High-tech urban farming
a business model to enable breakthrough development

Berkel, B.E.

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High-Tech Urban Farming: A Business Model to Enable Breakthrough Development

by
B.E. Berkel

Science & Innovation Management
Student identity number: 0752378

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Supervisors:
dr. U. Konus, TU/e, ITEM
dr. Ir. W. (Michel) van der Borgh, TU/e, ITEM
A.C.G. Bekker, Siemens Nederland N.V.

University: Eindhoven University of Technology
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Abstract

Due to global climate changes and the accompanied threats on agriculture, high-tech urban farming had been increasingly mentioned as a sustainable solution for food security. However, the development of urban farming stagnates due to questions around value creation and value capture. A compelling business model is required to break this vicious circle.

This master thesis presents the research in the development of a business model for urban farming. A conceptual model is applied in which the customer value proposition, the key resources, the key processes and the profit formula are amalgamated. The business model is extended with collaborative elements to include an open innovation approach towards this venture. Subsequently, a scenario analysis was performed to alight future opportunities.

The collected data includes semi-structured interviews with 15 experts from commercial organizations, academic institutions and governmental organizations and economic data. The analysis of this data indicates the presence of numerous impediments and a lack of social acceptance towards this type of farming.

Key elements of the business model include the combination of products, the location and the necessity to include numerous stakeholders. Also, collaborative elements are desirable due to the fact that urban farming is still very much in a development phase. Finally, national opportunities will emerge in a niche market and international opportunities allow for a more large-scale production in the future. Implications are that collaboration with the customer should be considered in the developmental phase of urban farming and the developing private grow systems could be a business opportunity.
Acknowledgements

This master thesis and the corresponding research are the final part of the master program ‘Innovation Management’ which was conducted at the faculty ‘Industrial Engineering & Innovation Sciences’ at Eindhoven University of Technology. This document also marks milestone in my academic education that started with the bachelor ‘Science & Innovation Management’ at Utrecht University and via an adapted pre-master program allowed me to participate in this highly regarded master.

The research and write up of this thesis, in which a business model for high-tech urban farming was examined, was commissioned by the technology company Siemens at their Dutch headquarters in The Hague. By combining a part of my education trajectory with an internship, I had the opportunity to get acquainted with the daily activities of a multinational commercial organization. This internship did confirm my ambitions to become part of an organization like Siemens in the near future.

Looking back at the last six months, I had the challenge and opportunity to perform a large research project and combine my academic competencies from both the bachelor and master study and use these to investigate a relatively novel topic. Despite some demarcation challenges, I have been energized by the topic as it embraces a sustainable solution for the future. I believe that the high-tech type of farming discussed in this document is going to become a significant part of food production and food security in multiple regions in the world. Whether the products are going to be regular crops, specialized herbs, or health-enhancing products, their impact is going to be seen globally. But as with other products that do have a radical character like the electric car or solar cells, it may take decades before a considerable scale is reached.

I would like to express my thanks to my primary university supervisor dr. U. Konus and my secondary university supervisor, dr. W. van den Borgh for their comprehensive advice and thorough feedback in choosing and demarcating the research subject, but most of all for their support with the write up of the research. Furthermore, special thanks go out to Louis Bekker, my supervisor at Siemens. His open and enthusiastic attitude and his significant feedback made the internship a very enjoyable period. At Siemens, I would also like to express my thanks to Max Remerie, for giving me the opportunity to perform this research at his department Business Development and Leo Freriks, for his useful comments regarding my research. I am grateful to many friends for their support but I would like to mention Ed and Pieter here especially for their help during my research and for reviewing the final document.

Finally, I would like to thank my parents and my sister for their mental support during my education and preparation for the upcoming working life.

Bas Berkel
Amsterdam, March 2013
Summary

Introduction

Global climate changes are believed to become a severe threat to agriculture and the corresponding food security in the world. This trend and other acknowledged trends have resulted in a quest for finding sustainable solutions for the future. One of these sustainable solutions is high-tech urban farming. This type of farming cultivates products in an artificial environment by supplying sufficient amounts of CO₂, light, water and nutrients. However, due to a lack of knowledge concerning the profitability of this type of urban farming, development seems to stagnate. More specifically, due to the lack of knowledge on how to create value and capture value from urban farming, the profitability is questioned. According to Chesbrough & Rosenbloom (2002), value is best captured by a business model. Therefore, a business model for urban farming was composed and evaluated in this thesis.

Literature indicated that breakthrough technologies (Vogel, 2008) and interdisciplinary cooperation (Germer, et al, 2011) are necessary to enhance the development of urban farming. Provided by this information and the recognized changes in innovation economics (Chesbrough, 2006), an open innovation approach was included in the composition and evaluation of the business model for urban farming. Further, given the fact that urban farming is envisioned as a sustainable solution for food security in the future, a complementary scenario analysis was executed. Using this scenario analysis, future opportunities for urban farming could be linked to the business model.

For the composition and evaluation of the business model, a ‘design science’ research design by March & Smith (1995) was used. Using this research design, the objectives and associated methods to build and evaluate the business model for urban farming could be systematically identified.

This research contributes to the sparse literature on high-tech urban farming and the use of a design science research design for the composition of a business model in a specific context. Also, by indicating how value can be created and captured and which necessary resources and processes are required to profit from urban farming, organizations are provided with an overview of what the urban farming business currently consists of. Combining this with the scenario analysis gives organizations an idea of the future opportunities that might arise in urban farming.

The research was conducted at the technology company Siemens. This multinational company and specifically the business development department are concerned with the development of growth opportunities in the future. Particularly if it involves overarching solutions for integrated area development or intelligent (energy) grids, Siemens technologies could be applied. Urban farming might become a part of these development areas or grids, hereby confirming the interest of Siemens in the subject urban farming.

