit collaboration strategy between agricultural and non-agricultural actors. The Dutch cases were chosen because the Netherlands is active in initiating and devel-

oping agro-industrial parks. Moreover, the Netherlands is the world's third largest exporter of agricultural products, and is recognized for being a frontrunner with many techno-managerial innovations in this industry. The case selection strategy brought us to three agro-industrial parks in the Netherlands: AgriportA7, Bergerden, and Biopark Terneuzen, where several sustainability-oriented collaborations among local organizations have been identified. These three specific cases allowed to constrain extraneous variation and sharpened external validity (Eisenhardt, 1989).

Agriport A7 is a self-organizing agro-industrial park located in the province of North Holland. Initiated in 2003 and established in 2006, Agriport A7 connects 24 organizations at 930 hectare area. The companies are heterogeneous according to their main activity, such as energy distributors, horticultural growers, logistics companies, a combined heat and power plant, an auction house, a feed producer, a construction business, a consultancy company, a food supplier, a network-brokering agency, and a human resource recruitment agency. Agriport A7 aims to create economic synergies, reduce the environmental burden, create social and environmental benefits, reduce traffic, and enhance innovation performance of networking organizations. Agriport A7 created a joint logistics system and a joint ownership of an energy company that produces energy via a geothermal heat and power system which supplies heat, gas, and electricity to all the glasshouses.

Bergerden is a self-organizing agro-industrial park located in the province of Gelderland. Initiated in 1990 and established in 2000, Bergerden connects 17 organizations at 320 hectare area. Bergerden connects horticultural growers, an energy distributor, a human resource recruitment agency, and a local development agency. Bergerden aims to establish synergies via joint heat, electricity, water, and CO_2 exchange systems. Moreover, Bergerden aims to use the rest heat and electricity created by bio-energy production technologies to recycle and reuse the bio-waste from greenhouses and to produce bio-energy and bio-fertilizer. Remarkably, twelve horticultural growers are co-located, allowing the establishment of formal ties among them via shared energy and water systems.

Biopark Terneuzen is a planned agro-industrial park located in the province of Zeeland. Initiated in 2005 and established in 2007, Biopark Terneuzen connects 23 organizations at 445 hectare area. The park connects energy generators and distributors, chemical companies, food and feed producers, horticultural growers, waste/recycling companies, and business

consultants. Biopark Terneuzen aims to strengthen the regional economy, attract new companies, create new employment and business opportunities, reduce environmental burden, increase the economic performance of local companies, and develop bio-based businesses. Biopark Terneuzen established a waste heat and CO_2 supply system from the industrial companies to the local horticultural companies.

These three agro-industrial parks are spread over the country, being located in three different provinces of the Netherlands. Organizations in these three agro-industrial parks are expected to improve their environmental performance, such as reduced greenhouse gas emission, and to provide opportunities for biomass use and bioenergy production (Smeets, 2011). Although different in occupied areas, the three agro-industrial parks studied are comparable in network size, which is the number of organizations engaged in networks. The comparability of network size allowed us to pool the collaborating organizations when conducting the quantitative study.

Organizations engaged in the three agro-industrial parks are heterogeneous not only according to their main activities, but also to their age and size. Table 4.1 groups organizations by age (years since establishment at the location) and size (fte: categorized according to the EU definition (2003/361/EC) of micro, small and medium-sized enterprises) across the agro-industrial parks.

Table 4.1. Number of organizations grouped by age and size across the three agro-industrial parks

	Agriport A7	Bergerden	Biopark Terneuzen
Organizations grouped by age (years)			
1–9	8 (33%)	8 (47%)	8 (35%)
10–19	4 (17%)	2 (12%)	3 (13 %)
20–29	3 (13%)	–	4 (17%)
30–39	1 (4%)	3 (18%)	2 (9%)
> 40	8 (33%)	4 (23%)	6 (26%)
Organizations grouped by size (fte)			
Micro: 1–9	9 (25%)	9 (53%)	7 (30%)
Small: 10–49	4 (29%)	7 (41%)	6 (26%)
Medium: 50–249	6 (25%)	1 (6%)	5 (22%)
Large: ≥ 250	5 (21%)	–	5 (22%)
Total (network size)	*24 (100%)*	*17 (100%)*	*23 (100%)*

As Table 4.1 shows, the organizations are more or less similarly grouped by size and age in Agriport A7 and in Biopark Terneuzen. In these two agro-industrial parks, the age and size of organizations are more or less uniformly distributed. In Bergerden, however, organizations established less than ten years ago (47%) and organizations with micro size (53%) are dominant. Overall, organizations differ not only in their main activities, but also in their size and age across the three agro-industrial parks.

4.3.2. Data collection and analysis

The data was collected primarily from interviews, official websites of the agro-industrial parks and individual organizations within the parks, scientific and professional publications.

For network analysis, the local organizations were indicated and listed in advance. During the interviews, the respondents were asked to check the list and add missing relevant organizations. All organizations that had at least one formal tie with another local organization were considered. The organizations that were co-located at agro-industrial parks for different reasons (for example, availability of land and cheap rent), but had no formal ties – the so-called isolates – were excluded from the network analysis.

In total, sixty four organizations that collaborate in one of the three parks have been contacted. One respondent per organization was selected. The respondents were managers involved in decision-making regarding the agro-industrial parks (Ackermann and Eden, 2011; McDonald and Westphal, 2003). They were the most knowledgeable to provide the required information (Galaskiewicz and Burt, 1991; Pina-Stranger and Lazega, 2011). Face-to-face interviews with 44 managers and online or phone interviews with 16 managers were conducted, adding up to 60 organizations [1]. The respondents included 39 CEOs, 12 business development managers, four strategic managers, two financial managers, two managers of spatial development, and one operational manager. The respondents provided general information about the park and the organization (for the qualitative study), about the network ties and their sustainability improvement perceptions (for the quantitative study).

[1] Unfortunately, managers from four organizations were unwilling to participate in the study. The missing values of perceived performance are, therefore, replaced with the overall mean.

As explained in Section 4.2.3, a tailored questionnaire was created using 7-point Likert scales considering the indicators of sustainability performance (Figure 4.1). Specifically, respondents reported on economic, environmental, and social performance, as well as the extent to which the collaborations in agro-industrial parks were perceived as productive and satisfactory (Appendix D, part 2 and 3). The respondents reported the point of view of the representing organizations. Therefore, controlling for their personal characteristics, such as age and education level, was considered less relevant in this study than in other perception-based studies. Instead, the size and the age of the organizations have been controlled while running the linear multivariate hierarchical regression analysis (Section 4.4.2). The responses have been cross-checked with the information found in (online) documents to ensure accuracy. If mismatch was found, the respondents have been contacted once again for clarification. Eventually, the analysis relied on the interviewees responses, because they provided the most recent views.

Dichotomous questions were used to find formal, informal, and interdependency ties. The formal ties encompass four, informal ties three, and interdependency ties two variables (Appendix D, part 4.) that were grouped and counted according to the tie type. The assumption was that if organization A answered "yes" to any variable or a combination of them that formed a tie with organization B, then the value of the related tie A→B was one. Whereas, if A answered "no" to all variables, then the value of the related tie A→B was zero. The ties were non-directional allowing to symmetrize the matrix, assuming that if A indicated a tie with B, then the reverse was as likely to be the case (Ashton, 2008; Ashton and Bain, 2012).

Using UCINET/NetDraw network analysis software (Borgatti *et al*., 2002), the ties were coded, analyzed, and mapped. Accordingly, network centralization and density have been calculated using the algorithms (Appendix E). The binary coding (1:0) indicated the presence or absence of a particular tie among each pair of organizations (Ashton, 2012). A scheme suggested by Sueur *et al*. (2012) was used to classify the networks according to centralization (Table 4.2).

Table 4.2. Classification of inter-organizational networks according to centralization score

Network classification	Centralization score (%)
Absolute centralized	100
Highly centralized	> 75
Moderate centralized	> 50
Moderate decentralized	> 25
Highly decentralized	> 12.5
Absolute decentralized	> 0 or $1/(n-1)$

Source: Sueur *et al*. (2012).

Next, the three centralities (i.e. degree, betweenness, and closeness) were calculated for every organization separately. The centrality scores of individual organizations together with the perceived performances were inserted into SPSS statistical software for further quantitative analysis. The measures of network structural properties and related algorithms are presented in Appendix B.

Network analysis was run in UCINET software, version 6.587 (Borgatti *et al*., 2002), and the statistical analysis at organizational level was run in SPSS Statistics 22 software. In SPSS, the number of variables was reduced by running a principal components analysis (PCA). Finally, a hierarchical regression analysis of the extracted factors controlling for size and age of the organizations was conducted.

4.4. Sustainability oriented network structures

In this section, the results of the qualitative and quantitative analysis are presented first at network level followed by the analysis at organizational level.

4.4.1. Network level

Network size. Network size indicates the number of collaborating organizations at the agro-industrial park location. A larger inter-organizational network size enables a wider access to necessary resources and may attract external businesses (Anbumozhi *et al*., 2010). However, increased network size may bring complexity because of increased heterogeneity and inter-

dependency (Van de Ven and Fery, 1980). Consequently, achieving an alignment of strategies and overcoming complexity becomes more challenging in larger agro-industrial parks. The respondents often emphasized that the collaboration for a long time period with many heterogeneous organizations was complex and challenging, although a growing network could guarantee improved sustainability performance through successful exchanges.

Tie type and centralization. Table 4.3 presents the centralization of the networks, tie types and the number of ties in the three agro-industrial parks.

Table 4.3. Network centralizations (C) and number of ties (No.) by tie type in the three agro-industrial parks

	Agriport A7		Bergerden		Biopark Terneuzen	
Tie type	*C (%)*	*No.*	*C (%)*	*No.*	*C (%)*	*No.*
Formal	22.3	211	37.9	178	57.6	148
Informal	49.8	128	72.5	65	48.7	120
Interdependency	27.9	41	35.9	129	50.5	93

As Table 4.3 shows, in Agriport A7, as a self-organizing agro-industrial park, the network of formal ties is highly decentralized (see Table 4.2 for classification of centralization), while the network of informal ties is moderately centralized. Moreover, the network of interdependency ties in Agriport A7 is moderately decentralized with a very low number of ties. A closer look at the data indicates that about 13 organizations in Agriport A7– including horticultural companies, an energy company, and a network broker – share the same amount of formal ties and perceive low interdependencies.

In Bergerden, as a self-organizing agro-industrial park, the networks of formal ties and of interdependency ties are moderately decentralized, whereas the network of informal ties is nearly highly centralized (Table 4.3). The network of informal ties in Bergerden is the most centralized, with a small number of ties. In the network of formal ties, seven organizations – including six horticultural firms and an energy company – show the highest degree centrality (Figure 4.2). Instead, in the network of informal ties, only two organizations, both horticultural firms, take the lead (nodes AB and AM in Figure 4.2). Remarkably, the number of formal ties is about 2.5 times larger than the number of informal ties (Table 4.3).

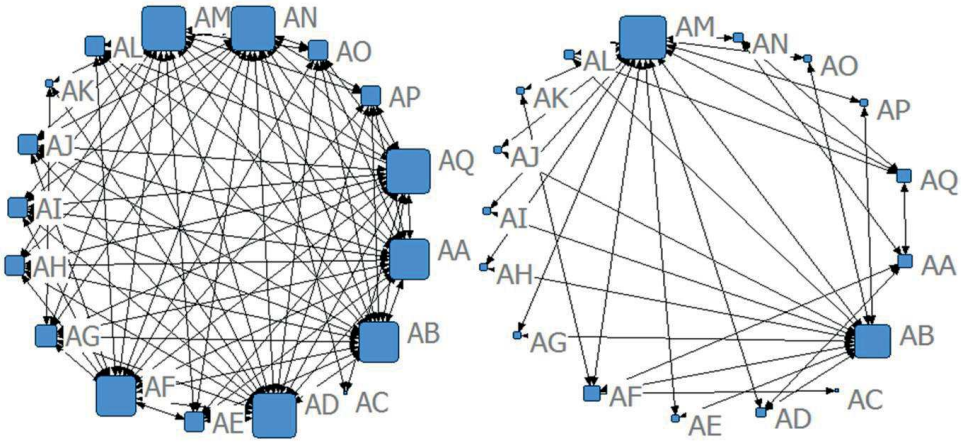

Figure 4.2. Network of formal and informal ties in Bergerden in 2013; each node represents one organization; node size by degree centrality; each edge indicates a tie between two nodes; relations are non-directional
Left: Network of formal ties; *Right:* Network of informal ties

In contrast to Bergerden, the networks of formal ties and interdependency ties are moderately centralized in Biopark Terneuzen, as a planned agro-industrial park, while the network of informal ties is moderately decentralized (Table 4.3).

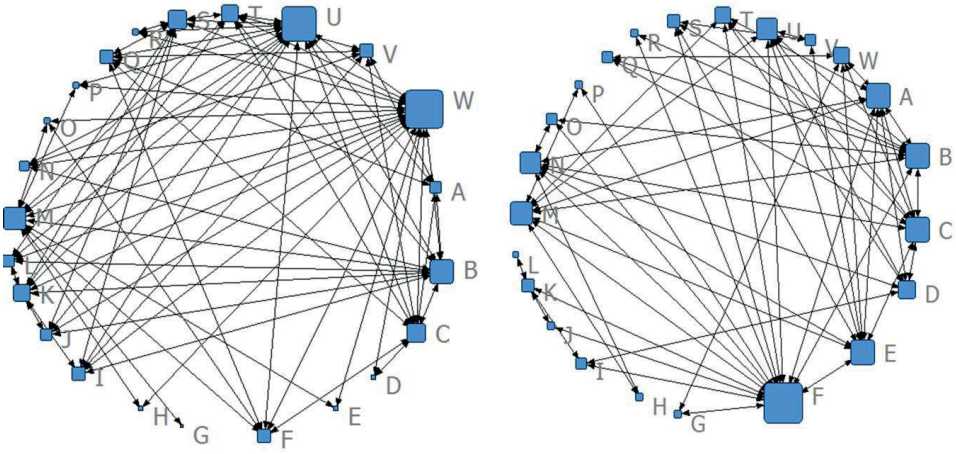

Figure 4.3. Network of formal and informal ties in Biopark Terneuzen in 2013; each node represents one organization; node size by degree centrality; each edge indicates a tie between two nodes; relations are non-directional
Left: Network of formal ties; Right: Network of informal ties

Two organizations are central in the network of formal ties (nodes W and U in Figure 4.3); one of these is a semi-governmental organization that provides financial, human, and other resources to local companies, whilst the other is a network-broker organization active in bringing local organizations together. These two central organizations in the network of formal ties are also central in the network of interdependency ties. A closer look at the data indicates that the network of informal ties is led by a different organization (node F in Figure 4.3), which is involved in bio-based business.

Tie type and density. Table 4.4 presents the densities of formal, informal and interdependency ties in the three agro-industrial parks.

Table 4.4. Network density (D) and number of ties (No.) by tie type in the three agro-industrial parks

	Agriport A7		Bergerden		Biopark Terneuzen	
Tie type	*D (%)*	*No.*	*D (%)*	*No.*	*D (%)*	*No.*
Formal	38.2	211	65.4	178	29.2	148
Informal	23.2	128	23.9	65	23.7	120
Interdependency	7.4	41	47.4	129	18.4	93

As Table 4.4 shows, the networks of formal ties are denser with higher number of ties than the networks of informal ties across the three parks. The formal ties in Bergerden have the highest density (65.4%), while the interdependency ties in Agriport A7 has the lowest density (7.4%). In contrast, the network of interdependency ties in Bergerden is very dense with a large number of ties.

In general, Agriport A7 has well established formal ties, which are perceived as decentralized, dense and less interdependent; whereas, in Bergerden the formal and interdependency ties are decentralized and dense. The formal ties in Biopark Terneuzen are centralized and relatively sparse. The densities of the informal ties in all three parks are rather sparse and relatively centralized.

4.4.2. Organization level

Table 4.5 presents the factor loadings of the extracted components of network structural properties at organizational level, i.e. individual centralities – degree, normalized degree, betweenness, and closeness – in networks of formal, informal, and interdependency ties. The Cronbach's α = 0.85 and the Cronbach's α of standardized 12 items = 0.89.

Table 4.5.Factor loadings, means and standard deviations (SD) of network structural properties

Network structural properties	Loadings	Mean	SD
(1) Interdependency			
• Dependency of own organization on others	0.93	3.09	1.66
• Dependency of others on own organization	0.90	2.98	1.62
(2) Centrality informal ties			
• Betweenness centrality informal	0.97	12.34	25.47
• Degree centrality informal	0.95	4.99	3.81
• Normalized degree centrality informal	0.93	24.54	19.18
(3) Centrality formal ties			
• Betweenness centrality formal	–0.93	9.87	17.26
• Degree centrality formal	–0.83	8.22	5.06
• Normalized degree centrality formal	–0.69	41.71	26.78
(4) Closeness centrality			
• Closeness centrality informal	–0.95	41.43	16.46
• Closeness centrality formal	–0.88	48.68	22.89

Table 4.5 shows the loadings, means, and standard deviations of each variable under the four extracted components. The rotation method is direct oblimin with Kaiser normalization (KMO = 0.61; $p < 0.01$), which resulted in the following correlation matrix of extracted network properties (Table 4.6).

Table 4.6 shows significant negative correlations between interdependency and centrality of formal ties ($r = -0.30$, $p < 0.05$), and between interdependency and closeness centrality ($r = -0.34$, $p < 0.01$). The negative scores suggest the presence of contrasting measures of network structural properties.

Table 4.6. Component correlation matrix of network structural properties; VIF = variance inflation factor

Network structural properties	(1)	(2)	(3)	(4)	VIF
(1) Interdependency	1.0				1.24
(2) Central informal ties	0.08	1.0			1.09
(3) Central formal ties	–0.30*	–0.24^{+}	1.0		1.17
(4) Closeness centrality	–0.34**	–0.18	0.23^{+}	1.0	1.18

Notes: asterisks $^{+}$, * and ** respectively denote significance at 10%, 5% and 1% levels.

Next, the PCA of the managers' perceptions of sustainability performance extracted six components (Table 4.7): innovation, satisfaction and reputation, economic performance, environmental benefits for local population, environmental performance, and employment performance. The Cronbach's α = 0.89, and the Cronbach's α of standardized 18 items = 0.89.