Theory and Conceptual Framework

Three subjects were centralized in the literature review: urban farming, business models and open innovation. The urban farming literature indicated the limits of on-land urban farming and the succeeding quest into other solutions for local food production. High-tech urban farming was found to have multiple advantages like minimal crop loss, more control over food safety and security, minimal use of pesticides and minimal water use. Press articles further showed that numerous urban farms have been established in the world. However, literature also indicated the developmental challenges currently present. These developmental challenges impede the lack of interest from commercial organizations which in turn impedes the lack of funding for research. As mentioned, business models are a method for capturing value. Capturing value and validation of profitability might break this vicious circle. Therefore, business models in academic literature were examined to formulate a solid definition for a business model and select a business model for this research. Open
innovation literature was also examined to familiarize with the subject and research its possible role in the business model.

As reference model, the business model by Johnson, Christensen & Kagermann (2008) was selected, accompanied by sufficient argumentation. This business model contains four interrelated elements: (1) customer value proposition, (2) profit formula, (3) key resources and (4) key processes. This reference model was converted into a conceptual model by combining sub-elements of the reference model with previously published urban farming categories and the open innovation approach. This conceptual model could subsequently be evaluated to answer the main research question and sub-questions.

Method

A multiple case-study methodology was used in this research. Here, semi-structured interviews with 15 experts were conducted to evaluate the conceptual model. These experts were selected based on a Triple Helix approach (Leydesdorff & Etzkowitz, 1998) and came from commercial organizations in urban farming, academic institutions and municipal organizations. Also, economic data about a profitable urban farm in Japan was collected to reveal information on sub-elements in the conceptual model.

The interview data was analyzed by applying constant comparison analysis (Glaser & Strauss, 1967). Prior to this analysis, all respondents were labeled and the transcripts were converted into one language using the back translation technique (Broslin, 1970). The economic data was analyzed by calculating the Net Present Value and Pay Back Period.

For the scenario composition, the GBN-Matrix by Schwartz (1991) was used. Here two polarities were constructed as x-axis and y-axis from which four scenarios can be derived.

Results

The results indicated that the customer value proposition is determined by the products that are produced and sold. Here, four product categories could be distinguished: (1) food products with a low profit margin, (2) food products with a high profit margin, (3) private grow systems and (4) possible future products. The intended customer was found to be very much dependant on the social acceptance of urban farming and the urban farming products. Here, forcing circumstances, competitive pricing, involvement of education and touristic elements were found to influence this social acceptance. The element profit model was found to be determined by the revenue possibilities of the urban farm, distinguishing for instance the sale of private grow systems, the sale of low- or high-profit margin products or a hybrid model. The economic data revealed that urban farming might currently indeed be profitable. Results from the economic data also revealed which key processes and possible key resources needs to be included in an urban farm. Further, interview data indicated the types of stakeholders that are to be involved in urban farming. Here, supply side stakeholder, installation, operation and maintenance stakeholders and demand side stakeholders were distinguished. Moreover, results revealed the location possibilities for an urban farm like the use of empty buildings or the automation of production. Finally, the reasons and possible implications of collaboration were revealed like to establish a platform for knowledge exchange or to utilize the crowd in the development of urban farming.

Numerous impediments were also found regarding the current implementation of urban farming. Results revealed that is these impediments were removed or mitigated; national and international opportunities may arise. The polarities for the GBN-matrix were selected as overarching numerous other polarities. The applied polarities are equilicities-urbanization and technology push-market pull (equilicities represent cities stagnating in growth). Using these polarities, four scenarios could be made: (1) Gradual Adjustment, (2) Collective Necessity, (3) Trendy Niche and (4) Stimulated Share. Using these scenarios, national and international opportunities could be further determined.
This section first discussed the findings for the business model and the scenarios. Subsequently, the academic implications, the managerial implications and the limitations and avenues for future research are indicated.

Regarding the customer value proposition in the business model, the low profit margin food product and high profit margin food product categories confirmed the types of food products that can be cultivated in urban farming mentioned in previous literature. New categories of urban farming products that were found are the private grow systems and the urban farming food products for other purposes than basic consumption like healthcare. Three types of customers were found. Food products for regular customers or hospitality purposes were also acknowledged in previous literature but customers in the healthcare sector were found as a new type of customer. Another key finding was the existing lack of social acceptance towards high-tech urban farming (products). Creation of incentives for more social acceptance might enhance the customer value proposition of urban farming products.

Regarding the profit formula, a number of revenue possibilities where listed in line with the product categories identified. Here, it was found that revenue possibilities have to be combined to create a profitable business model. The economic data analysis revealed, as mentioned, the profitability of urban farming. However, the high product price and relatively long payback period of a potential investment demonstrate that development has to occur on several levels to make the urban farming business more attractive. The economic data analysis did find a number of economic activities that have to take place in urban farming. However, which activities have to be performed within the farm and which activities could be outsources was not revealed.

Regarding the key resources and key processes, three stakeholder categories were found. Which stakeholder would actually perform which activity was not distinguished in great detail in this research. Specifically concerning the location, the possibility use of empty buildings also confirmed previous research, as is the use of automated growth systems. One key finding as a location possibility is the use of private grow systems to fill building floors and thereby be able to use different systems for different crops. Collaboration was found to be considered with local authorities, also acknowledged in previous literature. However, collaboration with customers in the development phase of urban farming (products) emerged as a new finding.

Implications for academics are that urban farming can be called a relatively new but interesting research domain as it considers a sustainable solution for food security in the future. Further, the use of a design science research design for business model research could be applied. Managerial implications focuses on the combination of urban farming products or the private grow system in the customer value proposition in urban farming business. Collaboration with authorities and customers in the urban farming business also has to be considered by managers. Limitations include the linguistic barrier to retrieve information from Japan and South-Korea and limited amount of collected data that could be collected due to the novelty of the subject.
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List of Abbreviations

BRIC- : Brazil, Russia, India, China (-countries)
CVP : Customer Value Proposition
I.A.D. : Integrated Area Development
IPRO : International Patent Research Office
LED : Light-Emitting Diode
NPV : Net Present Value
OI : Open Innovation
PBP : Pay Back Period
PGS : Private Grow System
SOP : Standard Operating Procedures
UF : Urban Farming
1. Introduction

1.1 Background & Indication of Literature Gap

Changes in the global climate, partially due to the continuous increase of greenhouse gasses in the atmosphere (WMO, 2012), is believed to be accompanied by droughts, floods and hurricanes (Despommier, 2011a) and may turn the world in an unrecoverable state within the next century (Goudie, 2005). One industry that will suffer severe from these impacts is farming (Germer, et al, 2011). According to Despommier (2011a), a 1°C increase in atmospheric temperature will turn 10% of the current arable land into an unusable state. Furthermore, the agricultural industry is for a large part dependant on resources with a limited nature. In the US, for instance, 20% of the total fossil fuel consumption is utilized by agricultural activities (Despommier, 2011a). In the current society, the agricultural products, once harvested, travel on average over 1,500 miles before being consumed (Hill, 2008).

The expected climate changes and the finiteness of fossil fuels have committed people and organizations to search for more sustainable solutions for today’s and tomorrow’s world. These sustainable solutions have to take into account two other widely recognized global trends: exponential population growth is expected to reach approximately nine billion by the year 2050 (Goudie, 2005) and increasing urbanization. In fact, it is predicted that 60% of the world’s citizens will be living in urban areas by the year 2025 (Siemens AG, 2009).

With the identification of these trends, urban farming (UF) has received an increased amount of attention as one of many envisioned sustainable solutions (de Boer, 2013; Despommier, 2009a; Fischetti, 2008; Grewal & Grewal, 2012). The production of food in and around urbanized areas (in multi-story locations) in a completely secluded artificial environment has several multifunctional benefits like optimal growth conditions, minimize of yield losses, continuous production and minimal transport distances (Despommier 2011b; Germer et al, 2011). Additionally, the sustainability of processes in a city towards more energy efficient solutions, waste minimization and water use can be further enhanced the by integration of urban farming in existing and non-existing energy and materialistic cycles (Despommier, 2011b).

Urban farming has however been subject to a lot of skepticism. Arguments against the feasibility of urban farming are topics like excessive energy use in the production process (Bomford, 2010), lack of potential to replace the current farming system (Kretschmer & Kollenberg, 2011; The Economist, 2010) and various (technological) development challenges (Monbiot, 2010; Reinato, et al, 2006). According to Germer, et al (2011, p.248), these technological development challenges “require a highly interdisciplinary cooperation due to the very close inter-linkage of all areas of competency.” Also, the commercial profitability of urban farming has been debated by several (Monbiot, 2010; Reinato, et al, 2006; Roberts, 2009). According to Bowman & Ambrosini (1998), a firm creates value through the production and sale of products. If this value exceeds the costs involved in creating a product, a firm is profitable (Porter, 1985, 38). The created value is best captured by a business model (Chesbrough & Rosembloom, 2002; Osterwalder, 2009; Shafer, Smith & Linder, 2005). Literature discussing urban farming indicates that until today development of this business model has not been attempted. Due to the absence of this business model, the profitability of urban farming remains to a large extent unknown. This unfamiliarity impedes the commercial potential of urban farming which in turn may hinder the required development of urban farming to refute the skepticism and eventually become a sustainable solution for food security in the future. On the contrary, identifying the content of the business model discloses how value in urban farming is created and for what kind of customer, thereby linking the physical domain of urban farming products to the economic domain of value and profit. Furthermore, the business model reveals the corresponding activities that are necessary for capturing the value as well as indicate possible resources. The business model may even provide insight in the differentiation from competition.

[12]
is particularly useful since traditional agriculture products already exist for competitive prices (Perner, n.d.). All together, aggregation of the required content for the business model of urban farming contributes to the knowledge of this potential sustainable solution for food security in the future.

1.2 Problem Statement

Reflecting on the information from academic publications and press articles, research has demonstrated the technological feasibility of cultivating various agricultural products in urban farming. Theoretically, these products can be produced and subsequently sold in order to create value for an organization and thereby, the organization is able to make a profit. However, reality implies that this process is a lot more comprehensive. The types of products that are to be cultivated and the customers for whom the products are cultivated are for instance unknown. Further, the processes and activities that have to take place, together with the resources that have to be utilized are just a few of the extensive parts that come with the production and sale of (urban farming) products. According to Johnson, Christensen & Kagermann (2008), these are examples of parts that are included as elements in a business model. These elements are in a certain way connected and thus interrelated to create and capture value. What these elements exactly consist of and how they are interrelated on the subject of urban farming is yet undiscovered. Therefore, in sum of what was written above, the following problem statement was formulated:

*It is unknown how to create value and capture value from urban farming due to the absence of a business model that contains the knowledge regarding the specific elements, their content and their interrelatedness in the business model.*

1.3 Main Research Question & Sub-questions

The problem statement addressed the absence of knowledge on how to create and capture value from urban farming. Business models and corresponding elements are a widely studied subject in academic literature. The term ‘business model’ has over two million hits on Google Scholar alone. Therefore, it can be stated that a universal business model for value creation and value capture does not exist. The research for this thesis focuses on the identification of the elements that have to be combined to compose the optimal business model for urban farming.