Table 4.7. Factor loadings, means and standard deviations (SD) of perceived sustainability performances

Perceived performance	Loadings	Mean	SD
(1) Innovation			
• Product and/or service quality has improved	0.86	4.78	1.32
• Number of innovations has increased	0.85	5.08	1.29
• We got new and innovative ideas	0.84	5.27	1.31
• Product or service capabilities have improved	0.76	4.75	1.35
(2) Satisfaction and reputation			
• We are satisfied with the collaborations within the park	0.93	5.25	1.16
• Our collaborations within the park are productive	0.82	5.41	1.12
• Reputation of our organization has improved	0.73	5.20	1.29
(3) Economic performance			
• Profits have increased	0.78	4.33	1.45
• Turnover has increased	0.76	4.61	1.29
• We became economically stronger	0.61	4.91	1.50
(4) Environmental benefits for local population			
• Odor nuisance and noise are decreased	0.89	4.39	1.29
• Environmental and health risks are decreased	0.51	4.78	1.05
(5) Environmental performance			
• We have less waste and CO_2 and greenhouse gas emissions	0.91	5.14	1.29
• We use less energy and other resources	0.88	4.94	1.49
(6) Employment performance			
• Number of qualified workers has increased	-0.92	4.42	1.25
• Number of employees has increased	-0.84	4.44	1.39

Table 4.7 shows the loadings, means, and standard deviations of each variable under the six extracted components. While most loadings are positive, the employment performance loadings are negative, and the decrease in environment and health risks has a rather low loading. The rotation method is direct oblimin with Kaiser normalization (KMO = 0.69; $p < 0.01$), which resulted in the correlation matrix of extracted perceived performance (Table 4.8).

Table 4.8. Component correlations matrix of perceived sustainability performances; VIF = variance inflation factor

Perceived performance	(1)	(2)	(3)	(4)	(5)	(6)	VIF
(1) Innovation performance	1.0						1.36
(2) Satisfaction and reputation	0.35**	1.0					1.19
(3) Economic performance	0.18	0.15	1.0				1.09
(4) Environmental benefits for local population	0.04	0.01	-0.05	1.0			1.03
(5) Environmental performance	0.40***	0.11	0.09	0.13	1.0		1.22
(6) Employment performance	-0.22^{+}	-0.26*	-0.24^{+}	-0.07	-0.16	1.0	1.16

Notes: asterisks +, *, **, *** respectively denote significance at 10%, 5%, 1%, and 0.1% levels.

A remarkable outcome of Table 4.8 is the strong positive correlations between innovation performance and satisfaction and reputation ($r = 0.35$, $p < 0.01$), and between innovation performance and environmental performance of organizations ($r = 0.40$, $p < 0.001$).

Next, a linear hierarchical regression analysis was run to explore significant associations of network structural properties with perceived performance of sustainability improvement in agro-industrial parks (Table 4.9).

Table 4.9 presents the relevant associations of network structural properties as predictors of perceived sustainability performance at organizational level. The non-significant results are excluded from the table.

Table 4.9. Network structural properties as predictors of perceived sustainability improvement performance

Sustainability improvement performance	Network structural properties	β	Control variables
Environmental performance	Interdependency	0.26*	ln size β = –0.15**
	Centrality formal ties	–0.24+	ln size β = –0.15**
Employment performance	Interdependency	–0.30*	ln size β = –0.15**
	Closeness centrality	–0.40**	ln size β = –0.15**
Satisfaction and reputation	Centrality formal ties	–0.26*	_
	Centrality informal ties	0.25*	_
	Closeness centrality	0.47***	_
Economic performance	Closeness centrality	0.33*	_
Innovation performance	Centrality formal ties	–0.35**	_
	Closeness centrality	0.24+	_

Notes: Control variables are organizations' ln age and organizations' ln size; only significant results are shown; asterisks +,*, **, *** respectively denote significance at 10%, 5%, 1%, and 0.1% levels.

First, Table 4.9 illustrates that interdependency in the agro-industrial parks is positively associated with environmental performance. However, during the interviews the respondents mentioned that formal contracts hindered organizations to build new or additional ties in waste stream exchanges. Although formal ties decreased the flexibility, organizations perceived improved environmental performance when interdependent.

Second, Table 4.9 shows that closeness centrality is positively associated with economic performance and with innovation performance. Moreover, the organizations that are more central according to this measure are more satisfied with the collaboration and perceive their reputation positively. In contrast to this, the organizations that are more central according to degree and betweenness centrality in the formal networks perceived their reputation and satisfaction negatively. Respondents of organizations with high degree and betweenness centrality in formal networks mentioned that they had high expectations for improved environmental performance, such as CO_2 reduction, waste heat use, waste water use, bio-waste valorization, and energy efficiency, when signing formal contracts. Achieved improvements in environmental performance, however, did not always reach the expectations, causing dissatisfaction.

Third, the higher is the degree centrality in formal networks, the more negative the managers' perception become regarding innovation and environmental performance (Table 4.9).

The respondents related the negative perceptions to the high ambitions and expectations at the time the agro-industrial parks were established. The horticultural organizations, for instance, expected to increase energy use efficiency and reduce costs by using waste heat and CO_2 from other local organizations. However, the supply of waste heat and CO_2 appeared to be insufficient to cover the demand of the glasshouses, especially in the winter. Moreover, in all three parks, after local protests, intensive livestock farming had to be banned, so the possibility to use the bio-waste from intensive livestock farming to produce bio-energy and compost was lost.

The perceptions on improved sustainability performance have also been influenced by the economic crisis right after the establishment of the agro-industrial parks. A number of companies in horticultural production and in bio-based businesses went bankrupt, creating a chain effect for the other network partners. The bankruptcy of local organizations together with the financial and economic downturn created negative perceptions on employment performance.

The results at the organizational level suggest that the enhanced environmental performance is associated with high interdependency. Organizations with resource commitments that have many direct formal ties in the network of formal ties perceive their sustainability performances negatively. Whereas, organizations that can build ties with other organization via a small number of intermediary partners (high closeness centrality), perceive their sustainability performance relatively positively.

4.5. Discussion

This study explored the network structures of inter-organizational ties that can lead to improved sustainability performance of organizations in agro-industrial parks. The following sections discuss the structures of the three agro-industrial parks at network level and at organization level.

4.5.1. Network level

At the network level, the main structural properties considered are network size, centralization, and density. Compared to large industrial parks, where usually more than 100 organizations collaborate (e.g., Albino, 2012), the size of the studied networks in agro-industrial parks (about twenty organizations each) can be indicated as medium. The parks vary less in network size than in organizations' size, with Bergerden being dominated by micro and small organizations. Size variation between organizations might impact the network centralization and density.

In line with the expectation (Section 4.2), decentralized networks are composed of more formal ties than centralized networks (Table 4.3). The two self-organized agro-industrial parks indicated decentralized structures of formal networks, whereas the planned park showed a centralized structure of formal networks. The distribution of formal ties and the risk of dependency were essential for enhanced sustainability performance. Therefore, a decentralized structure of formal ties seemed to be more preferable than a centralized one (Chertow and Ehrenfeld, 2012).

Although Ashton (2008) found a correlation between informal and formal ties in industrial symbioses, no confirmation could be found for the networks in agro-industrial parks. Moreover, Chertow and Ehrenfeld (2012) state that self-organized networks often involve informal ties. However, the results of this study show that the formal ties dominate informal ties in self-organized parks (Table 4.3). This contrast is most probably caused by the organizations being more heterogeneous in agro-industrial parks than in industrial parks. The high density of formal ties indicates well-established exchanges. However, the low density of informal ties can be interpreted as a missed opportunity to exchange knowledge, information,

and eventually to advance the collaborations in waste streams processing (McDonald and Westphal, 2003; Pina-Stranger and Lazega, 2011).

4.5.2. Organization level

At the organizational level the managers' sustainability improvement perceptions are explored. The results confirm that inter-organizational networking enhances the environmental performance, but not specifically the economic and social performance (Table 4.9). However, environmental performance is strongly associated with interdependencies (Table 4.9). Organizations enhance their environmental performance through dense interdependent networks, and have to rely on others in achieving common sustainability goals.

Respondents from organizations with many formal ties often associated the agro-industrial parks with increased interdependency that may increase the environmental performance, but also the risk of failure. For instance, the respondents from Agriport A7, that had a sparse interdependency network, often positively perceived the formal ties as a way to use waste and by-product, such as CO_2, heat, and water. Whereas, the respondents from Bergerden, that had a dense interdependency network, often showed more negative perceptions if the formal ties led to increased interdependencies.

Although the informal ties are less dense than formal ties at network level, the individual organizations that are central in the network of informal ties perceived their reputation positively and felt more satisfied with their collaborations. This result is in line with previous studies showing the relevance of informal ties (Muller-Seitz, 2012; Pina-Stranger and Lazega, 2011). However, a strong evidence to show the impact of informal ties on formal ties was not found, most probably because of the sparsity of informal ties.

In line with the expectation (Section 4.2), organizations that can build ties with other organizations within the network via a small number of intermediary partners (i.e. high closeness centrality), have relatively positive perceptions of many indications of sustainability performance. In contrast to this, organizations with relatively more direct ties (i.e. a high degree centrality), and more bridging ties (i.e. high betweenness centrality), have poor innovation

performance, and environmental performance (Table 4.9). These findings are unexpected because dyadic direct exchanges are considered critical in waste streams processing and in utility sharing. Probably, a large number of direct ties of a central organization in networks of heterogeneous organizations bring about a (perceived) risk of network failure, if such an organization fails to fulfil the promises (Ashton, 2008).

This study brings the concept of waste streams exchanges among co-located companies in agro-industrial parks to a new field of analysis by examining them as inter-organizational networks. Contributing to the discussion of power distribution and network success, as well as the discussion of network structure and sustainability improvement performance, the study shows the importance of decentralized network structures. Moreover, it contributes to the discussion on efficient network positioning by showing the importance of the quality of indirect ties instead of the quantity of direct ties. With regard to practical implications, the study suggests that organizations seeking advanced environmental performance should build ties with other organizations. However, collaborations create interdependency, a high level of which may increase reluctance to expand the network.

Additionally, organizations can enhance their innovation performance and economic performance if they position themselves in a formal network such that the network provides access to other organizations via a small number of intermediary partners (i.e. high closeness centrality). Finally, organizations may enhance their reputation if they build informal ties with other local organizations in agro-industrial parks.

4.6. Conclusions

This study grounds in industrial ecology and the literature on inter-organizational networks through the application of social network analysis. The exploration of the social structure of sustainability-oriented inter-organizational networks in agro-industrial parks resulted in expected and unexpected insights leading to the following conclusions.

First, this study confirms the social network theory on closeness centrality as indication of efficient positioning of individual organizations in a network. The organizations in agro-industrial parks are more efficiently positioned (i.e. perceive more positive sustainability per-

formance) in the network of formal ties if they can build ties with other organizations via a small number of intermediary partners (i.e. high closeness centrality) instead of having a large number of direct ties.

Second, according to the findings, a decentralized structure of formal ties in combination with a sparse interdependency has shown a relatively positive influence on sustainability improvement perceptions. The decentralized formal ties and sparse interdependencies were (quantitatively and qualitatively) most clearly indicated in the self-organized parks, confirming that, for the sake of sustainability improvement, a self-organized agro-industrial park is preferable to a planned park.

Third, this study accentuates that at network level the number of informal ties among the organizations in agro-industrial parks is rather sparse, which could be interpreted as a missed opportunity to achieve the necessary resources and knowledge through informal contacts (Section 4.5.2.). Finally, formal ties are dominant in decentralized networks, showing the importance of power distribution for the collaborating organizations to avoid dependency on one (or a small number of) central and/or powerful actor(s).

The following limitations of this study should be considered in future research of social structures for inter-organizational networks. First, a binary coding was used to find and analyze the ties. However, the binary coding ignores the intensity of the ties, which can play a role in perceptions. Second, the managers' characteristics, such as age, education and experience, are considered less relevant for the objective of this study (Section 4.3). However, these characteristics can be relevant for further studies focusing more on personal relations among influential persons in agro-industrial parks. Third, the measures of sustainability performance are perceptual. Although justified for the current study, the perceptual measures may not always reflect the objective reality. Therefore, future studies can consider developing objective measurement units, applicable to heterogeneous organizations, in order to reduce the potential issues of embeddedness and biases. Moreover, future research should consider the organizations that have no formal ties (i.e. isolates) especially if these organizations can potentially influence on sustainability perceptions. Finally, the fact that the studied agro-industrial parks were not yet fully realized, providing room to exploit additional economic and environmental opportunities, advocates conducting a longitudinal follow-up study.

CHAPTER 5: AN EVOLUTIONARY AND STRUCTURAL PERSPECTIVE ON INTER-ORGANIZATIONAL NETWORKS IN AGRO-INDUSTRIAL PARKS

This chapter is based on:

G. Nuhoff-Isakhanyan, E.F.M. Wubben, S.W.F. Omta. An evolutionary and structural perspective on inter-organizational networks in agro-industrial parks, *Journal of Industrial Ecology,* Submitted December 2015, under revision.

5. AN EVOLUTIONARY AND STRUCTURAL PERSPECTIVE ON INTER-ORGANIZATIONAL NETWORKS IN AGRO-INDUSTRIAL PARKS

5.1. Introduction

The increasing complexity of the competitive environment requires organizations to improve their sustainability performance (Albino *et al*., 2012). The growing need for consideration of all aspects of sustainability stimulates organizations to foster collaboration. Collaboration among individual organizations may provide access to renewable sources and improve cleaner production not attainable by individual organizations alone (Albino *et al*., 2012; Gray and Stites, 2013; Lozano, 2007; Fadeeva, 2005). Recently, a number of inter-organizational collaborations, such as agro-industrial parks, have emerged among co-located organizations, targeting enhanced sustainability performance (Anbumozhi *et al*., 2010; Smeets, 2011). Sustainability performance achieved via collaborations in agro-industrial parks includes cleaner production, renewable energy production, improved bio-mass utilization, and utility synergies (Smeets, 2011; Wubben and Isakhanyan, 2011). Collaboration in agro-industrial parks represents organizational networks with symbiotic ties among geographically proximate heterogeneous organizations, such as horticultural, agri-food, logistics, and other industrial companies (Ge *et al*., 2011; Hoes *et al*., 2012; Smeets, 2011).

The application of social network analysis can help to explore the network structures of inter-organizational networks in agro-industrial parks (Jacobsen, 2006; Provan *et al*., 2007). The network structures usually develop though an evolutionary process of previous events. Events occur over time, playing a major role in shaping the behavior of organizations that make-up network (Morgeson *et al*., 2015). The network evolution is considered as an evolving constellation of organizations that encompass inter-organizational networks (Boons *et al*., 2011; Spekkink, 2013). Through networks, organizations build partner-specific experience, strengthen relationships and establish new ones (Morgeson *et al*., 2015; Zollo *et al*., 2002). In addition, organizations share knowledge and experience, which, in the long run, can enhance their mutual alignment (Innes and Booher, 1999). As a result, over time different organizations may hold different positions within the network and together shape specific network structures. Thus, a better understanding of the evolution of inter-

organizational networks may help explain network structures at a given point in time (Boons *et al*., 2011; Spekkink, 2013).

Studies on inter-organizational networks refer either to the structural perspective or to the evolutionary perspective (for example, Boons *et al*. (2011), Spekkink (2013) Spekkink (2015), Ashton and Bain (2012), Gibbs and Deutz (2005), Boons *et al*. (2014), Schiller *et al*. (2014). The objective of this study is to show that the combined use of structural and evolutionary perspectives can enrich the understanding of inter-organizational network structures in agro-industrial parks. This brings about the central research question of this article: What is the added value of combining an evolutionary perspective and a structural perspective in studying inter-organizational networks in agro-industrial parks?

This study is grounded in the time dimension of sustainability (Lozano, 2008b). The study bridges the structural perspective and evolutionary perspective by showing the salience of inter-organizational network theory and event system theory. Accordingly, we combined cross-sectional and longitudinal study designs. We used a cross-sectional study design for the structural perspective and longitudinal design for the evolutionary perspective. Two illustrative cases of agro-industrial parks (Agriport A7 and Biopark Terneuzen) were analyzed to demonstrate the complementarity of the evolutionary and structural perspectives. These two agro-industrial parks attempt to create synergies between companies from the agricultural sector (primarily horticulture) and from other sectors, such as logistics in the case of Agriport A7 and process industry in the case of Biopark Terneuzen. Both agro-industrial parks are taken from the Netherlands, which is a densely populated, highly industrialized country with an internationally leading agricultural sector (Lambert and Boons, 2002).

Consistent with a cross-sectional design, the data were collected from organization managers by conducting interviews, and analyzed by using network analysis (INA) methods. Consistent with a longitudinal design, data were collected from secondary sources by collecting media documents, and then analyzed by using event sequence analysis (ESA). Using INA, we draw attention to the structural characteristics of inter-organizational networks at one time (in this study the reference year is 2013). Using ESA, we draw attention to the sequence of actions itself and study temporal patterns in actions.

This article is structured as follows. In the next section we introduce our conceptual framework of inter-organizational network analysis and event sequence analysis, and provide the theoretical ground for the structural and evolutionary perspectives. Next, we describe the

methods, followed by the results and analysis. Finally, we discuss the findings and conclude our article by showing the complementarities of the two methods that contribute to a better understanding of inter-organizational networks in agro-industrial parks.

5.2. Literature review

This section discusses the structural perspective and the evolutionary perspective of inter-organizational networks.

5.2.1. Network structural perspective

The structural perspective on networks goes beyond dyadic interactions and captures multiple relations among organizations at network level (Ahuja, 2000; Ahuja *et al.*, 2009; Burt, 1995; Wasserman and Faust, 1994). The structural perspective provides a deeper understanding the distribution of inter-organizational ties among organizations within a network (Ahuja, 2000; Borgatti, 2009; Burt, 1995; Corsaro *et al*., 2012; Rowley, 1997; Stuart, 2000). Scholars deploy different theories, such as exchange theory, transaction cost theory, structural holes theory, and network theory, to explain inter-organizational networks. Among these theories, the network theory is the one that offers network analysis methods than can be adopted to analyze agro-industrial park networks of heterogeneous organizations (Ashton, 2008; Ashton and Bain, 2012; Schiller *et al*., 2014).