In line with the identified research gap and the problem statement, the following main research question was formulated:

**How can a business model be composed in order to create value and capture value from high-tech urban farming?**

Next to the research question, this thesis intends to integrate two subjects into the research to take into account current and future circumstances, i.e. ‘open innovation’ and ‘scenarios’. A brief explanation of the relevance of these subjects is provided together with the associated sub-research questions that are examined.

Section 1.1 briefly mentioned the skepticism towards the, mainly (technological) development challenges as well as the excessive energy usage of urban farming. Ideally, this energy usage will have to be reduced to lower the cost of urban farming, also requiring technological improvements and/or innovations. The necessity of interdisciplinary cooperation to meet these challenges was declared by Germer, et al (2011). Furthermore, Chesbrough (2006) acknowledged the changing economics of innovation due to the rising cost of technology development and shorter product life cycles, recommending an open (innovation) business model. Organizations working alone will not deliver the right solutions fast enough.
The following sub-question is formulated to take these circumstances and the possibility for interdisciplinary cooperation into account:

1. **Should an open innovation approach be integrated into the business model for urban farming?**

   As mentioned in section 1.1, urban farming is envisioned as a sustainable solution for food security in the future due to global changes that may threaten the current food system. To anticipate future (ecological) changes and accommodate potential urban farming opportunities, a scenario analysis is conducted, resulting in the following sub-question:

   2. **Which scenarios could emerge in the future that might affect the business model for urban farming?**

The research questions lead to the identification of:

- The elements of the business model for urban farming.
- The content of the elements in the business model for urban farming.
- The interrelatedness of the elements of the business model for urban farming.
- The necessity to integrate an open innovation approach in the business model for urban farming.
- Future scenarios that could have an impact on the urban farming.

**1.4 Research Design**

Traditional academic research in, for instance, mainstream management, is often focused on theory building and theory testing or, in other cases, understanding a phenomenon. Business model research is rather a problem-solution finding approach, according to Osterwalder (2004). This also applies for the business model for urban farming, for which a model does not exist yet and the solution is to build one. This type of research is not focused on theory building. Osterwalder (2004) however, questions the validity and viability of this type of research, stating it could be interpreted as ‘simple’ consultancy work. In this research however, a design science approach is applied to assure scientific the scientific contribution. Whereas natural science attempts to understand reality, design science tries to create feature for human purposes (March & Smith, 1995). In the context of urban farming, a business model is created so that humans can make a profit from engaging in urban farming activities. Regarding this design science approach, March & Smith (1995) constructed a research framework in which the horizontal axis represents research activities and the vertical axis represents the research output. The resulting sixteen cells, identified at the intersection of the research activities and the research output, represent research objectives. Figure 1 on the next page depicts the research framework.

Although the research framework in figure 1 was initially constructed by March & Smith (1995) for application in information technology research, Osterwalder (2004) also uses it for business model research in his dissertation. For this reason, this research framework is also used for the research into the business model for urban farming in this thesis.

On the horizontal axis, the research activities ‘Build’ and ‘Evaluate’ are considered the two main issues in design science (March & Smith, 1995). The other two activities, ‘Theorize’ and ‘Justify’ are used in natural science and are thus excluded from the research in this thesis. ‘Build’ refers to the construction of artifacts, constructs and models and ‘Evaluate’ alludes to the development of criteria and use those criteria to assess what has been built.
The vertical axis in figure 1 distinguishes four outputs:

- **Constructs**: form the vocabulary of a domain.
- **Model**: a set of propositions or statements expressing relationships among constructs.
- **Method**: the steps used to perform a task.
- **Instantiation**: the realization of an artifact in its environment (Osterwalder, 2004, p.5).

Figure 2 depicts the cells from the research framework in figure 1 which are covered in this thesis and each of these cells or combination of cells consists of a research objective(s). The research starts with gaining in-depth understanding of the topic urban farming followed by acquiring knowledge on business models. After evaluation of numerous definitions in the literature, a solid definition is formulated. To make a well-founded choice on the ‘reference’ business model to be used in this research, a large number of business model are evaluated. Finally, understanding is gained on the topic of open innovation. The above described activities are covered in the literature review described in section 3.1 and are therefore aggregated in one big cell, since ‘building’ and ‘evaluation’ are performed interchangeably. Following the literature review, Section 3.2 described how a conceptual business model is composed, based on the selected ‘reference’ model for urban farming and open innovation. Evaluation of this conceptual model is the final objective and is elaborated in sections 4, 5 and 6. Figure 2 illustrates the various objectives of this research within the research framework for this thesis.
March & Smith (1995) explain that every cell in figure 2 might call for a different methodology. Therefore, a method or combination of methods for each cell or combination of cells has to be determined to reach the stated objectives. As mentioned briefly, the objectives in the ‘big’ cell are completed by conducting a literature review. This literature review assists in examining and synthesizing previous research and subject-crossing publications. The literature review is complemented by secondary, non-academic, information coming from press articles and other public information. The latter information will disclose recent developments and provide information regarding real-life established urban farms and is beneficial to combine with academic literature. The literature review and complementary secondary data is also used as method for the composition of the conceptual model, again combining previous research to make well-founded choices in the composition process.