Three main characteristics of inter-organizational network structures can be considered in studying agro-industrial parks networks: density, centralization, and actor centrality (Ahuja, 2000; Tichy *et al*., 1979).

First, the **network density** is a network level variable that shows the connectedness of organizations, reflected by the number of ties. Network density is a characteristic of the whole network that shows the speed of exchanges, and stimulates imitative behavior (Burt, 2000; Rowley, 1997). Because of imitative behavior, organizations may become familiar and establish shared expectations. High density may facilitate knowledge diffusion, stimulate imitative behavior, and shorten cognitive distances among heterogeneous organizations (Rowley,

1997). Network density may however also signal a "lock-in" situation, where the organizations of the network become strongly dependent on the resources of partner companies. In general, a dense network of organizational collaboration can create greater overall trust (Nooteboom, 2006).

Second, **network centralization** is a network level variable that shows the degree to which relations are conducted through hierarchies, to the extent where a single organization or a group of organizations can dominate the network (Ahuja, 2000; Borgatti, 2006; Borgatti, 2009). Centralized networks create stronger control rights, which might be more cost-efficient than decentralized networks (Grandori, 1997). Decentralized structures are criticized for causing inefficiencies and for being resource-intensive, especially in large networks (Provan *et al*., 2007). Decentralized structures are, however, promoted for preventing conflicts and attaining more agreements, especially when collaborating organizations are heterogeneous with low levels of mutual trust (Lawler and Yoon, 1993; Nooteboom, 2002). Decentralized structures advance the structural homophily, indicative of homogeneous groups with similar connections (Ahuja *et al*., 2009).

Third, **actor centrality** is an individual organization level variable that shows the position of an organization within a network (Ahuja *et al*., 2009; Freeman, 1978). Highly centralized networks usually have one central organization (or a small group of central organizations) that can take over network administrative responsibilities (Provan and Kenis, 2008; Rowley *et al*., 2000; Rowley, 1997). Organizations with a central position have better opportunities to gather relevant information and to access necessary resources than organizations in the periphery of networks. This leverages their power, which can be used to build a coalition (Ackermann and Eden, 2011). The presence of a central organization (or a small group of central organizations) that is usually large and powerful may discourage new organizations from joining the network, especially if they are small and medium sized entrepreneurial companies. Central organizations have comparatively more opportunities to mobilize other organizations in the network for collective action (Rowley, 1997; Ackermann & Eden, 2011) and consequently can play the role of anchor tenant (Korhonen, 2001; Mirata, 2004). Anchor tenants are organizations within the network that take coordination roles with regards to planning and facilitating synergetic relations, and assisting in network evolution (Mirata, 2004).

In sum, the structural perspective can be used to describe inter-organizational network structures. Inter-organizational network structures can be characterized by network density, network centralization and actor centrality. However, the structural perspective does not explain how network structures come about.

5.2.2. Event evolutionary perspective

The event evolutionary perspective on agro-industrial parks allows examination of the dynamic processes of inter-organizational networks that involve many subsequent actions of individual organizations (Boons and Howard-Grenville, 2009; Boons *et al*., 2011; Morgeson *et al*., 2015). Subsequent actions represent the interaction of different organizations and constitute events bounded in space and time (Morgeson *et al*., 2015). Through the events, organizations establish, strengthen or loosen relationships. Events influence the expectations that organizations perceive as windows of opportunities for engaging in further actions together (Boons *et al*., 2011; Morgeson *et al*., 2015; Spekkink, 2015). Consequently, social learning may occur in the long run, as organizations may find new ways of dealing with common problems in networks (Innes and Booher, 1999). The evolutionary perspective suggests that a systematic longitudinal analysis is necessary to gain a full understanding of network evolution (Boons *et al*., 2014; Spekkink, 2013; Spekkink, 2015).

An event evolutionary perspective of event system theory helps to understand collaboration among geographically bounded organizations, such as in eco-industrial parks (Boons *et al*., 2014; Morgeson *et al*., 2015). Similarly, agro-industrial park network evolution can be analyzed as a multitude of actions that constitute events. Event sequences uncover temporal patterns, such as the order and duration of events.

In general, although the inter-organizational network and event sequence analyses target the understandings of inter-organizational networks in agro-industrial parks from two different perspectives (that is network evolution and structure), we expect complementarities and synergies in combining these two perspectives. Specifically, we expect that the sequences of actions that constitute events in agro-industrial park evolution may be related with the network outcome: density, centralization and actor centrality.

5.3. Data and methods

Inter-organizational collaboration is often studied using qualitative case study methods (Heeres *et al*., 2000; Liwarska-Bizukojc *et al*., 2009; Spekkink, 2013). Agriport A7, North Holland, and Biopark Terneuzen, Zeeland, were selected as the cases because (1) these agro-industrial parks engage and contain heterogeneous organizations, (2) earlier interviews suggested that local companies in these parks systematically collaborate with one another, and (3) these two agro-industrial parks have frequently attracted media attention and have been referred to as archetypes for agro-industrial parks in the Netherlands.

We combined two designs to study the agro-industrial parks from evolutionary and structural perspectives. First, through cross-sectional design we investigated inter-organizational network structures. Second, through longitudinal design, we investigated actions that constitute events. Below we explain these two methods in detail.

From the structural perspective, we conducted a cross-sectional study. Specifically, we interviewed 34 organization managers: 19 in Agriport A7 and 15 in Biopark Terneuzen using a face-to-face semi-structured interview technique. The respondents from Agriport A7 included nine entrepreneurs, eight strategic managers and two financial directors. The respondents from Biopark Terneuzen included eleven new business development managers, four CEOs and one strategic manager. We collected information about the formal dyadic ties that connected organizations in the year 2013. A formal tie indicates a dyadic tie between two organizations that have formal contracts together, exchange waste and by-product on a regular basis, and/or share resources.

The inter-organizational network analysis has been executed through the use of UCINET 6 software (Borgatti *et al*., 2002; Hanneman and Riddle, 2005), in which we coded, mapped the networks, and calculated network structural properties: density, centralization and actors' degree centrality. The algorithms used to calculate network structural properties are the followings.

Density $\mathrm{D} = \frac{\mathrm{N}}{\mathrm{n}*(\mathrm{n}-1)}$, (Ahuja, 2000)

where D = network density: percentage in the scale of [0;100]

N = total number of connections

n = network size

Centralization $C = \frac{\sum_{i=1}^{n}[C^* - C_i]}{(n-2)(n-1)}$, (Freeman, 1987)

where C = centralization of entire network: percentage in the scale of [0;100]

n = network size: $n > 2$

C_i = centrality of organization i: percentage in the scale of [0;100]

C^* = largest value of centrality within the network: percentage in the scale of [0;100]

Actor degree centrality $C_{Di} = [1;\ n - 1]$, (Borgatti, 2005)

where C_{Di} = degree centrality of organization i

n = network size

Network centralization range is [1/(n-1); 100], which can be interpreted as absolute decentralized to absolute centralized (Sueur *et al*., 2012). Network density range is [0; 100], which can be interpreted as absolute sparse (no tie exist among organizations) to absolute dense (all possible ties exist) (Provan *et al*., 2007).

From the evolutionary perspective, we conducted a longitudinal investigation to find the action that took place since the inception of the two agro-industrial parks. Event sequence analysis requires the collection of rather large amounts of longitudinal data that usually cover a long period of time. The longitudinal data were found from secondary sources, such as the academic LexisNexis. Academic LexisNexis has the largest electronic database of public ecords and legal related information that covers news articles of the leading newspapers at national, regional and local level (http://www.lexisnexis.nl). Therefore, the data were collected from within the Academic LexisNexis online database through web searches guided by a search protocol. Initially, we used the terms “Agriport”, “Biopark Terneuzen” for the preliminary search in Dutch and in English. Then we used the names of the main organizations to find further relevant information.

The media items collected from LexisNexis were screened and filtered to remove duplicates and irrelevant items. Duplicates were items reporting the same action(s) found from different sources. Irrelevant items were those that reported actions which were not related to the establishment of network ties, such as opinions and PR related actions. Usually, the relevant items describe actions as “opening”, “settlement”, “fusion”, “investment”, “subsidize” and

so on. Finally, we end up with 158 media items for Agriport A7 and 64 media items for Biopark Terneuzen (Table 5.1).

Table 5.1. Data screening process

Agro-industrial parks	Total items	Duplicates	Irrelevant	Relevant
Agriport A7	987	108	652	158
Biopark Terneuzen	305	20	221	64

Table 5.1 shows that Agriport A7 had greater media attention than Biopark Terneuzen (987 versus 305). The media attention to Agriport A7 is, however, often related to promotional (PR) actions, such as organizing cultural and sport related activities and fairs at the main building of Agriport A7. Nevertheless the number of relevant media items on Agriport A7 is more than double that of relevant items on Biopark Terneuzen. Unfortunately, we do not have enough evidence to explain the difference. It may be that the PR policy of the project developers, and high number ties in Agriport A7 are reasons for the greater media attention.

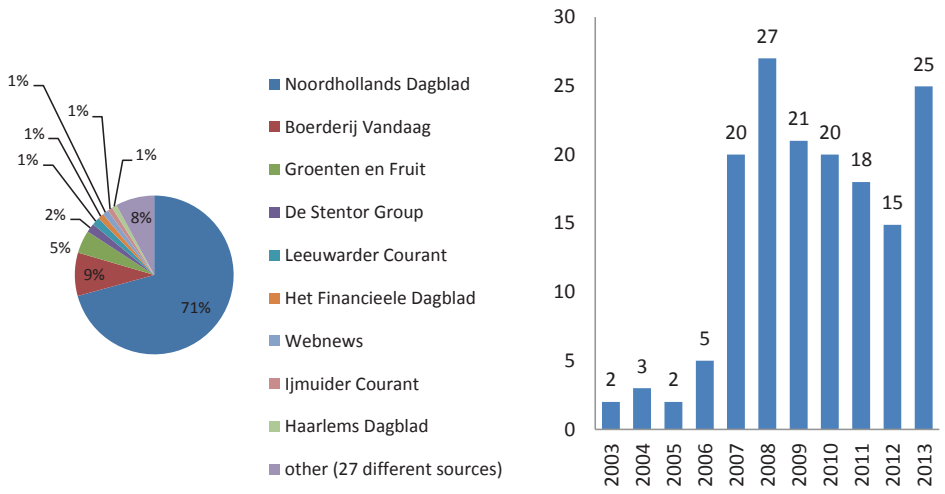

Figure 5.1. The origin and the number of relevant media items on Agriport A7

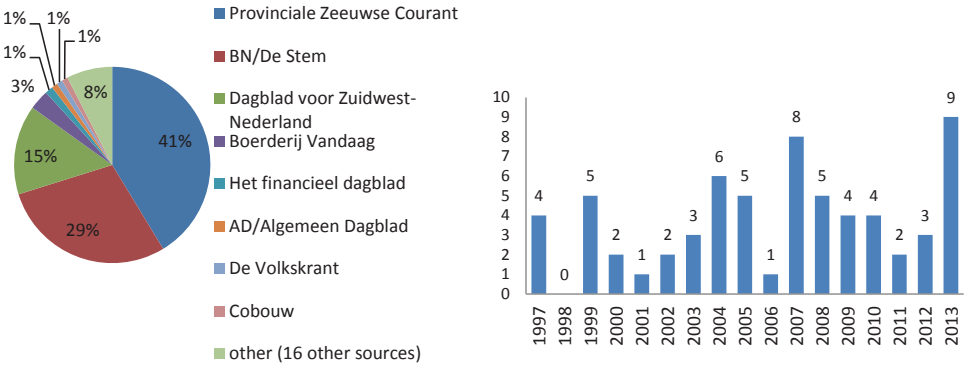

Figure 5.2. The origin and the number of relevant media items on Biopark Terneuzen

Figure 5.1 and Figure 5.2 show the origin and the number of collected media items on Agriport A7 and Biopark Terneuzen. The media attention to the two agro-industrial parks fluctuated notably, but in general it has increased throughout the years. However, the majority of the media items in both parks remained dominated by the provincial newspapers.

The relevant media items were used to extract actions and to group them into events. Actions were brief empirical descriptions of behaviors and facts that happened throughout the process. As already mentioned in the conceptual framework, an event is a constellation of subsequent actions bounded in space and time, and represent the interaction of different organizations. Therefore, the basic information collected included the date at which the actions occurred, the organizations involved, the actions and the source of information. The actions were recorded in the event sequence dataset in a chronological order using Microsoft Excel format.

Following this, we used a bottom-up approach to code the actions and colligated them into four main events. The first event focuses on the spatial planning policy, which provides a centrally imposed frame of conditions, and is typical to the Netherlands (Gerrits *et al*., 2012). The spatial planning policies regarding horticultural developments are often oriented to organizational collaboration by offering clustering opportunities (for example, the policy on

cross-sectoral collaboration). The second event is the facilitation, which comprises the actions of regional and local authorities, such as infrastructure building and maintenance, subsidies, permits and research. The third event concerns new business developments and acquisition, which is the essence of inter-organizational collaboration in agro-industrial parks (Anbumozhi *et al*., 2010; Smeets, 2011; Wubben and Isakhanyan, 2011). The fourth event is related to outcomes and results of the inter-organizational collaboration at individual organization or at network level, such as reduction of CO_2, reduction of energy use and waste, job creation, harvest, and various financial results. The actions on the timelines have been coded either positive or negative, forming positive or negative events. For instance, actions described as "start building", "buying land", or "acquiring license" have been coded as positive. Whereas, actions described as "delayed constructions and investments" or "rejected plans" have been coded under negative events.

Accordingly, the events were coded as E1, (E1), E2, (E2), E3, (E3) and E4, (E4). Positive or negative actions regarding spatial planning and area development, national laws and regulations were coded E1 and (E1) respectively. Positive or negative actions regarding facilitation, such as subsidies, infrastructure services, research, permissions and licenses were coded E2 and (E2) respectively. Positive or negative actions regarding new business development and acquisition, including new business establishment, moving, and expansion were coded E3 and (E3) respectively. Positive or negative results and outcomes related to harvest, reduced costs, reduced CO_2 were coded E4 and (E4) respectively.

Finally, we created two timelines to show how the actions have evolved over time in Agriport A7 and in Biopark Terneuzen separately (Appendix F). The coding enabled recognition of patterns of how the actions follow one another and evolve along the timeline.

5.4. Results

Agriport A7 and Biopark Terneuzen are located in the northwest and in the southwest of the Netherlands respectively. We introduce insights into the evolution of these two parks and analyze the effect of events on the network structure. First, we present the results of the cross-sectional analysis followed by the results of the longitudinal analysis.

5.4.1. Inter-organizational network analysis

For cross-sectional analysis we considered the formal ties of inter-organizational networks in two parks, and analyzed the density, network centralization, and actor centrality.

Table 5.2 shows the descriptive statistics of network analysis in Agriport A7 and in Biopark Terneuzen. It is apparent from this table that the minimum and maximum numbers of direct ties presented as degree centralities are comparable in the two parks. The mean is, however, larger in Agriport A7 than in Biopark Terneuzen, although the mean is less reliable in Agriport A7 than in Biopark Terneuzen because of high standard deviation. The data is skewed and contains outliers (organizations with very large numbers of ties). Therefore, the median is used, which is twice as large in Agriport A7 as in Biopark Terneuzen. The large median in combination with the large number of ties (n=216) indicate that the ties are more distributed among collaborating organizations in Agriport A7 than in Biopark Terneuzen, which is also confirmed by the centralization score (22.3% versus 57.6%).

Table 5.2. Descriptive statistics of actor centrality, network centralization, network density and the total number of ties by the two agro-industrial parks

Agro-industrial parks	№ of organizations	Actor degree centrality					Centralization (%)	Density (%)	Total № of ties
		Min.	Max.	Mean	SD*	Median			
Agriport A7	24	1	17	9	5.9	12	22.3	39.3	216
Biopark Terneuzen	23	1	18	6.4	4.3	6	57.6	29.2	148

*SD = standard deviation

Agriport A7, with a centralization score of 22.3% (Table 5.2) can be categorized as highly decentralized. Zooming in on the network picture of Agriport A7 (Figure 5.3), we see that none of the organizations has a clear dominant position in the network. Moreover, the majority of the organizations have a comparable degree of centrality, which has also been shown by the large median. The decentralization of formal ties indicates the structural homophily and a well-balanced distribution of ties among collaborating organizations within the network.

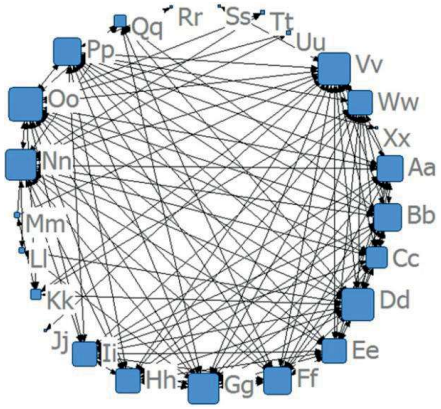

Figure 5.3. Network picture of formal ties among companies in Agriport A7 in 2013; each node represents one company, node size by degree centrality, each edge indicates a formal tie between two nodes, and relations are non-directional

Biopark Terneuzen, with a centralization score of 57.6% (Table 5.2), can be categorized as moderately centralized. Zooming in on the network picture of Biopark Terneuzen, we can see that two organizations are central in the network of formal relations (W and U in Figure 5.4); one of which is the Zeeland Seaports, a semi-governmental organization that facilitates network relations within the park and provides financial, human, and other resources to local companies. The other central organization is the foundation Biopark Terneuzen, a network-broker organization active in connecting local organizations and attracting new businesses to the location.

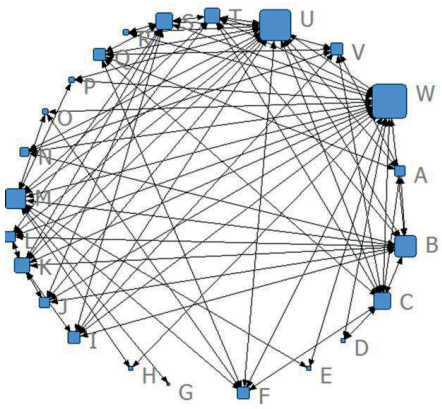

Figure 5.4. Network picture of formal ties among companies in Biopark Terneuzen in 2013; each node represents one company, node size by degree centrality, each edge indicates a formal tie between two nodes, and relations are non-directional

The centralization of the inter-organizational network of formal ties in Biopark Terneuzen and the central position of the two organizations indicate structural asymmetry of ties.

Regarding density, the formal ties are relatively dense in Agriport A7 compared to Biopark Terneuzen. This indicates that the organizations are more embedded and that the ties are better established in Agriport A7 than in Biopark Terneuzen.

5.4.2. Event sequence analysis

As already mentioned, we created two timelines of actions and colligated them into main events for the two parks separately (Appendix F). Table 5.3 shows the numbers and frequencies of coded actions, and the duration of the events.

Table 5.3. Event names, codes, and number, proportion, and duration of actions per event in two Agriport A7 and in Biopark Terneuzen

Events	Code*	Agriport A7			Biopark Terneuzen		
		N	**P**	**D**	**N**	**P**	**D**
Positive actions regarding spatial planning and area development laws and regulations	E1	5	3%	2003-2011	5	5%	1997-2002
Negative actions regarding spatial planning and area development laws and regulations	(E1)	0	-	-	0	-	-
Positive actions regarding facilitation	**E2**	**29**	**19%**	**2004-2013**	**29**	**29%**	1997-2013
Negative actions regarding facilitation	(E2)	10	6%	2007-2013	2	2%	2005, 2013
Positive actions regarding new business development and acquisition	**E3**	**66**	**42%**	**2003-2013**	**39**	**36%**	1997-2013
Negative actions regarding new business development and acquisition	(E3)	10	6%	2007-2013	4	4%	2008-2011
Positive actions regarding results and outcome	E4	28	18%	2007-2013	17	17%	1999-2013
Negative actions regarding results and outcome	(E4)	8	5%	2007-2013	7	7%	2005-2013

* N=number of actions; P= Proportion; D=duration in years

As Table 5.3 shows, the proportion of actions related to facilitation (event E2) is smaller in Agriport A7 (19%) than in Biopark Terneuzen (29%). In contrast, the proportions of actions related to new business development and acquisition (event E3) are larger in Agriport A7 (42%), than in Biopark Terneuzen (36%). These two differences of events between the two agro-industrial parks illustrates the involvement and positive attitude of commercial companies in Agriport A7, and the active involvement of authorities in Biopark Terneuzen. In both agro-industrial parks the event E3 comprises the largest number of actions, indicating the predominance of new business development and acquisition in agro-industrial park evolution.

Figure 5.5 and Figure 5.6 visualize the grouping of actions into events along the timeline of the two agro-industrial parks. First, the timeline of Agriport A7 starts in 2003 with the start of the negotiations by the province of North Holland, the municipality of Hollands Kroon and the entrepreneur Hiemstra to establish a park on available land in the northern part of the province. As Figure 5.6 shows, the number of actions has dramatically increased since 2006 in Agriport A7. The actions have become less frequent in the period of 2009 and 2010, but have increased again since 2011. This fluctuation can probably be explained by the 2008 financial crisis and subsequent economic crisis in Europe.

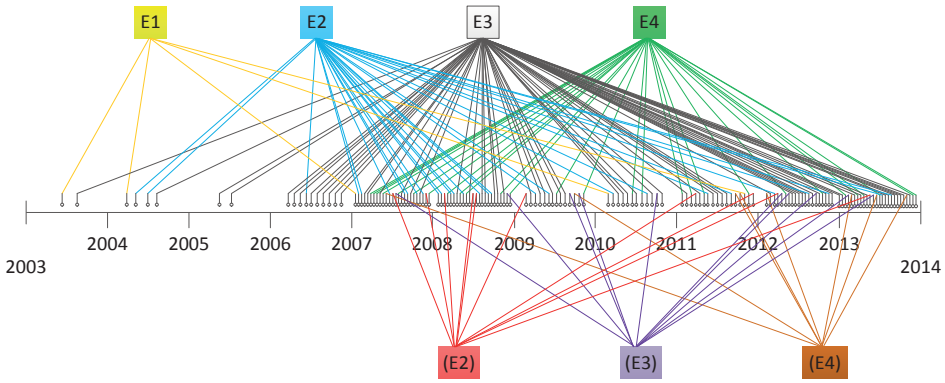

Figure 5.5 Visualization of actions grouped in events by year for a period of 1 Jan. 2003 and 1 Jan. 2014. Each point on the timeline indicates one action. Along this timeline of Agriport A7, the positive events are visualized above and negative event below the timeline.

Second, the timeline of Biopark Terneuzen starts in 1997 with the establishment of Zeeland Seaports from a merger of the ports of Vlissingen and Terneuzen. Zeeland Seaports, as a semi-governmental organization, launched and has been actively involved in the development of the Biopark Terneuzen. Figure 5.6 shows that the number of actions strongly fluctuates per year in Biopark Terneuzen. It can be seen that the actions in Biopark Terneuzen occur less frequent than in Agriport, which can be related to the relative sparse network of formal ties (Density = 29.2%).

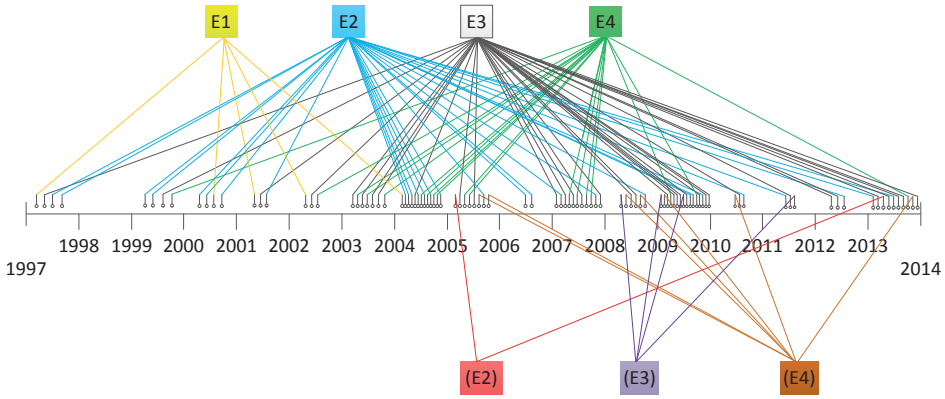

Figure 5.6. Visualization of actions grouped in events by year for a period of 1 Jan. 1997 and 1 Jan. 2014. Each point on the timeline indicates one action. Along this timeline of Agriport A7, the positive events are visualized above and negative event below the timeline.

The initial evolution of both agro-industrial parks started with actions related to spatial planning. The areas where the two parks were developed vary greatly: an existing industrial area versus a classic Dutch polder with farmland. In both parks, no negative actions regarding spatial planning and area development laws and regulation (event (E1)) were found. Remarkably, negative actions regarding the events facilitation (event (E2)) and new business developments (event E3) are more frequent in Agriport A7 than in Biopark Terneuzen. The number of positive or negative actions regarding the results and outcomes (events E4 and (E4)) are nevertheless comparable in both parks: E4=18% and (E4) =5% in Agriport A7, and E4=17% and (E4) =7% in Biopark Terneuzen (Table 5.3). This comparability indicates that the

events E4 and (E4) - results and outcomes - are standalone events in both parks, meaning that these outcomes were not dependent upon previous events within the two cases.

Most of the events, especially E2 and E3, comprise actions along the entire timeline of the two agro-industrial parks. The long duration of facilitation and of new business development and acquisition indicate that the realization of an agro-industrial park is an ongoing, dynamic process, and predicts the continuous involvement of new businesses and continuous facilitation.

5.5. Discussion and conclusions

5.5.1. Discussion

The objective of this Chapter was to show that the combined use of structural and evolutionary perspectives can enrich the understanding of inter-organizational network structures in agro-industrial parks. Table 5.4 combines the findings of the evolutionary perspective and the structural perspective in Agriport A7 and in Biopark Terneuzen. We will discuss some insights that illustrate the useful complementarity of the two perspectives.

Table 5.4. Inter-organizational network analysis and event sequence analysis findings in Agriport A7 and Biopark Terneuzen

	Evolutionary Perspective (ESA)	**Structural Perspective (INA)**
Agriport A7	○ Launched by entrepreneurs ○ Majority of actions are related to new business development and acquisition ○ The events are ongoing	○ Structural homophily ○ Relatively dense network ○ Decentralized ○ No anchor tenant
Biopark Terneuzen	○ Launched by authorities ○ Majority of actions are related to facilitation ○ The events are ongoing	○ Structural asymmetry ○ Relatively sparse network ○ Centralized ○ Two anchor tenants

First, the study shows that the evolution of agro-industrial park networks through the subsequent events plays an important role in network formation. The findings of the event sequence analysis show that the evolution of both agro-industrial parks started with actions related to spatial planning. The findings of the inter-organizational network analysis showed a decentralized, dense network structure in Agriport A7, and a centralized, sparse network structure in Biopark Terneuzen. During the evolution of Biopark Terneuzen, the initiator Zeeland Seaports systematically facilitated the establishment and maintenance of inter-organizational ties, which clarifies the centralized network structure in Biopark Terneuzen and the central position of the Zeeland Seaports therein. Whereas, during the evolution of Agriport A7, the project developer entrepreneur Hiemstra, even though being in charge, delegated the network-related activities to the newly established organizations, leading to a decentralized network structure in Agriport A7. Thus, we can conclude that the involvement of authorities at the start, and in subsequent events, including frequent facilitation, formed a centralized network. In contrast, the involvement of entrepreneurs at the start, and in subsequent events, and frequent new business developments and acquisitions, formed a decentralized network.

Second, the role of anchor tenants, as recognized in the structural analyses of the agro-industrial parks, contrasts with the findings of the longitudinal analysis. The literatures attributes an important role to central organizations as anchor tenants to attract new businesses, develop collaboration opportunities, and further develop the networks (Korhonen, 2001; Mirata, 2004). Biopark Terneuzen has two central organizations, but Agriport A7 has no central organization. Thus, it is to be expected that Biopark Terneuzen is more active in attracting new businesses than Agriport A7. Indeed, both agro-industrial parks developed collaboration opportunities through negotiations among different partners. Nevertheless, the two agro-industrial parks differ strongly in attracting new businesses. Counter to expectations, the two central organizations in Biopark Terneuzen attracted fewer businesses than Agriport A7 which has had no anchor tenant. We derive from the time series that a decentralized structure of inter-organizational networks has attracted more businesses to collaborate than a centralized structure regardless of the role of anchor tenants.

Third, the structural homophily of inter-organizational ties in Agriport A7 can be explained by the involvement of entrepreneurs at the start of the agro-industrial park evolution, and

by the majority of actions related to new business developments. Whereas, the structural asymmetry of inter-organizational ties in Biopark Terneuzen can be explained by the active involvement of authorities and passive involvement of entrepreneurs (Table 5.4). Additionally, the majority of actions in Biopark Terneuzen are related to facilitation (Table 5.3). Based on these findings, we can conclude that the frequent facilitation by authorities and the continuous interventions have led to centralized and sparse networks, whereas frequent new business developments and acquisitions have led to network decentralization and relatively high density. The organizations in Agriport A7 seem to prefer collaboration in decentralized networks rather than in centralized networks.

5.5.2. Conclusions

To show the added value of combining evolutionary and structural perspectives, we combined a cross-sectional design with a longitudinal design through two case studies of agro-industrial parks in the Netherlands. Accordingly, we analyzed the data through inter-organizational network analysis (INA) and through event sequence analysis (ESA). The combination of the two perspectives has provided a deeper understanding of how the network structures evolved over time. Moreover, the combination of approaches created new insights that are more informative than a single perspective approach.

In general, structural and evolutionary perspectives complement each other and bring deeper understanding of network structures by showing how the actions that evolve over time shape network structures. More specifically, the evolutionary perspective provides enhanced understanding of the role of governmental interventions with frequent facilitation leading to centralized networks, and the engagement of entrepreneurs with frequent new business developments leading to decentralized networks.

This study brings conceptual insights and demonstrates an innovative methodological approach in analyzing agro-industrial parks. However, the research limitations should be considered when generalizing the conclusions. First, we studies only two agro-industrial parks that are still in development. Second, our sample is based in the Netherlands, a highly industrialized country with a leading agricultural sector. These limitations should be carefully considered when applying the findings in fully realized networks outside the Netherlands.

Since the two agro-industrial parks are still in development, data on the events are by definition incomplete, prohibiting a final evaluation of their network evolution and network structure. The two cases provide, however, robust information, because the longitudinal study included both the economic upturn till 2008, and the ensuing downturn with the financial and economic crisis in Europe. These crises obviously have an impact on organizations' network behavior, causing negative actions in the period of 2008 and 2009. Nevertheless, the positive actions have continued after the downturn in both parks indicating the stability of the two networks.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

This chapter answers the main research question:

In what way can inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular enhance sustainability?

6. DISCUSSION AND CONCLUSIONS

The aim of this research was to advance knowledge of how inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular can enhance sustainability. This chapter discusses the main findings and draws general conclusions by answering the main research question:

MAIN RESERACH QUESTION

In what way can inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular enhance sustainability?

To answer the main research question and to meet the research aim, we have taken several theoretical perspectives and zoomed in on inter-organizational collaboration and sustainability aspects through different theoretical lenses. The main theoretical perspectives taken were industrial ecology, network theory, collaboration theory, stakeholder theory, and event system theory. Accordingly, the network structures, network governance forms, event systems for network evolution, and sustainability performance of organizations have been studied.

Across four studies (presented in Chapter 2 through Chapter 5) with different designs employing several theories and combining various methods, this thesis brings the concept of waste streams exchanges and utility sharing among co-located organizations in agro-industrial parks to a new field of analysis. In doing so, this thesis expands the existing studies on sustainability-oriented inter-organizational collaboration.

This chapter is structured as follows. First, Section 6.1 presents the main conclusions regarding the four studies conducted to meet the study objectives presented in Section 1.6. Then, Section 6.2 summarizes the main conclusions and brings together the main issues covered, which is followed by the theoretical contributions in Section 6.3. Next, Section 6.4 discusses

the main limitations and accordingly recommendations for future research. Finally, Section 6.5 closes the thesis by providing implications for policy makers and managers.

6.1. Conclusions per research objective

As already mentioned, the main research aim was reached by integrating different theoretical perspectives and by translating it into four research objectives. This section shortly outlines the motives of the individual studies and the method used, as well as presents the conclusions regarding the research objectives of the four individual studies.

Research Objective 1

To systematically integrate the scientific knowledge on sustainability benefits and challenges of inter-organizational collaboration in bio-based business.

Chapter 2 presented the primary approach of this thesis to achieve the research aim taking a global view of inter-organizational collaboration. Prior desk study showed that bio-based business, although often considered sustainable mainly because of substituting fossil-fuel-based business, is criticized for causing new sustainability challenges. In response to sustainability challenges, organizations are urged to explore collaboration channels, for example, exchanging waste streams and sharing utilities (Anbumozhi *et al*., 2010; Jensen *et al*., 2013). However, the available knowledge is scattered and not systematically integrated to conclude if inter-organizational collaboration in bio-based business can enhance sustainability if all three aspects of sustainability are considered.

A systematic literature review was conducted to find, gather, and integrate the available knowledge on sustainability effects of inter-organizational collaboration in bio-based business. The screening of hundreds of articles collected from three major academic databases, i.e. Web of Science, Scopus, and EconLit, resulted in a set of about one hundred potential articles that could provide an answer to the research question (Section 2.2). The content analysis of a final set of 24 articles (Table 2.2) provided empirical evidence of both sustainability benefits and challenges found by other scholars.

Although the authors do not refer to inter-organizational collaboration in bio-based business as a mechanism to mitigate all challenges of bio-based business directly, such as land use conflict and soil erosion, they highlight substantial sustainability benefits of collaborations, such as CO_2, greenhouse gas emissions and waste reduction, cost reduction, competitive advantage, enhanced innovation performance, energy supply security, and additional employment. The scholars that conducted their study in industrialized and emerging economies highlight different sustainability benefits and challenges. The difference is especially evident in the social and economic aspects of sustainability (Table 2.4). Several authors emphasized rural empowerment, job and income generation, eventually leading to poverty prevention or reduction in emerging economies, and traffic congestion, decreasing recreational value, odor and noise nuisance in industrialized economies. Therefore, sustainability outcomes seemed to be more positively assessed in emerging economies than in industrialized economies, although the investigated environmental benefits and challenges are relatively similar in the two economies.

This systematic literature review pioneers the research on sustainability-oriented inter-organizational collaboration in bio-based business. The conclusion that inter-organizational collaboration can provide a variety of sustainability benefits next to (region-)specific challenges strengthens pleas to pursue sustainability studies and develop political agendas on inter-organizational collaboration in bio-based business.

Research Objective 2

To explore the opportunities for and barriers to agro-industrial park realization focusing on network structures and governance forms.

Chapter 3 focused on inter-organizational collaboration in agro-industrial parks, launched and developed in the Netherlands as a frontrunner in agricultural innovations. A narrative literature review on agro-industrial parks, and two focus group discussions with stakeholders engaged in agro-industrial park realization in the Netherlands were used for analysis (Section 3.2). Based on the results, an integrated conceptual framework of the opportunities for and barriers to agro-industrial park realization was been built according to the heterogeneity and

engagement of stakeholder, network size, tie type, density, and governance forms (Table 3.2), which brought about the following conclusions.

First, a large number of heterogeneous stakeholders seem to be essential to create opportunities for agro-industrial park realization. The density of informal ties among engaged stakeholders has potential to intensify information exchange for tacit knowledge transfer, and knowledge development for enhanced innovation. In contrast, the density of formal ties is perceived as barrier that increases interdependencies and accordingly the risk of failure. This perception keeps new organizations especially away from joining the network and developing the park. New organizations are often reluctant to build formal ties if high investments and a long-term commitment to previously unknown partners are required.

Second, small organizations generally meet difficulties with regards to administrative tasks in inter-organizational collaboration. Small organizations often avoid collaborating with large organizations because they try to prevent additional dependencies. Instead, small organizations often prefer to delegate network administrative responsibilities to professional organizations. Accordingly, a brokered governance form is preferred to avoid administrative burden and maintain independency.

Research Objective 3

To explore the inter-organizational network structures in agro-industrial parks that can enhance sustainability performance.