Evaluation of the conceptual model and examination of the content of the business model for urban farming is performed by a qualitative multiple case-study analysis. Although the conceptual model contains predefined and examined elements, exact interpretation of the elements in the context of urban farming still remains up for investigation, partially due to the novelty of the subject. Primarily, case studies are a favorable research method for answering ‘how’ (and why) questions (Yin, 1989). Further argumentation on the choice for case studies is explained in section 4. One element of the conceptual model, the profit formula, assumes the requirement for economic data. Therefore, tangible value (e.g. profit) can only be determined if actual revenue and costs can be compared. To accomplish this, numerical data is collected to determine the feasibility of an urban farm. This quantitative data also improves the construct validity of the research. Figure 3 illustrates the methodology per cell.

<table>
<thead>
<tr>
<th>RESEARCH ACTIVITIES</th>
<th>Build</th>
<th>Evaluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructs &amp; Model</td>
<td>• Literature Review</td>
<td>• Secondary Data Review</td>
</tr>
<tr>
<td>Instantiation</td>
<td>• Literature Review</td>
<td>• Secondary Data Review</td>
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<tr>
<td></td>
<td>• Case Study Analysis</td>
<td>• Economic Data Analysis</td>
</tr>
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1.5 Contribution & Relevance

This master thesis contributes to both the academic knowledge and business knowledge. First of all, the commercial potential of urban farming is examined by composing a business model. The doubts that exist around the profitability of urban farming can be confirmed or contradicted through examining this commercial potential. When the commercial potential is confirmed, this will show future investment opportunities for organizations and encourage funding of research in urban farming. On the contrary, if the commercial potential is contradicted, organizations will be provided with information concerning the challenges or developments that have to be realized in the future to increase the profitability chances of urban farming.

Regarding the content of the business model, this research contributes to illuminating the content of relevant elements of the business model for urban farming and their interrelatedness.
Identification of the possible products that can be cultivated in urban farming and the customers, for whom these products are cultivated, will provide information of the profitability of urban farming. Details on for example the production process can indicate which activities have to take place and which resources are required. This in turn can elucidate which organizations have to collaborate, the objective of the collaboration and the format of the collaboration. An open innovation approach can be confirmed as a potential approach.

This research applies a design science approach to perform research into business models and this thesis contributes to the use of this approach for examining business models in a specific context. This specific context in this thesis is urban farming.

The composition of the business model provides an overview of the requirements to engage in urban farming. Specifically, the business model indicates the current status of the requirements for urban farming. When this status is connected to future scenarios it is possible to judge on the potential of future opportunities in urban farming.

1.6 Organization of the Report

This master thesis comprises the following sections. Section two introduces the commercial organization Siemens Nederland N.V. for which the research is performed. Here, a brief overview of the company is provided, Siemens’ vision to sustainability is explained and the business opportunities for Siemens related to urban farming are briefly elucidated. Section three starts with a literature review on the introduced topics. The section concludes with the composition of the conceptual model applied in this thesis. Section four elaborates on the methodology used for evaluating the conceptual model. The types of data used and the strategies for data collection and data analysis are explained in this section. Also, the type of scenario analysis that is used is explained. Section five provides a detailed overview of the results. The final section elaborates on the findings of this thesis and discusses the academic implications, managerial implications, limitations of the research and avenues for future research.
2. Siemens

The research project was conducted at Siemens Nederland N.V. A brief overview of the company and its divisions is given followed by Siemens’ vision on sustainability. The final part of this section discusses the link with the company and the research topic in this thesis.

2.1 The Company

Siemens AG is a German multinational company and a pioneer in energy efficiency, industrial productivity, affordable and personalized healthcare and intelligent infrastructure solutions (Siemens, 2011a). Siemens Nederland N.V., headquartered in The Hague, is divided into four main sectors, namely energy, healthcare, industry and infrastructure & cities. These divisions are complemented by a number of country functions and departments. Siemens Nederland N.V. employs 2408 people and reached total revenue of € 1.3 billion in 2011. The core activities embrace the delivery of products, systems, installations and services to customers in the industry, energy and healthcare market. Apart from products and systems, Siemens Nederland N.V. also offers services like project management, consultancy, engineering and specific development of hardware and software (Siemens, 2011b). Appendix C depicts an overview of the sectors and divisions of Siemens Nederland N.V.

2.2 Siemens & Sustainable Development

Sustainable development is defined as “development that meets the needs of the present without comprising the ability of future generations to meet their own needs” (UN, 1987). Sustainability in centralized as the ‘Guiding Principle’ in all Siemens activities worldwide. Megatrends such as urbanization, climate change and demographic shifts are central in composing the portfolio of Siemens. A typical example of such a megatrend is the Dutch national goal to reach 20% sustainable energy production by 2020. Approximately €30 billion of the global revenue of € 73 billion is obtained from a broad portfolio of energy saving and environmentally friendly technologies (Siemens, 2011b).

The sustainability program at Siemens Nederland N.V. covers (1) the application of the portfolio en engineering knowledge in the Dutch economy, (2) the economic handling of raw materials and reduction of greenhouse gas emissions, (3) the engagement in the dialogue with stakeholders to look for opportunities to involve these stakeholders in sustainability activities and (4) the active social performance in the areas where Siemens is operating (Siemens, 2011b).

Siemens recognizes the fact that increasing sustainability is not only ‘doing’ but also about ‘communicating’. This increases involvement of stakeholders and society and Siemens benefits from it too. The collaboration with BMW in building electric vehicles exemplifies this (Siemens, 2011a).