In this journey of gaining insight into sustainability-oriented network structures, Chapter 4 presented three empirical case studies of agro-industrial parks from the Netherlands. Combining qualitative and quantitative methods, the research explored general characteristics of agro-industrial parks, and formal, informal, interdependency ties among 64 collaborating organizations (Section 4.3). Additionally, the research explored the managers' perceptions of sustainability performance of the representing organizations. The analysis was conducted at network and at organization level using UCINET and SPSS analytical software.

The findings at network level emphasize that informal ties among organizations in the three agro-industrial parks are rather sparse (Table 4.4). The scarcity of informal ties contrasts with the findings in Chapter 3 that emphasize the importance of informal ties for infor-

mation exchange, knowledge development, and innovation enhancement (Table 3.2). The sparsity of informal ties in three studied agro-industrial parks can therefore, be interpreted as a missed opportunity to achieve the necessary resources and knowledge through informal contacts. Meanwhile, the empirical evidence presented in Chapter 4 shows that formal ties are denser in decentralized networks (Table 4.3 and 4.4), indicating the importance of well-balanced distribution of ties especially for the organizations that avoid dependencies on one (or a small number of) central and powerful organization(s).

The findings at the organization level confirm that inter-organizational collaboration enhances the environmental performance of a company in agro-industrial parks (Albino *et al*., 2012; Pittaway *et al*., 2004). However, environmental performance is strongly associated with interdependencies (Table 4.9). It seems that organizations enhance their environmental performance through dense interdependent networks, and have to rely on others in enhancing sustainability.

Research Objective 4

To investigate if the combined use of the structural and the evolutionary perspective can enrich the understanding of inter-organizational network structures in agro-industrial parks.

Finally, **Chapter 5** contributes to the understanding of event developments that shape the network structures. Designing a cross-sectional study and combining it with a longitudinal study, this research used illustrative cases of two agro-industrial parks, launched and developed in the Netherlands. Data for the cross-sectional study were collected through semi-structured interviews with managers from 34 organizations from these two parks. It was complemented by data for the longitudinal study of about 17 years collected from secondary sources, i.e. Academic LexisNexis (Section 5.3). The analysis was conducted at network level by using UCINET software and by extracting actions related to network formation that constructed certain events (Figure 5.5 and Figure 5.6).

The findings show that the subsequent events during the evolution of agro-industrial park have impact on the formation of certain network structures (Table 5.2 and Table 5.3). First, the active engagement of public authorities and frequent facilitation seem to advance net-

work centralization in Biopark Terneuzen. Second, the active engagement of entrepreneurs and frequent new business developments from the start throughout the evolution of Agriport A7 seems to advance network decentralization. Moreover, the reverse is as likely to be true: decentralized networks attract more businesses to collaborate than centralized networks regardless of the role of public authorities as anchor tenants (Table 5.4).

Based on the findings, the study presented in Chapter 5 concludes that structural and evolutionary perspectives complement each other and bring deeper understanding of network structures by showing how the actions that evolve over time shape network structures and influence on network developments.

6.2. General conclusions

As mentioned, the aim of this thesis was to understand how inter-organizational collaboration can enhance sustainability. Taking a critical approach to sustainability outcomes as result of inter-organizational collaboration among co-located heterogeneous organization, this research analyzed inter-organizational network structures, network governance forms, and network evolution. As stated in Chapter 1, multiple theoretical perspectives have been integrated in the research that generated new insights into sustainability-oriented inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular focusing on network structures and network governance forms (Section 1.3). These collaborations are recently developed forms of inter-organizational collaborations not extensively nor coherently studied before. Considering the novelty of these collaborations, this thesis deploys industrial ecology, stakeholder, network and event system theories.

Focusing on sustainability-oriented network structures, network governance forms, and network evolution, this thesis uses empirical data from agro-industrial parks launched and developed in the Netherlands. Through designing a systematic review, cross-sectional, and longitudinal studies, and through combining qualitative and quantitative methods, the research has arrived at several conclusions presented in the Chapter 2 through Chapter 5. The integration of conclusions from the individual studies brought about the following two main conclusions.

First, the academic literature often emphasizes the environmental benefits of inter-organizational collaboration in bio-based business, such as the reduction of carbon and greenhouse gas emissions, waste, and mineral fertilizer use (Chapter 2). These environmental benefits have also been recognized in Dutch agro-industrial parks (Chapter 3 and Chapter 4). In addition to emission and waste reduction, the environmental benefits of inter-organizational collaboration in Dutch agro-industrial parks are often presented as the production of renewable energy and increase of material use efficiency. Moreover, this thesis provides evidence that environmental performance is strongly related to the innovation performance (Table 4.8). However, the organizations that have formal ties within the Dutch agro-industrial parks do not always perceive enhanced economic and social performance (Table 4.9). Meanwhile, a high economic value, such as higher turnover/profit, cost reduction, higher income, and additional employment is given to inter-organizational collaboration in emerging economies and social challenges in industrialized economies (Table 2.4), which seems to give more sustainability credits to collaborations in underdeveloped regions in emerging economies.

It can be concluded that inter-organizational collaboration among co-located heterogeneous organizations enhances the environmental aspect of sustainability. Whereas, the economic and social aspects of sustainability are more positively perceived in cases from emerging economies than in cases from industrialized economies, and less positively perceived in Dutch agro-industrial parks.

Second, the conclusions presented in the Chapters 2 through Chapter 5 indicate that heterogeneous organizations often avoid high investments and formal, long term commitments to new partners. For instance, chemical and horticultural companies avoid joint investments in the construction of pipelines for CO_2 transportation, and in the construction, operation and maintenance of biomass gasifiers (Table 3.2). Organizations avoid building direct ties in agro-industrial parks mainly because of the following two perceptions: (1) the added value of investments is perceived less viable and payback periods are usually long, and (2) the risks of investing with previously unknown partners are perceived as very high. Therefore, many organizations do not want to build ties and prefer to remain in control in managing networks

and in decision-making (Section 4.5 and Section 5.5). Therefore, decentralized network structures, indicating a well-balanced distribution of ties among engaged organizations, are recommended to realize inter-organizational collaboration and enhance sustainability. Still, decentralization may cause administrative burdens for small entrepreneurial organizations, such as vegetable growers, that lack appropriate resources to invest in network management and maintenance (Section 3.5).

It can be concluded that decentralized network structures indicating a well-balanced distribution of ties among organizations advance sustainability-oriented inter-organizational networks. Decentralized network structures also decrease the risk of being dependent on one (or a small group of organizations). The decentralized structures, therefore, can attract new business to collaborate in waste streams exchanges and utility sharing.

This thesis provides evidence that inter-organizational collaboration in agro-industrial parks have an extensive potential to enhance environmental aspect of sustainability. This thesis contributes to the existing theories by bringing the concept of waste streams exchanges and utility sharing to a new field of analysis. Taken together, the results offer meaningful contributions to literature on industrial ecology and organizational network studies. In the subsequent section, the theoretical contribution of the thesis is detailed accordingly.

6.3. Theoretical contributions

By studying the realization of agro-industrial parks as inter-organizational networks and underlying sustainability issues leading to collaborative actions, using different theoretical perspectives and several methodologies, this thesis contributes to the industrial ecology and organizational network studies in a number of ways.

First, the findings in Chapter 2 contribute to previous research on environmental benefits of inter-organizational collaboration in bio-based business (e.g., Park *et al*. (2011), Pfau *et al*. (2014), Schmidt *et al*. (2012), and Smeets (2011). The main conclusion of this thesis that sub-

stantial reduction of carbon and greenhouse gas emissions can be achieved together with other waste reductions already adds to the importance of collaborations for waste streams exchanges and utility sharing. This research is original in showing the stronger emphasis to social and economic benefits in emerging economies and less in industrialized economies, thereby contributing in steering sustainability-oriented development studies.

Second, the integrated framework developed in Chapter 3 presents new insight into opportunities for and barriers to agro-industrial park realization (Table 3.2), and contributes to the theoretical discussion on inter-organizational collaboration among co-located organizations focusing on network structures and network governance forms (e.g., Berkers and Geels, 2011; Hartwich and Negro, 2010; Heeres *et al*., 2000; Hoes *et al*., 2012; Klein Woolthuis *et al*., 2005, Mizruchi and Galaskiewicz, 1993; Provan *et al*., 2007; Provan and Kenis, 2008). Particularly, regarding formal ties as essential properties of network structure, the research concludes that the lack of shared history with new partners hinders formal commitments in long-term investments. Regarding network governance forms, the research indicates that, although shared and lead governance forms may be suitable to agro-industrial parks because of their moderate network size (Box 1.1 and Table 4.1), brokered governance seem to be more preferred because of two reasons: (1) small and medium-sized organizations perceive network administration as a barrier and prefer to delegate network administrative responsibilities to professional organizations known as network brokers, and (2) organizations in agro-industrial parks avoid dependency on the lead partner and prefer brokered organization instead of a lead organization.

Third, Chapter 4 contributes to organizational network theories (e.g., Ashton, 2008; Ashton and Bain, 2012; Posch, 2010; Posch *et al*., 2011; Schiller *et al*., 2014) by integrating and applying the existing literature to agro-industrial parks, and by bridging network structural properties (such as centralization, density, and actor centrality) and managers' perceptions on sustainability performance. In doing so, the study shows that organizations with better reach to all other partners (closeness centrality) perceive better economic performance, innovation performance, and reputation than organizations having many direct ties. This is an essential contribution to the discussion on efficient network strategies (e.g., Freeman, 1978; Friedkin, 1991; Powell *et al*., 1996). Additionally, Chapter 4 confirms the findings of the study

presented in Chapter 3 by showing the importance of well-balanced distribution of ties (decentralized structure) in networks of heterogeneous organizations.

Last, Chapter 5 contributes to event system theory in increasing the understanding of the evolution of inter-organizational networks among co-located organizations (e.g., Boons *et al*., 2011; Spekkink, 2013; Spekkink, 2015). By combining evolutionary and structural perspectives, the study integrates two methodological approaches and shows the long-term effects of consequent events on the structure of inter-organizational networks. The study does not merely show the added value of integrated methodologies, but also demonstrates that frequent and continuous intervention of pubic authorities with frequent facilitation may lead to network centralization, and the engagement of entrepreneurs with frequent new business developments may lead to network decentralization. This study confirms the findings presented in Chapter 3 and Chapter 4 on the importance of decentralized structures in sustainability-oriented inter-organizational networks of heterogeneous organizations.

This thesis is pioneering in bringing research on sustainability-oriented collaborations among co-located heterogeneous organizations to a new field of analysis by examining them as inter-organizational networks among co-located heterogeneous organizations. By illustrating the sustainability benefits of inter-organizational collaboration and elaborating the associations between network structural properties, network governance forms, and network evolution, this thesis contributes to the discussion of well-balances distribution of ties within the networks showing the importance of network decentralization in realizing sustainability-oriented inter-organizational networks.

6.4. Limitations and recommendations for further research

This thesis adds to existing theories in industrial ecology and organizational networks, and demonstrates an innovative methodological approach in analyzing agro-industrial parks. However, the research findings should be treated with caution and limitations should be considered when generalizing the conclusions. This section presents limitations and provides constructive recommendations for further research.

6.4.1. Limitations

When addressing the limitations of this thesis, the following items are emphasized as important to consider when generalizing the conclusions on sustainability-oriented inter-organizational collaboration among geographically co-located organizations.

First, the main limitation of this research is caused by the scarcity of academic literature if the search is narrowed down to agro-industrial parks. While popular in media and in political agendas, only a limited number of academic papers on inter-organizational collaboration in bio-based business in general, and in agro-industrial parks in particular, has been published (Chapter 2 and Chapter 3). The research on this topic seems limited mainly because the concern on sustainability of bio-based business is a relatively new topic that attracted the attention of scientists primarily since the turn of the turn of the 21st century (Pfau *et al*., 2014). However, the interest towards inter-organizational collaboration in bio-based business is growing (Chapter 3), supporting the importance of research on sustainability-oriented collaborations in bio-based business. Still, the academic literature is mainly based on qualitative studies and fails to give substantial quantitative evidence on different aspects of sustainability, making it impossible to assess both the size and the trade-offs between sustainability benefits and challenges (Chapter 2).

Second, agro-industrial parks, as launched and developed in the last two decades in the Netherlands, represent a system innovation for sustainability. The thesis builds evidence based arguments instead of model-based or opinion-based arguments. However, the availability of suitable empirical cases of agro-industrial parks was limited, restricting us to conduct quantitative analyses at network level in Chapter 3 and in Chapter 4. Since at the close of data gathering most agro-industrial parks were still in development, data on the events are by definition incomplete, inhibiting a final evaluation of their network structure and evolution in Chapter 4 and Chapter 5. The fact that the studied agro-industrial parks were not yet fully realized, provides room to explore long-term sustainability effects.

Third, we recognize that the dataset used in Chapters 3, 4 and 5 represents the practices of agro-industrial park realization in the Netherlands. The Netherlands is a highly industrialized country with an advanced horticultural sector, allowing it to be a frontrunner in agricultural

innovation and collaboration for sustainable production. Therefore, it is difficult to generalize the conclusions, advocating longitudinal studies and studies on other countries. Chapter 2 indicates that around the globe different effects were addressed. However, the findings of Chapter 3, 4, and 5 represent the Netherlands, the formats of these agro-industrial parks can be used as archetypes in realizing agro-industrial parks in other countries.

Fourth, the study presented in Chapter 5 uses secondary data for longitudinal analysis. The rich archival database of news items, however, may not represent the complete picture of incidents and events related to network evolution. Certain historical actions relevant to the study objective may have been misrepresented, ignored by the media or not even known by outsiders. To reduce the impact of reporter bias in media items, we collected additional data from different official websites to check the completeness of the original data. Although no evidence was found that shows incompleteness of the original data, it was beyond our means to check for non-public information, such as confidential agreements.

These limitations should be considered when transferring the findings of the study or when developing agro-industrial parks either inside or outside the Netherlands. Based on the limitations and learnings from this thesis, the following section presents recommendations for future research.

6.4.2. Recommendations for further research

The main conclusion of this thesis, specifically the sustainability enhancing potential of inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular, will hopefully commence further sustainability-oriented research. Based on the findings and limitations, we arrived at the following four recommendations for further research.

First, we recommend further research to conduct longitudinal studies to trace and track the long-term effects on sustainability through inter-organizational networks. This thesis is primarily based on cross-sectional studies and data. Sustainability-oriented inter-organizational networks among co-located heterogeneous organizations may be classified as relatively new types of collaboration, the long-term effects on sustainability was not and typically could not

be measured. Thus, although the cross-sectional studies provided evidence on sustainability effects of inter-organizational collaboration, the long-term effects on sustainability remain unknown. The built-up of a longitudinal database may distinguish the stable from the transient effects on sustainability.

Second, we recommend further research to develop more objective measurements, still applicable to heterogeneous organizations, to reduce potential issues of embeddedness, and common method bias. This thesis has considered the perceptions of managers as representatives of their organizations (Chapter 4). The study, therefore, suffers for common method bias. Although perceptions impact decision-making processes to build inter-organizational ties, itself a justification of the measures used in this thesis, they cannot present the objective reality. Additionally, data regarding age, education, and experience of the interviewed managers have been considered less relevant to this study and have been neglected for the set tasks. The objective data concerning especially formal and informal ties and sustainability performance are typically insufficiently detailed, incomplete, not comparable, not accessible, or even non-existent. Although the perception based observations are common in studies on agro-industrial and eco-industrial parks (Chapter 2), further research should still try to develop objective and feasible measurement units, applicable to heterogeneous organizations, in order to reduce the potential issues of biases. Moreover, this thesis recommends future research to consider more quantitative measures of sustainability when studying inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular.

Fourth and final, when studying inter-organizational collaboration among co-located organizations in Chapter 4 and Chapter 5, all organizations that have at least one tie with other organizations at the location have been considered. Thus, the organizations that are co-located at agro-industrial parks for different reasons (for example, available land and cheap rent), but have no formal tie with other organizations – so-called isolates – have been excluded from the network analysis. Although these isolates do not take part in inter-organizational networks, they might have unrealized capacities to join and strengthen the networks in agro-industrial parks. Further research, therefore, is advised to include isolates in the study of more or less successful realization of inter-organizational networks in agro-industrial parks.

6.5. Policy and managerial implications

This thesis was grounded in the practical challenges of enhancing sustainability through inter-organizational networks. Considering the relevancy of the research, the implications of policy making and decision making processes at public and commercial organizations are presented in turn in the following sections.

6.5.1. Policy implications

Support inter-organizational collaboration in rural and underdeveloped regions: With regard to policy implications, the findings of this thesis first show that inter-organizational collaboration provides possibilities to enhance welfare, increase energy availability and security, as well as increase employment, meanwhile sustaining natural resource use, and promoting the escape from poverty, especially in emerging economies. Therefore, the support of sustainability-oriented developments can benefit from inter-organizational collaboration, especially in rural and underdeveloped regions (Chapter 2).

Large-scale capital investments upfront: The findings of the Chapters 2 and Chapter 3 show that the realization of sustainability-oriented inter-organizational collaboration is capital intensive due to the huge investments required, for the construction and maintenance of infrastructures for waste streams exchanges and utility sharing, such as the construction, operation and maintenance of large, joint installations (e.g., pipelines and biomass gasifiers). The capital required upfront is not always affordable for commercial companies alone, or merely at a high risk premium. Financial support by public authorities may be needed to break related deadlocks. However, the results presented in Chapter 3 and Chapter 5 accentuate that frequent and continuous interventions of public authorities, such as continuous subsidizing and funding collaboration related activities, can decrease the motivation of commercial organizations to explore innovative solutions. We suggest that public authorities mediate and pamper organizations leaning backwards, although no clear-cut evidence of it can be found in the data. Therefore, public policy makers are advised to support primarily inter-organizational collaboration in bio-based business in general, and in agro-industrial

parks in particular, by supporting the establishment of the necessary infrastructures and incidental investments, for example, to construct a biomass installation. Moreover, policy makers can speed up the realization processes by being, on the one hand cooperative in issuing necessary licenses and permissions for activities that are sustainability-oriented, while on the other, strictly impose anti-pollution policies. Finally, policy makers can increase the efficiency of policy making instruments, by enforcing stricter taxation for emission (Chapter 3).

Step aside from continuous intervention: Finally, the public authorities should decrease their intervention over the longer term and avoid taking a central position in inter-organizational networks (Chapter 5). By supporting inter-organizational collaboration and using relevant policy tools, without deep involvement in operations governmental organizations may promote environmental (especially renewable energy) goals, and strengthen their social mandate.

6.5.2. Managerial implications

Advance environmental performance via collaborations: With regard to managerial implications, the thesis first suggests that organizations seeking advanced environmental performance, such as reduced carbon and greenhouse gas emissions, next to less waste, are advised to build formal ties with other organizations in agro-industrial parks. As stated in Section 6.1, this thesis presents empirical evidence on the sustainability effects of inter-organizational collaboration in bio-based business in general, and in agro-industrial parks in particular. In a stimulating environment, organizations may thereby enhance their sustainability performance through collaborations. Evidence shows that organizations in collaborations can reduce their environmental footprint, reduce costs via reduced resource use, recover part of the costs for waste management and emissions, expand businesses via innovative solutions, and increase their corporate social responsibility.

Attention to inter-organizational collaboration in emerging economies: Results of this thesis indicate that inter-organizational collaboration has the potential to enhance environmental performance, such as the reduction of carbon and greenhouse gas emissions and waste.

However, the data indicate relatively more sustainability benefits in emerging economies, mainly due to positive social aspects. According to this finding, organizations may emphasize the social aspect, when pondering investing in emerging economies.

Awareness of capital intensity upfront: Managers should consider the capital intensity in building sustainability-oriented inter-organizational collaboration, be it in industrialized or in emerging economies. The capital intensity may slow down or restrict achieving the potential in collaborations, as happened in Dutch agro-industrial parks, where evidence on potential benefits is larger than suggested by the actual realization (Chapter 3, 4, and 5).

Build informal ties: The findings presented in Chapter 3 emphasize the importance of informal ties in establishing sustainability-oriented inter-organizational networks in agro-industrial parks. As defined in Chapter 3 and Chapter 4, informal ties are non-contractual focusing on information and knowledge exchange to enhance joint innovations among co-located organizations. Informal ties are useful for tacit knowledge transfer and for increasing trust levels between new partners, advancing opportunities, knowledge transfer, open innovation, and explicit information exchange. However, the empirical evidence in Chapter 4 shows that the informal ties among organizations in agro-industrial parks are sparse. The sparseness of informal ties can therefore be seen as a missed opportunity to exchange knowledge, information, and eventually to advance sustainability-oriented collaborations. To promote agro-industrial park realization and stimulate new business developments, especially the commercial organizations with central positions in networks of formal ties, are advised to strengthen their informal ties with other co-located, as well as with potential partner organizations helping them to build trust.

Positioning in the networks: Chapter 4 highlights that organizations can enhance their innovation performance, economic performance, and reputation, by positioning themselves in a way that the network provides access to other organizations via a small number of intermediary partners (i.e. high closeness centrality). Nevertheless, organizations should be aware of creating direct (inter-)dependencies and related risks. Therefore, the organizations are advised to build their formal ties in inter-organizational networks in a way that the dependencies are kept at a manageable level, while benefitting from the most efficient position to reach the necessary resources via a minimum number of intermediaries.

SUMMARY

The accumulation of diverse competences of organizations enables the tackling challenges that individual organizations are not capable of solving independently. Therefore, inter-organizational collaboration is considered as mechanism to enhance sustainability. Efforts in creating inter-organizational collaborations in bio-based business have led to the development of agro-industrial parks. Agro-industrial parks connect co-located heterogeneous organizations for waste streams exchanges and utility sharing.

Although inter-organizational collaborations suggest a promising potential to enhance sustainability, often the achieved sustainability performance in agro-industrial parks remains ambiguous. The full realization of inter-organizational collaborations towards more sustainable production is a long-term and challenging path that requires intensive, continuous interactions, and high investments. The challenges that heterogeneous stakeholders experience along the long-term realization of inter-organizational collaborations goes beyond the control of one individual stakeholder and becomes a network level challenge. However, the research on sustainability-effects of inter-organizational collaboration is not clear-cut and needs further investigation. Aiming to advance knowledge of how inter-organizational collaboration in bio-based business in general and in agro-industrial park in particular can enhance sustainability, this thesis answers the main research question:

MAIN RESEARCH QUESTION

In what way can inter-organizational collaboration in bio-based business in general and in agro-industrial parks in particular enhance sustainability?

Across four studies with different designs employing several theories and combining various methods, this thesis brings the concept of waste streams exchanges and utility sharing among co-located organizations in agro-industrial parks to a new field of analysis. In doing so, this thesis expands the existing studies on sustainability-oriented inter-organizational collaboration.

Sustainability Benefits and Challenges

Realization of inter-organizational collaboration in bio-based business is challenged by disputed use of bio-based resources. The available knowledge, however, is scattered and not systematically integrated for providing empirical evidence on sustainability outcomes achieved through inter-organizational collaboration in bio-based business. Chapter 2 of this thesis takes a broader view of inter-organizational collaboration across industrialized and emerging economies, and discusses effects on sustainability considering the three aspects: environmental, economic, and social. Since the demand to integrate available knowledge and to complete the entire puzzle of effects on sustainability through collaborations has been growing, the following research objective has been formulated.

RESEARCH OBJECTIVE 1. *To systematically integrate the scientific knowledge on sustainability benefits and challenges of inter-organizational collaboration in bio-based business.*

Taking a global view of inter-organizational collaboration, a systematic literature review was conducted to find, gather, and integrate the available knowledge. The screening of hundreds of articles collected from three major academic databases, i.e. Web of Science, Scopus, and EconLit, resulted in a final set of 24 articles that provided empirical evidence of both sustainability benefits and challenges found by other scholars.

Although the scholars do not refer to inter-organizational collaboration in bio-based business as a mechanism to mitigate all challenges of bio-based business directly, such as land use conflict and soil erosion, they highlight substantial sustainability benefits of collaborations, such as CO_2, greenhouse gas emissions and waste reduction, cost reduction, competitive advantage, enhanced innovation performance, energy supply security, and additional employment. The scholars that conducted their study in industrialized and emerging economies highlight rural empowerment, job and income generation, eventually leading to poverty prevention or reduction in emerging economies, and traffic congestion, decreasing recreational value, odor and noise nuisance in industrialized economies. Therefore, sustainability outcomes seemed to be more positively assessed in emerging economies than in indus-

trialized economies, although the investigated environmental benefits and challenges are relatively similar in the two economies.

Chapter 2 concludes that inter-organizational collaboration can provide a variety of sustainability benefits next to (region-)specific challenges. This conclusion strengthens pleas to pursue sustainability studies and develop political agendas on inter-organizational collaboration in bio-based business.

Opportunities for and Barriers to Agro-Industrial Park Realization

As a type of system innovation, agro-industrial park realization requires involvement of heterogeneous stakeholders that rely on trust and shared vision to build networks and achieve common sustainability goals. Unfortunately, the available literature often discusses collaborations either across supply chain partners or among relatively homogeneous organizations. Being aware of the potential and realized sustainability benefits an agro-industrial park can provide, there is a need for an improved understanding of the opportunities for and barriers to agro-industrial park realization. The need to adapt available theories and gain new insights in current agro-industrial park realization led to the following research objective.

RESEARCH OBJECTIVE 2. *To explore the opportunities for and barriers to agro-industrial park realization focusing on network structures and governance forms.*

Chapter 3 presents a narrative literature review and two focus group discussions with stakeholders engaged in agro-industrial parks launched and developed in the Netherlands. The results show that a large number of heterogeneous stakeholders seem to be essential to create opportunities for agro-industrial park realization. The density of informal ties among engaged stakeholders has potential to intensify information exchange for tacit knowledge transfer, and knowledge development for enhanced innovation. In contrast, the density of formal ties is perceived as barrier that increases interdependencies and accordingly the risk of failure. This perception keeps especially new organizations away from joining the network and developing the park. New organizations are often reluctant to build formal ties if high investments and a long-term commitment to previously unknown partners are required. Finally, small organizations generally meet difficulties with regards to administrative tasks in

inter-organizational collaboration, and often avoid collaborating with large organizations preventing additional dependencies. Instead, small organizations often prefer to delegate network administrative responsibilities to professional organizations. Accordingly, a brokered governance form is preferred to avoid administrative burden and maintain independency.

Network Structure in Sustainable Agro-industrial Parks

Realization of inter-organizational collaboration among co-located organizations, such as in agro-industrial parks developed in the Netherlands, is related to the sustainability performance of engaged organizations. Through collaborations, organizations construct inter-organizational networks and occupy a certain position within such networks. However, organizations in agro-industrial parks are often unaware of their network position and possible effects of network behavior on sustainability performance. It is expected that the sustainability performance of (organizations in) agro-industrial parks can be associated with the structural properties of inter-organizational networks. Although inter-organizational network structures and the sustainability performance of organizations in agro-industrial parks are frequently discussed in the literature, the relations between these two concepts have not so far been studied empirically that led to the following objective.

RESEARCH OBJECTIVE 3. *To explore the inter-organizational network structures in agro-industrial parks that can enhance sustainability performance.*

Chapter 4 presented three empirical case studies of agro-industrial parks from the Netherlands. Combining qualitative and quantitative methods, the research explored general characteristics of agro-industrial parks, and formal, informal, interdependency ties among 64 collaborating organizations. Additionally, the research explored the managers' perceptions of sustainability performance of the representing organizations.

The findings at network level emphasize that informal ties among organizations in the three agro-industrial parks are rather sparse, which contrasts with the findings in Chapter 3 that emphasize the importance of informal ties for information exchange, knowledge development, and innovation enhancement. The sparsity of informal ties in three studied agro-

industrial parks can therefore, be interpreted as a missed opportunity to achieve the necessary resources and knowledge through informal contacts. Meanwhile, the empirical evidence presented in Chapter 4 shows that formal ties are denser in decentralized networks, indicating the importance of well-balanced distribution of ties.

Inter-organizational collaboration enhances the environmental performance of a company in agro-industrial parks. However, environmental performance is strongly associated with interdependencies. It seems that organizations enhance their environmental performance through dense interdependent networks, and have to rely on others in enhancing sustainability.

Evolution and Structure of Inter-Organizational Networks in Agro-Industrial Parks

A better understanding of the evolution of inter-organizational collaboration is needed to explain network structures at a given point in time. However, the literature fails to explain how the evolution of inter-organizational collaborations can shape the network structure. The need to understand how event developments over time impact inter-organizational network structures at a given of point in time led to the following objective:

RESEARCH OBJECTIVE 4. *To investigate if the combined use of the structural and the evolutionary perspective can enrich the understanding of inter-organizational network structures in agro-industrial parks.*

Chapter 5 studies two agro-industrial parks launched and developed in the Netherlands. Data for the cross-sectional study were collected through semi-structured interviews with managers from 34 organizations from these two parks. It was complemented by data for the longitudinal study of about 17 years collected from secondary sources.

The findings show that the active engagement and frequent facilitation of public authorities seem to advance network centralization in Biopark Terneuzen. The active engagement of entrepreneurs and frequent new business developments from the start throughout the evolution of Agriport A7 seems to advance network decentralization. Moreover, the reverse is

as likely to be true: decentralized networks attract more businesses to collaborate than centralized networks regardless of the role of public authorities as anchor tenants.

Chapter 5 concludes that structural and evolutionary perspectives complement each other and bring deeper understanding of network structures by showing how the actions that evolve over time shape network structures and influence on network developments.

General Conclusions

Taking a critical approach to sustainability outcomes as result of inter-organizational collaborations among co-located heterogeneous organization, this thesis focuses on inter-organizational network structures, network governance forms, network evolution, and sustainability performance. Through designing a systematic review, cross-sectional, and longitudinal studies, and through combining qualitative and quantitative methods, the research has arrived at two general conclusions.

First, it has been concluded that inter-organizational collaboration among co-located heterogeneous organizations enhances the environmental aspect of sustainability. Whereas, the economic and social aspects of sustainability are more positively perceived in cases from emerging economies than in cases from industrialized economies, and less positively perceived in Dutch agro-industrial parks.

Second, it has been concluded that decentralized network structures indicating a well-balanced distribution of ties among organizations advance sustainability-oriented inter-organizational networks. Decentralized network structures also decrease the risk of being dependent on one (or a small group of organizations). The decentralized structures, therefore, can attract new business to collaborate in waste streams exchanges and utility sharing.

In summary, this thesis explores the additional sustainability potential of inter-organizational collaboration among co-located heterogeneous organizations in bio-based business in general, and in agro-industrial parks in particular. On the journey of finding sustainability-oriented inter-organizational network structures and network governance forms, the thesis provides evidence that inter-organizational networks induce sustainability benefits, especially to the environmental aspect of sustainability. Regarding network structural properties, a well-balanced distribution of formal ties encourages network development, mainly due to

the heterogeneity among co-located organizations. Regarding the network governance, the brokered governance form is recommended to promote collaboration of small- and medium-sized companies. Although sustainability benefits through inter-organizational collaborations cannot be considered self-evident, and new challenges should be recognized and dealt with, the evidence of sustainability benefits found in this thesis strengthens pleas to not only pursue studies on inter-organizational collaborations, but also to develop business strategies and political agendas that encourage sustainability-oriented inter-organizational collaboration in bio-based business in general, and in agro-industrial parks in particular.

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APPENDICES

Appendix A. Keywords and search strings

Keywords/search subsets		Search strings
Inter-organizational collaboration		Alliance*, Coalition*, Collaborati*, Cooperati*, Eco-industrial park*, Supply chain, Industrial symbiosis, Inter$firm, Inter$organi?ational, Inter$sector* relation*, Joint-venture*, Network*, Partnership*
Sustainability outcome	*Social*	Community, Corporate social responsibility, Education, Employee health, Employment, Human right*, Labo$r condition*, Poverty, Social, Wellbeing, Working condition*
	Environmental	Eco-efficien*, Biodiversity, Carbon, Climate change, Cradle-to-cradle, Ecological, Emission*, Global warming, Life cycle assessment, Pollution, Resource use, Waste
	Economic	Company performance, Competitive advantage, Corporate performance, Cost*, Economic, Financial, Innovation, Profit*, Revenue* Sustainab*, Triple-bottom-line
Bio-based domain		Alga*, Bio$based, Bio$diesel, Bio$economy, Bio$electricity, Bio$energy, Bio$ethanol, Bio$fuel*, Bio$gas, Bio$heat, Bio$mass, Bio$material*, Bio$park*, Bio$plastic*, Bio$refin*, Bio$region*, Bio$resource*, Bio$tech*

Appendix B: Inclusion criteria

Criteria	Argumentation for inclusion
Social Science Citation Index (SSCI)	To limit the scope of the research to relevant social mechanisms at play.
English language	To make the process universally replicable.
As of year 1990	The first publication containing word 'bio-based' is from year 1990.
Peer-review articles, review papers	To get a comprehensive overview of relevant mechanisms
Qualitative and quantitative empirical studies, case studies	To get a comprehensive overview of all relevant mechanisms
Search "collaboration" in title and "bio-based" in topics	To collect the studies on inter-organizational collaboration in the bio-based domain, assuming that articles dealing with these topics may report on the sustainability outcomes of collaboration efforts.

Appendix C: Exclusion criteria

Terms	_cell*, mobile, *oxid*, acid*, ad hoc network*, antenna, bandwidth, cataly*, DNA, equilibri*, ester, gene_, quantum, queu*, information system*, infra*, internet, IT, modif*, molecul*,multimedia, nano*, neural network*, neuro*, optic*, phone, polymer network*, polyurethane*, psych*, radio, react*, resist*, road network*, robotics, satellite, sensi*, senso*, software, switch*, television, transmi*, transport* network, video, wave, weight*, wireless.
Categories	public environmental occupational health, political science, anthropology, area studies, history philosophy of science, women's studies, psychology experimental, history of social sciences, psychology educational, history, agricultural economics policy, ethnic studies, cultural studies, philosophy, humanities multidisciplinary, agronomy.
Themes	Intra-organizational collaborations instead of inter-organizational collaborations, models without any empirical example, e.g., mixed-integer linear programming of supply chain optimization, bilateral relations of science and commercial R&D, roles of academics and policy makers, and career network dynamics, red bio-technology.

Appendix D: Questions of structural interviews

1. **General**

    1. Respondent name
    2. Respondent job title
    3. Name of the organization
    4. Organization main activity
    5. Total number of employees (fte)
    6. Organization exist since (year)
    7. Organization is active in the agro-industrial park since (year)

2. **Perceived performances on a [1–7] Likert scale:** 1 – Strongly disagree, 7 – Strongly agree

Since we participate in the collaboration...	
We became economically stronger	☐
The turnover of our organization has increased	☐
The profit has increased	☐
The sales have increased	☐
The product and/or service quality has improved	☐
We got new and innovative ideas	☐
The number of innovations has increased	☐
The reputation of our organization has improved	☐
The product or service capabilities have improved	☐
We became socially stronger	☐
The number of employees has increased	☐
The number of qualified workers has increased	☐
The environmental and health risks are decreased	☐
The odor nuisance and noise are decreased	☐
We have less waste and CO_2 and GHG emissions	☐
We use less energy and other resources	☐

3. **Perceived satisfaction on a [1–7] Likert scale:** 1 – Strongly disagree, 7 – Strongly agree

Overall, ...	
our collaborations with other organizations are productive	☐
we are satisfied with the collaboration of our organization with other organizations	☐

4. **Questions on network ties (yes/no)**

		Org.1	Org.2	Org.3	Etc.
	Formal ties				
1	We have signed formal contract with				
2	We exchange waste and by-products on a regular basis with				
3	We share resources (e.g. infrastructure, facilities, logistics, human) with				
4	We work together as a formal team with				
	Informal ties				
5	We work together, but have not established a formal agreement with				
6	We have social (informal) contacts, e.g. via e-mails or social network websites with				
7	We discuss new ideas, exchange information or advice with				
	Interdependency				
8	Our organization will experience negative effects (delay, reduction in the scope or quality) if these organizations delay, cancel, or significantly alter the agreements				
9	These organizations will experience negative effects if our organization (delay, cancel or significantly alter the agreements				

Appendix E: Network structure measures, related algorithms, and explanations at network and at organization level.