2.3 Business Development

The research project was conducted at the department Business Development. This department concerns the development and implementation of growth opportunities of Siemens Nederland N.V. The Business Development department is part of the worldwide ‘Siemens One’ platform, which is called ‘an integral part of the Integrated Technology Company’. The goal of the platform is to integrate and collaborate between sectors, divisions, clusters and regions for growth opportunities and sustainable value creation. Getting closer to the customer and account management is of particular importance here. Siemens, a technology-oriented company, is involved in multiple activities in urban areas. Building technologies, energy generation, intelligent energy distribution and mobility are for example specialized divisions within this multinational company. To pursue its sustainability goals, Siemens is also involved in the development of SMART Cities. A SMART City is defined by Caragliu et al (2011, p.70) as “investment in human and social capital and
Traditional (transport) and modern (ICT) communication infrastructure will fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government”.

In its current portfolio, Siemens is not involved in the food supply, security or distribution of agricultural products in urban areas. However, integrated approaches for future sustainable solutions in urban areas might require Siemens to become involved in the food supply, security or distribution in urban areas as part of a SMART City. More specific, Siemens is involved in overarching solutions for integrated area development in the Netherlands and urban farming could become a part of this integrated area development. Siemens is also engaged in the development of intelligent energy grids known as Smart Grids. Urban farming has the potential to be included in these grids. Business opportunities for Siemens will arise in the future, when urban farming requires innovative technological solutions.
3. Theoretical Background and Conceptual Framework

Section three elaborates on the subject-related literature. The academic publications on urban farming are discussed, followed by a review of the content of press articles concerning this subject. Subsequently, a brief elaboration on the terms ‘value creation and ‘value capture’ is provided, after which the business model literature is reviewed to formulate a business model definition and gain understanding of the content of a business model. Finally, the topic open innovation is explicated and the last part of this section comprises the reviewed literature and explains the conceptual model utilized in this thesis.

3.1 Literature Review

3.1.1 Background and the limitations of on-land urban farming

For many centuries, humanity has been engaged in agricultural activities, which became part of the first urbanized areas. Once urbanized areas started growing and the land in these areas became more valuable, a clear distinction rose between urban areas and rural areas. Rural areas were used for the cultivation and production of agricultural products, and urban areas were used for the sale and consumption of agricultural products (Steel, 2008). According to Mougeot (2000), farming made its return to the city in the 1960s. Since then, urban farming has been practiced on both a small- and large scale worldwide. The pro-urban farming part of society referred to the reduction of fossil fuel use, the shortening of the food chain, the increased freshness of locally cultivated products, employment opportunities, and managing fresh water resources more effectively as advantages of urban farming.

Simultaneously with the ‘comeback’ of this type of farming, a vast amount literature has been published covering a diverging amount of subjects related to urban farming (Bakker et al, 2000; Bryld, 2003; Smit et al 1996). These subjects have been categorized by Mougeot (2000) and are depicted in table 1 on the next page. These categories are taken into account in this research into high-tech urban farming as will be explained in section 3.2.

The increasing popularity of the topic has also increased research into the disadvantages and risks, which are related to on-land urban farming (Bryld, 2003; Ellis & Sumberg, 1998; Van Veenhuizen & Danso, 2007). Mougeot (2000), in his publication on urban farming, discussed four areas of doubt. Firstly, urban farming would hamper urban development because farming is to be performed in rural areas and urban areas should be used for other economic activities. The threat to public health is the second argument of doubt. The soil in urban areas almost always contains some type of contamination which might end up in urban farming products. Another argument is the raising of livestock in the city, which might cause health risks. Thirdly, a number of environmental concerns were raised on the topic including soil erosion and siltation, pollution of resources and destruction of vegetation. The extensive use of fertilizers has also been found to be applied more in urban farming. A final contra argument is the profitability of urban farming, mainly due to the high ground prices in combination with low profit-margin products (Mougeot, 2000).

The above mentioned disadvantages of on-land urban farming have triggered entrepreneurs, scientists, academics, and governmental organizations to cogitate about other methods to produce agricultural products locally. Hitherto, this focus has been mostly on the cultivation of plants and fruits and less of the raising of livestock in the city (Frank, et al, 2011; Kretschmer & Kollenberg, 2011).
Table 1, Urban farming categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Products</td>
<td>Embraces cultivated and raised products fit for consumption by humans or livestock such as root, grain, vegetables, aromatic and medicinal herbs, fruit crops and livestock of all shapes and sizes. Among these types, the more biodegradable and high-value vegetable products and animal products are often emphasized as most suitable.</td>
</tr>
<tr>
<td>2. Destination</td>
<td>Concerns the destination of the products, distinguishing for instance trade and self-use. Market-oriented production requires analysis of the competitive advantages compared to other sources, both on consumer and producer level.</td>
</tr>
<tr>
<td>3. Economic activities</td>
<td>The production phase, the process phase and the subsequent trade and distribution phase can all be categorized as economic activities related to urban farming. Logically, interaction between these phases should be considered.</td>
</tr>
<tr>
<td>4. Location</td>
<td>The place where this type of farming should be executed is probably the most discussed aspect. Mougeot (2000, p.6) states: “This element is probably the biggest source of contention”. Whether the location concerns an urban or peri-urban area, the ground prices will always exceed the ground prices in rural areas.</td>
</tr>
<tr>
<td>5. Areas</td>
<td>Various research regarding the practice area covers topics like the location respective to residence, the land-use category of the sector, the modality of tenure of the site (for instance sharing, lease) or the development status of the site.</td>
</tr>
<tr>
<td>6. Scale</td>
<td>The scale of urban farming activities varies widely from small-scale family-based activities to large-scale trans-national activities.</td>
</tr>
</tbody>
</table>

3.1.2 High-tech urban farming

From the viewpoint of a plant, its necessities are light, CO₂, water and nutrients (Campbell, Reece & Mitchel, 2009; Turner, n.d.). Plants are able to grow hypothetically anywhere in an artificial environment, when these four ‘ingredients’ are provided in optimal conditions. Theoretically, this knowledge allows people to gain complete control over the production process and content of urban farming products. Also, this information has opened the doors towards a new perspective in the cultivation of food products in cities. Buildings, factories, cellars and rooftops suddenly became places to be considered as cultivation locations, as long as the necessary growth ingredients are provided. To cultivate in these new locations, the use of certain (to-be developed) technologies seems inevitable. Whether technologies used for traditional farming have to be adapted, or technologies normally used in the buildings have to be re-examined, change seems obvious due to different circumstances in which plants grow.

Multiple terms have been used in the literature to express this ‘new’ type of farming, like ‘skyfarming’ (Germer, et al, 2011), ‘urban agriculture’ (Foeken & Mboganie Mwangi, 2000), ‘urban farming’ (Frank, et al, 2011), and ‘vertical farming’ (Despommier, 2011). It is therefore important to provide one clear definition of urban farming in this document. Initially, on-land urban farming was defined as: “An industry that produces, processes, and markets food, largely in response to the daily demand of consumers within a town, city or metropolis, on the land throughout the urban and peri-urban area” (Smit, Ratta & Nasr, 1996). In essence, a resemblance exists with this definition and the type of farming focused on in this thesis. Therefore, parts of this definition are combined with the
definition of high-tech urban farming and the five major objectives formulated by Germer, et al (2011, p.242). This constitutes the following definition for urban farming in this research project:

\[
\text{Urban farming refers to an industry that produces, processes, and markets food in an indoor technically optimized environment within multi-story locations within a town, city of metropolis, largely in response to the daily demand of consumers.}
\]

Pescod (1992) is believed to be the first person to introduce urban farming as a possibility to cropping without soil. Emeritus Professor Dickson Despommier of the Columbia University started elaborating and promoting the idea as a solution for food security in the future after he came across the idea of urban farming in 1999 (Despommier, 2009a). In his publication, Despommier also designed an urban farm based on his ideas. This design is depicted in Appendix A and is meant to give an impression of what a high-tech urban farm might look like. Over the years, initiatives have risen all over the world to lift this idea off the ground (AVA, 2011; Despommier, 2011b; Frank, et al, 2011; Grewal & Grewal, 2011; IPRO, 2001; Roberts, 2009; Vogel, 2008). The advantages of this type of urban farming are listed in table 2.

<table>
<thead>
<tr>
<th>Advantages of Urban Farming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year round production can be realized due to independence of weather conditions</td>
</tr>
<tr>
<td>Crop loss due to unexpected weather conditions would be minimal</td>
</tr>
<tr>
<td>No agricultural runoff</td>
</tr>
<tr>
<td>More control of food safety and security</td>
</tr>
<tr>
<td>Fossil fuels use for harvesting would be reduced</td>
</tr>
<tr>
<td>The use of pesticides could be reduced because an artificial climate can be created inside buildings</td>
</tr>
<tr>
<td>Transportation cost and emissions of greenhouse gasses due to this transportation of products into urban areas would be reduced</td>
</tr>
<tr>
<td>Job opportunities would be created in urban areas</td>
</tr>
<tr>
<td>The water use could be reduced due to new production techniques</td>
</tr>
</tbody>
</table>

The benefits listed in table 2 enhance a more sustainable solution towards food production and distribution than is currently present. A publication of ATTRA by Hill (2008) stated that processed food in the United States travels over 1300 miles and fresh produce travels over 1500 miles. Together with the fact that 20% of the total consumption of fossil fuels comes from the agricultural sector (Despommier, 2011a) there must be room for more sustainable development in feeding the world’s inhabitants.

General informative documents on urban farming were published by Fischetti (2008) and Vogel (2008). Despommier wrote the first detailed book on urban farming called *The Vertical Farm - Feeding the World in the 21st Century* in 2010 and a second edition was released in 2011. In this book, it is stated that a 30-storey building in a city like New York could feed up to 50,000 inhabitants.

The link between urban farming and food security is recognized by many (Abel, 2010; Cadigan, 2011; Fletcher, 2012; Germer, et al, 2011; Matzenberger & Schipfer, 2012; Ndayambaje, 2009). Apart from the publications by Despommier, the self-reliance of cities and the role of urban farming is examined by Grewal & Grewal (2012), performing a scenario analysis on food security and publishing factual evidence on the yield or urban farming: “a model plant factory, Angel Farm in Fukui, Japan, claims a yield of 165 kg/m² through vertical farming and indoor lighting (Dr. Peter Ling, personal communication), compared to the hydroponic yield of 19.53 kg/m²” (Grewal & Grewal,
2012, p.9). Furthermore, Abel (2010) acknowledges Australia’s vulnerable position in food domestic food supply and mentions urban farming as a partial solution. Ndayambaje (2009) concluded the same for the country Rwanda and discussed the cultivation of tomatoes in urban farms.

The chlorophyll molecules in plants initiate photosynthesis by capturing light (Yeh & Chung, 2009). When agricultural products are produced indoors, they will not have access to the sunlight required to grow. Light-Emitting Diode (LED) lighting has been named significantly as an energy efficient producer of artificial sunlight (Germer et al, 2011; Doorduyn & Jansen, 2013). By emitting blue light, red light, deep-red light or a combination of these, scientists have confirmed that LEDs can be used for growing a variety of crop, vegetable, fruit or even flowers. LEDs are famous for their longer lifetime than conventional lamps and by eliminating other wavelengths found within normal white light, energy consumption can be reduced (Yeh & Chung, 2009). Further technological developments were patented by Jessel, et al (2003) and applied Chicago’s first vertical farm (IPRO, 2011). Integration in materialistic and energy cycles in a city was also analyzed. Matzenberger & Schipfer (2012) investigated microalgae production in ‘vertical farms’ to generate large amounts of biomass. The emphasis in this process is on the use of wastewater treatment. The captured products such as phosphorus could be applied as fertilizer in food production. Wastewater management and the possible link with urban farming in Vietnam were also referred to by Kasbohm, et al (n.d.). Banjerlee (2012) performed a market analysis study in his master thesis concerning urban farming. In this publication, the application of bio-generative modules in urban farming was examined. In summary, this paragraph elucidates some of the technological development challenges.