Measure	Algorithm	Explanation
Network level		
Centralization (Freeman, 1978)	$C = \frac{\sum_{i=1}^{n}[C^* - C_i]}{(n-2)(n-1)}$	C = centralization of entire network: percentage in the scale of [0;100] n = network size: $n > 2$ C_i = centrality of organization i: percentage in the scale of [0;100] C^* = largest value of centrality within the network: percentage in the scale of [0;100]
Density (Ahuja, 2000)	$D = \frac{N}{n * (n-1)}$	D = network density: percentage in the scale of [0;100] D = 0 if no ties exist D = 100 if all possible ties exist N = total number of connections n = network size
Organization level		
Degree centrality (Borgatti, 2005; Freeman, 1978)	$C_{\mathrm{D}i} = [1;\ n-1]$	$C_{\mathrm{D}i}$ = degree centrality of organization i n = network size
Normalized degree centrality (Borgatti, 2005)	$C_{\mathrm{D}i\mathrm{nrm}} = \frac{C_{\mathrm{D}}}{n-1}$	$C_{Di\mathrm{nrm}}$ = the normalized degree centrality of organization i, C_{D} = degree centrality n = network size
Betweenness centrality (Borgatti, 2005; Freeman, 1978)	$C_{\mathrm{B}i} = \sum_i \sum_j \frac{g_{kij}}{g_{kj}}$	i, j, k = organizations in the network; $i \neq j \neq k$ $C_{\mathrm{B}i}$ = the betweenness centrality of organization i g_{kj} = geodesic path (the shortest way) for k to reach j g_{kij} = number of geodesic paths between k and j through i
Closeness centrality (Borgatti, 2005)	$C_{ci} = \sum_j [g_{ij}]^{-1}$	C_{ci} = closeness centrality of organization i g_{ij} = geodesic path between i and j (the shortest way for i to reach j); $i \neq j$

Appendix F: Actions and event coding

1. Event name and coding

Event name	Coding *
Spatial planning and area development, laws and regulations	E1 or (E1)
Facilitation (subsidies, infrastructure services, research, permissions and licenses)	E2 or (E2)
New business development and acquisition (including new business establishment, moving, expansion)	E3 or (E3)
Operation and outcome (including results and activities)	E4 or (E4)

* (E1), (E2), (E3), (E4) were codes for negative actions.

2. Timeline Agriport A7

Year and actions	Event code
2003	
Negotiations among the province, municipality and an entrepreneur to establish a park on the available land at the northern part of the Province of North Holland started in 2003. Two driving factors played important role in these negotiations: (1) the need for sustainable agricultural production, and (2) the growing demand for horticultural areas in the Netherlands.	E1, E3
2004	
October 2004 the province of North Holland approved the new regional spatial plan regarding the northern region of the province. According to this plan, the region was made available to develop an agro-industrial park called Agriport A7.	E1, E2
The Platform Agrologistiek was established to facilitate, promote, and operate the pilot project with interested companies. The Platform Agrologistiek conducted a research on legal aspects of establishing an agro-industrial park.	E2
The tomato grower Van den Ende- Van Kleef bought 120 hectares land to build a new glasshouse in Agriport A7.	E3
2005	
A pepper grower horticultural company was established in around 60 hectares land in Wieringermeer by three entrepreneurs from Westland (a horticultural area in South Holland).	E3
The Agro-logistics center was opened. It provided space to the companies GAM Bakker, Hiemstra B.V. and Zon auction. Together they occupied 100 hectares in Business Park at Agriport A7.	E3
2006	
Five horticultural entrepreneurs established the Foundation Green Energy Central. Much organic waste was being produced by glasshouses in Agriport A7 and in the surrounding,	E3

including the wastes of livestock and regional diary production. The organic waste could be used to produce heat and electricity. A combined heat and power plant could reserve and deliver the energy preferably within the region. This could result in waste reduction, reduction of waste transportation, and production of clean energy. The Foundation developed a business plan together with HoSt to build a large scale bio-digester in Agriport A7.

The Foundation of Green Energy Central was taken over by a waste treatment organization called HVC.	E3
The pepper grower Wieringermeer, the tomato grower Van den Ende- Van Kleef and the development agency Agriport A7 established ECW, which produced energy via geothermal, heat and power system, and supplied heat, gas and electricity to the glasshouses.	E3
The large-scale glasshouses in combination with Business Park raised negative attitude at local population. Therefore, the development agency Agriport A7 and the local association De Buren agreed to inform each other about the developments at the location.	E2
The pepper grower Barendse from Poeldijk bough 45 hectares to build a glasshouse. They planned to start building 20 hectares in 2007, and the rest in 2009.	E3
The tomato growers Grootscholten and Kester bought 65 hectares plot in Wieringermeer.	E3
The brothers Berry and Ruud Helderman bought 29 hectares plot, on which they planned to build a glasshouse for growing pepper. The following year they would build the glasshouse on 23 hectare, and the rest was expected to be built in 2009.	E3
Two project developers bought a plot of six hectares at the entrance of Agriport A7 to build offices and administrative buildings, a gas station, a weigh bridge, a restaurant and an agricultural shop. The area was meant to rent or sell to interested companies.	E3
Van den Ende- Van Kleef, a mega grower at Agriport A7, joined the company Royal Pride from the grower group Action Pearl Growers.	E3
The logistics company Peter Appel Transport moved its main office to the business park in Agriport A7	E3

2007

Agriport 1 was successful and Agriport B.V., the project developer, asked permission to expand the area with almost 500 hectares for new greenhouses. At the end of 2007 the municipality de Wieringermeer agreed with the change and included it in the regional plan.	E1, E2
The municipality of Wieringermeer took an initiative to explore a suitable location to expand the agro-industrial park by 70 hectares. On the request of horticultural companies, it was decided to develop a new glasshouse location called Agriport 2.	E2
Red Harvest, Sweetpoint and CombiVliet were the first growers to settle at Agriport 2 to start with large-scale production of pepper and tomato.	E3
Agrocare built two glasshouses on 19 hectares in Wieringermeer	E3
The Royal Pride van den Ende van Kleef had its first harvest of tomatoes.	E4
The research conducted by Platform Agrologistiek concluded that the agro-industrial park Agriport A7 saved 256 000 driving kilometers, which is equivalent to 220 tons CO_2 per year.	E4
Agriport B.V. wins the price of the best entrepreneurship of North Holland in 2006.	E4
The development of Agriport A7 led to an increase of cargo transportation on the roads of Kop of North Holland. Therefore, the Province ordered a research to find alternative better solutions, although there was no traffic congestion yet.	E2

Simon Hiemstra was given a title of Knight of Oranje-Nassau. The title was given for being at the service for agricultural developments in Wieringermeer and for developing the Agriport.	E4
The tomato grower Royal Pride van den Ende van Kleef confirmed that a pepino mosaic virus was spread on about 30 hectares of tomatoes. They had to remove the sick plants and replace them with new ones.	(E4)
The negotiations started with NS to open a bus line to Agriport.	E2
Smit Constructie B.V. and B&S Watering Systems B.V. were rejected to settle in Agriport A7, because according to the municipality, their activity did not fit to the local spatial plan.	(E2), (E3)
Since the two horticultural productions in Agriport A7 had started, the unemployment in Wieringermeer had decreased by 24.8 %. About 500 people were working at the location of Agriport A7.	E4
Two plant growers from Westland bought 10 hectares in Wieringermeer. They did not decide about the production yet, but they considered the acquisition as an investment for the future.	E3
The growers in Agriport A7 required a license for cooling and heating installation.	E2
The new energy transformer ECW was opened, which was jointly owned by the growers at Agriport A7. ECW would provide energy via CHP to 200 000 households in the North Holland. The heat and CO_2 of the CHP was being used in glasshouses.	E2, E3
The expansion of Agriport 2 was sped up, because the first part of the project was realized and all the plots were sold. Agriport was considered economically successful.	E4
The city council of Wieringermeer approved the permit of starting the second part of Agriport in 2009, which offered 555 hectares land for glasshouses. The second part had 145 hectares available on which no glasshouses were allowed to build.	E2
Agriport A7 had non-contractual relation with Wageningen UR. They offered a location to Wageningen UR to build a knowledge center.	E3
A residential unit for 2 000 employers was built in Agriport A7.	E2
The neighborhood of Agriport A7 were increasingly worried about light and noise nuisance, traffic congestion, employment, housing, and water management that was happening in the large agro-industrial park on the polder. They raised their concerns about life quality and health concerns regarding the expansion of Agriport.	(E2)
The tomato grower Van Kester-Grootscholten had the first harvest, and the company got a new name Kesgro.	E4

2008

The municipality Wieringermeer received 1.35 million Euros for the maintenance at Agriport A7, such as the maintenance of the roads, bridges, and sewage system.	E2
Agriport A7 had an appointment with the community in the vicinity and with the Milleudefentie North Holland to use artificial light at certain time of the day in certain period of the year. However, Agriport A7 was looking for more opportunities to reduce the time of artificial lightening, which gave light nuisance. The growers had to invest in dark screens.	E2
The growers could not release the whole electricity they produced. The electricity sent to network via CHP was rejected, because the capacity of the net was not large enough. The growers at Agriport A7 were worried and sent their worries to the Ministry requiring an expansion of grid capacity.	(E2)

Anton Hiemstra was announced as the best logistic manager of the Netherlands.	E4
A new bus line was being built to Agriport.	E2
ECW made contract with Westland energy service, which would deliver 100 million cubic meters gas to the horticultural growers.	E2, E3
Barendse had the first harvest of orange peppers.	E4
A Glasshouse course was opened for the young employers to prepare them for the practice.	E2
Agriport A7 calculated 30 % less transportation use.	E4
The logistic company Peter Appel moved to Agriport A7.	E3
The waste water from local glasshouses was larger than it was predicted. The local waste treatment system did not have the capacity to process the whole waste water. Therefore, the municipality invested about 150 000 Euros to transport the waste water to another water treatment plan.	(E2)
The Agriport A7 was not connected to waste water system, which created a waste water crisis. The councilor of Wieringermeer resigned, because he failed to solve the issue on time. At that moment the community had to invest about 850 000 Euros for the transport of waste water.	(E2)
New roads were being built to connect the glasshouses with other local roads.	E2
The tomato grower Royal Pride got two 24 cylinder gas engine, which would expand the capacity of electrical power by 35 MW, which was enough to meet the demand of 40 000 households.	E3
LTO North and the Province of North Holland wanted to initiate the fish farm in Agriport A7.	E3
The new transformer station at Agriport A7 was released. This increased the capacity of electricity realization by 80 MW reaching to 200 MW in total.	E2
The permits were given to two new companies, which would be settled on the expanded area of Agriport A7. One of these companies was Sweetpoint established by four horticultural entrepreneurs. Sweetpoint would grow special sweet pepper on about 30 hectares plot. The first 12-14 hectares glasshouses would be built by the end of the year. The second company was the Red Harvest. They would build glasshouses on the 16 hectare.	E2, E3
Peter Appel opened its main office in September in Middenmeer, Agriport A7.	E3
Royal Pride Holland was chosen as the agricultural entrepreneur of the year 2008. The company won 12.500 Euros, which was sent to different charity funds.	E4
The ICT service provider Parthenon signed a contract with Agriport A7 to build a data center on two hectares land at Business Park in Agriport A7. According to the plans, there would be build a large hall full of computers. The waste heat from the computers should have been used in glasshouses, whereas, the glasshouses would deliver electricity via ECW to the ICT company.	E3
The pepper grower Barendse together with his brother wanted to invest in building a new glasshouse on the 18.5 hectares in Agriport A7. The finance would be received from Rabobank. The bank, nevertheless, became very careful and delayed the finance. According to the Rabobank, the risk of new horticultural business was high because of financial crisis.	(E3)
In November, Agriport A7 was officially opened by the mayor and the council of the community and by the commercial manager.	E4

2009	
The province rejected the plans of building a large-scale livestock farm in Agriport A7.	(E2)
Agrocare built one new glasshouse on 9.5 hectares in Wieringermeer.	E3
The municipality had to build a pumping system of waste water. The costs were 1.3 million Euros.	E2
Palletcentral B.V. started to build a new branch in Agriport A7. The company bought about two hectares land next to the Peter Appel.	E3
An arboricultural company Peter Mul Boomverzorging bought a land of 3 000 square meters in Agriport A7.	E3
The province of North Holland and EU granted an innovative project to develop robots that pick up the vegetable harvest. The pilot project was run by quest Innovations and Wageningen UR in Agriport A7.	E2
Panthenon Data Center and Royal Haskoning signed a contract to realize the large data center.	E3
Kesgro had 20 million kilogram tomatoes harvest per year.	E4
The Green Energy Central wanted to continue building biomass digester in Agriport A7.	E3
Yvette Hiemstra, the owner, opened the doors of the restaurant and lunchroom called De Tafel van Agriport.	E3
The expansion of Agriport A7 appeared in a difficult financial situation because of crisis. The further expansion could not even become a discussion point. Even more, the project developers and the community were hesitant about the financial health of the whole park. Therefore, many actions had been delayed and new spatial plan was developed.	(E3), (E4)
Agriport 2 was announced economically infeasible.	(E3)
The unemployment in Wieringermeer has dropped by 16% within a year.	E4
2010	
The regional spatial plan was revised, because Agriport appeared in economically difficult situation. According to changes, the companies outside horticultural sector could be located in Agriport A7.	E1, E2
Poelierbedrijf van der Laan started the construction in Agriport A7.	E3
Shell started building a gas station.	E3
An investment bureau IB Volkers bought a plot of one thousand square meters and settled in the business park of Agriport A7.	E3
Red harvest had its first harvest in the spring.	E4
The animal feed company Elsenga and Kieft moved to Agriport A7.	E3
The gas station of Shell was opened.	E4
Horticultural companies wanted to use the CO_2 of household waste processing company HVC in Alkmaar. The pipeline of 35 kilometers was needed to transport the 60 000 ton CO_2 per year. The exchange system could start as of 2013, whereas the building of pipeline was planned in 2012 and would cost 45 million Euros.	E2
Petra Barendse opened a company called “Visit the Agriport”. She offered guided tours to	E3

students, companies and families.	
The establishment of the second database was uncertain. The interested parties delayed their plans because of economic situation.	(E3)
CombiVliet, a biggest horticultural company from South Holland bought 125 hectares land in Agriport A7. The company planned to build glasshouses to grow tomatoes.	E3
2011	
By having 39 million Euros turnover, AgroCare was the largest tomato grower of the Netherlands. Agrocare provided 150 new jobs.	E4
Agrocare built one new glasshouse on 9.5 hectares in Wieringermeer, where it had 65 hectares plot in total.	E3
Agrocare received the price of being best agricultural entrepreneur of the year.	E4
The biomass digester was built five meters higher than it was allowed in the spatial plan.	(E2)
The construction of greenhouses for CombiVliet started.	E3
About 800 people were employed in the glasshouses at Agriport A7.	E4
The poultry company of the family Weel should move to another location to make space for glasshouses at Agriport A7.	E2
A CHP with a capacity of 150MW was installed.	E3
The Poeliersbedrijf van der Laan B.V. moved to Middenmeer. There, the company supplied chicken to retail, wholesale, butchering, and catering customers.	E3
The logistic company Transportbedrijf Schrooder V.O.F bought a plot in Middenmeer.	E3
Transportbedrijf Schrooder V.O.F built a property together with J.Hesp and Zonen. The joint construction would enable better utilization of the plot and reduce the construction costs.	E3
The community Wieringermeer gave permission to build barracks for about 960 foreign workers at Agriport A7.	E2
AgroCare had hundreds of thousands of loss because of the forbidden export to Germany because of EHAC bacteria. A few weeks later the export was again possible.	(E4)
Russia closed the market for European growers. The horticultural growers in Agriport A7 also faced the sale problems of the fresh vegetables.	(E4)
The Dutch Parliament recognized the region North Holland North as Greenport, which put the region under the top-sector policy.	E1
CombiVliet had the first harvest of tomatoes.	E4
The Polish hotel was definite forbidden because of critiques of community and the growers.	(E2)
2012	
The tomato growers made a loss of few million euros because of the storm.	(E4)
CombiVliet continued building of glasshouses. They planned to build 12 hectares per year until about 120 hectares was full of glasshouses.	E3
ECW had all permits for geothermal energy for all local companies at Agriport A7.	E2
The transport of CO_2 from household-waste processing company in Alkmaar into Agriport A7 via a 30 km pipeline was very expensive.	(E2)

The data center delayed its settlement again because of high costs.	(E3)
Agriport was the number four employer in the province.	E4
Parthenon Data center canceled its agreement with Agriport A7.	(E3)
Instead, a new Datahouse offered a new collaboration. The Datahouse run a research together with the province to find if the IT system of the three large communities could be served from the new location.	E3
Barendse opened a shop, in which fresh products from the glasshouse were sold.	E3
The building of a track wash center started.	E3
A cacao factory was being established in Agriport A7. The company called Dutch Crown Cacao bought a plot of about 2 100 square meters, and started building the factory. The company processed the cacao beans and produced cacao butter and cacao powder for food industries.	E3
The cacao factory invested in the modern techniques to minimalize the fire risks, the odor and noise nuisance. The factory planned to process 10 000 tons of cacao beans of fair trade. It was expected that the waste and by-product of cacao processing would be used for feed and for biodiesel.	E3
Cacao factory needed about 30 employees, and contacted the inter-municipal social service to get new employers.	E2
The company Cablon Assembly moved to Agriport. The company brought the seven employers to the new location.	E3
The project of building windmills at Agriport A7 was definitely canceled.	(E3)
The company Royal Pride was satisfied with its business of large scale (51 hectares glasshouses), on which 27 million kg tomatoes were produced. The company decided to expand the production by extra 7.1 hectare, which would deliver 35 new jobs.	E3, E4
Agriport A7 had in total 930 hectare. Although most of the plots were sold, about 150 hectares were still available for sale.	E3
The plans for geothermal heat were approved by the community.	E2
New drilling installations were replaced by the Agriport A7. ECW Geothermal Management and Agriport Warmte VOF wanted to gain hot water from about 2 300 meters.	E3
2013	
The Track Wash Agriport was opened, which was modern and large enough to wash tracks of about 25 meters.	E3
The construction of cacao factory was finished. The factory would start with the first trial production soon after.	E3, E4
ZON fruit and vegetables auction decided to stop the logistics activities in Wieringermeer. The main reasons given were reorganization and cost savings.	(E3), (E4)
CombiVliet expanded the glasshouses by another 12 hectare. It was expected that the expansion would deliver about fifty extra jobs. CombiVliet invested about five million Euros for the new constructions. At that time, the company was producing 21.6 million kg tomatoes per year.	E3, E4
The drilling installation for the geothermal heat was ready. The horticultural companies collaborated in this project with expectation to reduce gas consumption by 15%.	E3, E4

The logistic company BNT would build a warehouse of 7 000 square meters, and two 650 square meters office, despite the critiques that the company did not completely fit to the spatial plan.	E3
The wallpaper company Graham and Brown from Horn was rejected to get an area at Agriport A7. The project developers were, however, not happy with this decision. According to them, the spatial plan allowed a wholesale of construction products, which is Graham and Brown were planned to execute. The municipality, despite the critique, did not change the decision.	(E2), (E3)
In July, Agriport A7 had still 53 hectares unused land.	(E4), E4
The drilling for the geothermal heat was officially started.	E2, E3
The first phase of drillings for geothermal water gave the first findings. The water was 2 500 meters deep at 98 Celsius degree. The second phase of drilling followed just after the first.	E3
In September the wallpaper wholesale company was allowed to move to Agriport A7. The misunderstanding was solved and Hiemstra signed a rent contract of 6 500 square meters with the company.	E2, E3
Biogas Agriport B.V. would exploit a bio-digester which would use the waste of glasshouses. The realization of it would cost 4.2 million Euros. The Biogas started with processing 60 000 ton organic waste, and would increase the amount up till 180 000 ton per year.	E3
The company De Lier specialized in gaining geothermal heat started to build a heat network around the glasshouses.	E3
The establishment of datacenter was announced. In 2014, Microsoft would invest two billion Euros in the datacenter including related infrastructures at around 40 hectare.	E3
The storm gave enormous damage to newly built glasshouses.	(E4)
In November, the cacao factory officially opened its doors. The factory would precede 9 000 ton cacao beans.	E3, E4
The excursion company "Visit Agropark" had guided remarkable visitors in Agropark. In 2013 the number of visitors was 3 500 people, including people from the neighborhood, families, group of friends, pupils and students, representatives of the local, regional and national authorities, and guests from foreign countries, such as from South Korea and Japan.	E4

3. Timeline Biopark Terneuzen

Year and actions	Event code
1997	
Ports of Vlissingen and Terneuzen merged under the name of Zeeland seaports that was the main initiator of Biopark Terneuzen.	E1, E3
Zeeland Seaports conducted different researches to find collaboration possibilities among local organizations. One of the first attempts was a study to operate the industrial area Mosselbanken together with Dow, Delta and the province of Zeeland.	E2

Zeeland seaports received three million gulden (Dutch currency before Euro) subsidy from the government to build container terminal at the port.	E2
1999	
The Province of Zeeland gave two million gulden subsidy to Zeeland seaports to build container terminal in Terneuzen.	E2
The management of the terminal was taken by two companies: Verbrugge Terminals and Katoennatie.	E2
Heros Sluiskil, a recycling company in Sluiskil, took over the Cokefabric.	E3
The ports of Zeeland had a transshipment of 26.1 million ton, which was counted for 3% growth	E4
2000	
The building of container terminal was completed. The harbor of Terneuzen became a part of the container terminal. The container terminal was jointly owned by the Zeeland seaports, the logistics company Katoenatie and the chemical company Dow.	E2
Heros Sluiskil used its territory for water treatment.	E2
In the year of 2000, the government of the Netherlands decided to expand possibilities for agribusiness in the province of Zeeland.	E1
The province of Zeeland runs a study on feasibility of horticultural companies at the location.	E2
2001	
Dow signed an agreement with Delta Nutsbedrijven and Zeeland Seaports to build chemical infrastructure at the Mosselbanken, a Dutch chemical industry park. Each partner would invest 46 million U.S. dollars at around 140 hectares site.	E1, E3
Municipality Terneuzen run a study on the feasibility of greenhouse production at the location.	E2
2002	
Zeeland Seaports and Dow Benelux signed a contract of collaboration in the Valuepark, which was a combination of Mosselbanken and the logistic park.	E1, E3
Dow expected cost reduction and environmental benefits by combining the chemical and logistics parks.	E4
2003	
Alcohol producer Nedalco built an alcohol factory in Sas van Gent. Costs were about 30-40 million Euros.	E3
The new Nedalco factory was expected to deliver 10 direct new jobs and had a capacity of 40 million litter alcohol production per year.	E4
Nedalco planned to use the by-products of Cerestar (a daughter company of Cargill) that was one of the world's leading starch and starch derivatives companies.	E3, E4
Zeeland Seaports signed a contract with a German company Alpha Calcit about the establishment in Sluiskil. Alpha Calcit was a processing company of white industrial minerals for paper, plastic and cosmetics industries.	E3

The company was settled in three hectares area and would deliver 30 new direct jobs.	E3, E4
2004	
The Valuepark was expanded and a new railway was connected to the area. The costs of the railway were covered by the Valuepark.	E1, E2
The construction of a new jetty in Braakmanhaven (area between the Mosselen and the Dow Benelux) was started, which costed around eight million Euros.	E2
The research on establishing horticultural companies in the Canal-Zone arrived to the conclusions. According to the conclusions, the Smidschorrepolder, Koegorspolder and Autrichepolder were ideal for horticultural companies. The establishment of greenhouses on about 300 hectares could deliver 1 500 new jobs, half of which seasonal.	E2, E3
The construction of jetty of 28 tanks was completed and was used by Oil Tanking Gent.	E2, E4
The new container terminal was realized that could process 20 000 containers per year.	E2, E4
The new railway realized by a Swiss company that drove one to two trains per day to the Valuepark.	E2, E4
The Zeeland seaports had profit of 6.4 million Euros in 2004, which was 8.5% more than in 2003.	E4
The Seaports invested 28.8 million Euros in harbor development, infrastructure, and spatial activities to meet the demand of new business establishment.	E2
2005	
The road between Yara and Heros was closed because of the safety issues.	(E2)
Oil Tanking settled at the Valuepark in Braakmanhaven and delivers the products to Dow Benelux. Oil Tanking had 24 storage tanks with the capacity of 156 000 cubic meters.	E3, E4
Collaboration between Dow and Oil Tanks would save hundreds of shipping movements per year, which were counted as economic and environmental benefits.	E4
A new biogas plant under the name Biocups B.V. was planned to establish at the area next to reserved horticultural areas. The plant should have used the biomass of agricultural crops and other biodegradables. The biogas plant could deliver seven million Kw-hours electricity for the use of 2 200 households and organic fertilizers for agricultural use.	E3
Zeeland Seaports had 0.2 million Euros less profit in comparison with 2004. The decrease in profit was explained with the collaboration with the port of Rotterdam, with the loss in Valuepark Terneuzen, and with the less sell of the land to new companies.	(E4)
The sludge storage in the Terneuzen was stopped. The government provided 1.2 million Euros to Terneuzen as compensation for the costs made for sludge storage. This compensation went under the condition to reconstruct part of the Koegorspolder to make space for windmills, horticulture and recycling companies.	E2, (E4)
2006	
The province of Zeeland, the Water Board Rijkswaterstaat, municipality of Terneuzen, Dow and Zeeland Seaports agreed on building new roads of emergency around Valuepark.	E2
Transforum Project Biopark Terneuzen started.	E2

2007	
Valuepark Terneuzen opened the doors for a Spanish biodiesel factory called Biofueling. The investments were 45 million Euros. The new Biodiesel would provide about 30 new jobs. The production capacity was 200 000 ton biodiesel. The biodiesel would be produced from vegetable oil and bio-ethanol.	E3
The official opening of Biopark Terneuzen took place. The main partners were Zeeland Seaports, Nedalco, Cargill, EcoService Europe B.V., Heros, Rosendaal Energy, Valuepark Terneuzen, Yara, City council Terneuzen, and Province of Zeeland. Next to the biodiesel factory, a new center of biomass processing was being established to use and reuse the waste streams of agricultural and food production.	E2
On the location new waste water treatment system would be established and horticultural companies would be settled at about 250 hectare.	E3
Nedalco was considered sustainable, because it produced biofuels from bio-ethanol, which was not competing with food production. Additionally, it provided 65 new jobs.	E4
The control and inspection center of Societe Generale Surveillance (SGS Oil, Gas Chemical services) opened a new laboratory in the Vluepark. SGS would mainly run research for Dow Benelux and Oil Tanking.	E3
The establishment of SGS laboratory at the location would fasten the analysis processes. The Laboratory provided 10 new jobs.	E4
Rosendaal Energy started to build a biodiesel factory in Sluiskil. The factory had capacity of 280 million liters biodiesel. Rosendaal energy provided 25 new jobs.	E3, E4
Yara invested few hundred thousand Euros for the modernization of the factory.	E4
The British ESV Group invested 85 million Euros to establish a tank terminal for vegetable oil in Terneuzen. This company delivered 35 new jobs. The capacity of the terminal was 184 000 cubic meter.	E2, E3
2008	
The construction of Nedalco was being delayed. The feasibility of a new Nedalco factory was very low. The factory needed 150 million Euros investment, 40 million of which was expected to be subsidized by the Dutch government. The government was, however, unsure about subsidizing the second generation biodiesel factory and did not want to give more than 11.6 million Euros subsidy. Additionally, the prices of wheat, corn and other resources were so high that it was not profitable to run the bio-production.	(E3), (E4)
One Dutch and three Flemish growers signed a contract with the municipality and Zeeland Seaports to buy 80 hectares land and establish horticultural production. The growers also signed a contract with WarmCO_2, which would deliver heat and CO_2 to glasshouses.	E3
De Feijtergroep, a road construction and hydraulic engineering company signed a contract to buy about three hectares lands and move to the Biopark in 2009. On the location the Group was building an office and a huge workplace. It was expected that the Group would deliver 100 new jobs.	E3
The economy of the Province Zeeland was growing very slow, only by 2.4%, placing the Province on the latest position amongst other provinces of the Netherlands. The province was, however, convinced that the expected investments would boost the provincial economy the following years.	(E4)
The project Bio-Base Europe, which was a partnership between University of Gent, Wa-	E2

geningen University, Ghent Bio-Energy Valley, and Biopark Terneuzen, received six million Euros subsidies from the Europe. Bio-Base was focused on the second and third generation bio-products.

2009	
The growth of Biopark was slow because of the economic crisis, law oil prices, and investment fear in biomass and biofuel production. The ethanol factory Nedalco had eventually stopped the constructions and moved from Sas van Gent. The planned biomass central of Ecoservise Europe, which already had the licenses, was not yet established. The biodiesel factory ESV group and Biofueling were not functional yet.	(E3)
The Rosendaal energy in Sluiskil had production, but appeared in a difficult situation.	(E4)
The only action within Biopark Terneuzen project that was successfully realized, was the Westdorp glasshouse complex.	E3, E4
The family company Van Duijn started building an eggplant glasshouse in around five hectares.	E3
The family Reedijk bought 20 hectares and started building glasshouses for pepper production.	E3
The Flemish grower Tomaholic bought 10 hectares to build a glasshouse for tomato production	E3
Because of the financial crisis many other growers delayed their investments in Biopark.	(E3)
WarmCO_2, which was a joint venture between Yara, Zeeland seaports, and Visser and Smits Hannab, was established.	E3
Zeeland Seaports invested 65 million Euros in WARMCO_2.	E2
The glasshouses were less than a kilometer further from Yara, a factory that would deliver waste heat and CO_2. WarmCO_2 built a buffer of 200 cubic per hectare to reserve the waste heat and CO_2.	E2
The heat web of Biopark was released. Starting from December, the glasshouses received the waste heat and CO_2.	E4
The BioGlas (later renamed Greenhouse Project Zeeuwse Vlanderen) was established.	E3
The information and education center for glasshouse companies was opened.	E2, E3
The Maintenance Valuepark Terneuzen was opened, which was a joint venture between Zeeland Seaports and Dow Benelux. Maintenance Park was an industrial district aimed at stimulating innovation and collaboration in maintenance sector, which was meant to provide service to process industries.	E3
2010	
Rosendaal Energy went bankrupt.	(E4)
Lijnco Green Energy started building the Biomass Central at the area of Heros Sluiskil. Biomass Central was expected to become the largest in the Netherlands. The capacity was 135000 tone biomass to produce 8 MWe clean electricity. It offered new jobs to 10 people.	E3
A training center for Bio-Base Europe was opened in Terneuzen. The center would have been operational a year later and would train process operators, maintenance technicians and other technical specialists to prepare them for working in bio-based companies.	E2

2011	
Economic Impuls Zeeland, a local development company, received 50 000 Euros from the province to invest in Foodport, which was a project to stimulate innovation and collaboration among food production companies.	E2
A second biomass plant would be built at Heros Sluiskil by a consultancy and engineering company called Taken. The investments were 17.5 million Euros. A contract with Heros was signed and a subsidy of 47.5 million Euros from the government was confirmed. The biomass plant would be ready to operate in 2014.	E3
English company Goes on Green acquired the biodiesel factory (previously known as Rosendaal Energy). Although this company improved the biodiesel factory, it was not able to start the biodiesel production.	(E3)
2012	
The German company Remex Benelux GmbH took over the Heros Sluiskil. The German company operated in the same market as Heros. The name of the company and the workers remained unchanged.	E3
Electrawinds, a Belgian company acquired and restarted the biodiesel factory of Roosendaal Energy.	E3
The Province made six million Euros available for innovation, project development, and support to implementation of plans at Canal Zone.	E2
2013	
Bio-Base Europe decided to collaborate with German Nova institute, which helped companies use more renewable resources.	E2
Province of Zeeland, Zeeland Seaports, Dow and Delta collaborated with Municipality Borssele to converse the coal power plant into a biomass plant.	E3
The proposal of Delta did not yet meet the subsidy criteria.	(E2)
An Indonesian palm oil producer Musin Mas prepared to exchange resources with Dow Benelux which could support the industry of soap and shampoo. Musim Mas planned to invest 30 million Euros in the new factory.	E3
Yara received a subsidy of 295 000 Euros to build a water treatment system, in which the water would be filtered by algae. The pilot would run two years and provide opportunities to other local industrial companies.	E2
Artenis, a provider of industrial service, such as rental of industrial tools, decided to build a branch in Terneuzen.	E3
Maintenance Value Park was opened, in which huge investments were planned to connect knowledge, innovation and production.	E3
The crisis did not have negative impact on Heros. Even more, the interest towards the waste use has increased, which increased the production in waste treatment and their granules, the delivery of which was allowed by KOMO certificate.	E4
WarmCO_2 project made large losses, which costed about 65 million Euros to the Zeeland Seaports.	(E4)
The horticultural grower Adrichem bought nine hectares and started to build a glasshouse for tomato production.	E3

ABOUT THE AUTHOR

Gohar Nuhoff-Isakhanyan was born on 14 May, 1980, in Armash-Ararat, Armenia. She completed college in 1997 with honor. Following her desire towards higher education, she moved to Yerevan, the capital of Armenia. Despite her passion for Beta sciences (especially physics, chemistry, and mathematics), she went to the University of Economics, which she graduated from with Cum Laude. The interest she developed regarding transition economies from the authoritarian Soviet-regime towards the democratic sovereign system drove her career to the Government of Armenia. After five years of work as policy advisor, she went back to science to explore suitable models of sustainable development. At the same time, she won a grant to study at Wageningen University, the Netherlands, where she successfully accomplished a Masters study in Management, Economics, and Consumer Studies. There, she got acquainted with agro-industrial park projects that, together with sustainability-oriented developments, provided inspiration for further research. In 2010, she carried out a short-term research project for InnovationNetwork the Netherlands, on Marine Park projects, and meanwhile joined the Management Studies group, first as a student assistant, then, in 2011, as a PhD candidate financed by EU-Interreg IV-B NWE ARBOR project. She presented her research in many national and international conferences and meetings, supervised master students with their theses, and gave guest lectures about sustainability-oriented collaborations in bio-based business. In 2015 she was awarded as the best reviewer by the Organization Behavior Division, Academy of Management. In addition, she has been a member of the PhD council at Wageningen School of Social Sciences (WASS), at Wageningen Graduate School (WGS), and WASS Committee of Scientific Integrity. Her passion is in protecting the planet for future generations by increasing the corporate interests in sustainability-oriented actions.

TRAINING AND SUPERVISION PLAN

Gohar Nuhoff-Isakhanyan
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Writing the PhD Proposal	WASS	2011	6
Qualitative data analysis: procedures and strategies, YRM 60806	WUR	2011	6
Introductory social network analysis	University of Southern Denmark	2011	5
Sustainable Enterprise: emerging theory and practice	WASS	2011	0.5
Project meetings	ARBOR	2011, 2012, 2014, 2015	1
B) General research related competences			
Introduction course	WASS	2011	1
Methodology seminars: a practical course on the methodology of fieldwork	CERES	2011	2
Techniques for writing and presenting a scientific paper	WGS	2011	1.2
Scientific Publishing	WGS	2012	0.3
"Stakeholder and network analysis of Synergy Parks"	1st Academy of Business in Society Summer School, Lüneburg, Germany	2013	1
"Social Network Analysis of Synergy Parks"	PREBEM, 13th conference: Roadmap to the Future, Amsterdam Business School	2013	0.5
Systematic literature review	WASS	2013	2
"Network Structure to Realize Synergy Parks"	11th Wageningen International Conference on Chain and Network Management	2014	0.5
Scientific writing	WGS	2014	1.8
International conference - Global Cleaner Production & Sustainable Consumption Conference	Elsevier, Journal of Cleaner Production, Barcelona, Spain	2015	1
"Sustainability benefits and challenges of inter-organizational collaborations in agro-industrial parks"	International Conference Food in the Biobased Economy, Wageningen UR	2015	1
"Inter-organizational network for sustainability in agro-industrial parks"			
ARBOR NWE: Lessons learned	ARBOR NWE	2015	0.5
C) Career related competences/personal development			
Teaching and supervising thesis students	DO, Wageningen UR	2011	1
Teaching assistance, course Advanced management and marketing	MST21306	2012, 2013	2
Member WASS PhD council, Member WGS PhD Council	WASS	2012-2014	2
Total			**37.3**

*One credit according to ECTS is on average equivalent to 28 hours of study load

The research described in this thesis was financially supported by the ERDF-grant, via the EU-Interreg IV-B NWE project ARBOR. The statements made in this thesis are the sole responsibility of the author.

The cover page picture of this thesis expresses the Diversity and Oneness, an artwork drawn by Ms. Mikako Saga. Source: http://www.cleanerproductionconference.com/creativity-and-sustainability-forum.asp .