The socioeconomic and political implications were researched, by Reinato, et al (2006). The crucial role of city governors and planners is the establishment and development of urban farming in cities is further emphasized by Grewal & Grewal (2012) and Despommier (2009). An integrated approach with architecture could enhance the development of urban farming (Abel, 2010; Frank et al, 2011).

The literature of this type of urban farming is in some cases presented from an idealistic perspective and does not discuss concrete possibilities (Despommier, 2011; Germer, et al; Grewal & Grewal, 2012; Matzenberger & Schipfer, 2011; Vogel, 2008). Various hurdles are recognized by Despommier (2009) such as securing available or abandoned space in cities for production, converting wastewater into irrigation water and the supply of inexpensive sustainable energy. Jan Broeze, in the article by Vogel (2008) further states the idea of urban farming is inspiring, however large technological breakthroughs in lighting and waste management are required for the realization. Germer, et al (2011, p.248) complement this: “Some technical components for the construction of the environment are already available; however, they need to be adjusted substantially, combined and tested under the objective target of this approach”. For this and other ecological, societal and economic challenges, substantial and long-term funding for research is required (Germer, et al, 2011).

What the literature clearly does not discuss is how to create value from urban farming and subsequently capture this value. It remains unclear how to make a profit in the urban farming business. This impedes the involvement of commercial organizations. Indeed, commercial organizations want to make a profit from the activities they are involved in. This lack of involvement in turn hinders the required funding for research into the technological breakthroughs and other ecological, societal and economic challenges addressed in earlier published literature. Figure 4 depicts the current situation surrounding urban farming as explained above in an interdependent and vicious cycle. As mentioned in the introduction, created value is best captured by a business model (Chesbrough & Rosenbloom, 2002; Osterwalder, 2009; Shafer, Smith & Linder, 2005). Therefore, a business model is used in this research on urban farming. Section 3.1.5 reviews the business model literature, after section 3.1.4 first briefly explains the term ‘value creation’ and ‘value capture’. Prior to these sections, the next section (3.1.3) complements the academic literature review with a review of press articles and other public information on urban farming to extend the amount of gathered information for this research.
The type of urban farming in this thesis focuses primarily on the cultivation of crops in artificial environments for food purposes (and not for instance to serve as biofuels). This is supplemented by the possibility to breed fish (as this is part of the aeroponics technology, explained in Appendix B). The crops can be cultivated by applying or combining three methods, the methods explained in detail in Appendix B are:

1. Hydroponics
2. Aeroponics
3. Aquaponics

These methods were selected because they all concern the supply of the ingredients of a plant that were declared in the beginning of this section, namely light, CO$_2$, water and nutrients. Further, in all methods, technologies are involved to supply the ingredients.

### 3.1.3 Press articles and other public information discussing urban farming

Since 2007, urban farming has been a subject that has been noticed by the press. These articles have reported on or examined a wide variety of topics related to urban farming. To extend the amount of information concerning this subject, these articles are discussed here.

The general potential of this type of farming was published in multiple newspapers and news internet sites (Despommier, 2009b; Ellis & Zandri, 2012; Nelson, 2007). The potential of urban farms in New York was also noted (Despommier 2009b). Other articles go into more concrete details concerning the implementation of an urban farm. Ellis & Zandri (2012) calculated the building cost of a vertical farm. Chamberlain (2007) published a detailed design and the elements of an urban farm. Bonford (2010) calculated the approximate energy cost of an urban farm. Some journalists questioned the potential of this idealistic method for food production and doubt the profitability (Roberts, 2009), the overall feasibility (Monbiot 2010), the financial support (Nelson, 2007), the necessary government support (Silverman, 2013) and the high energy cost (Bonford, 2010; Kretschmer & Kollenberg, 2011). Despite these disadvantages or negative elements of urban farming, a number of established urban farms or urban farms currently being built were mentioned in the articles. Table 3 provides an overview of these real-life urban farms, their location, and the author of the article they were mentioned in.
Table 3, Real-life urban farms

<table>
<thead>
<tr>
<th>Company</th>
<th>City, Country</th>
<th>Author Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gotham Greens</td>
<td>New York, USA</td>
<td>Economist.com (2010)</td>
</tr>
<tr>
<td>Nuvege</td>
<td>Kyoto, Japan</td>
<td>Hsu (2012)</td>
</tr>
<tr>
<td>The Plant</td>
<td>Chicago, USA</td>
<td>Nsu (2012)</td>
</tr>
<tr>
<td>Plantagon</td>
<td>Linkoping, Sweden</td>
<td>Tohill (2012)</td>
</tr>
<tr>
<td>PlantLab</td>
<td>Den Bosch, the Netherlands</td>
<td>Kretschmer &amp; Kollenberg (2011)</td>
</tr>
<tr>
<td>Sky Vegetables</td>
<td>San Francisco, USA</td>
<td>Roberts (2009)</td>
</tr>
<tr>
<td>Suwon Vertical Farm</td>
<td>Suwon, South Korea</td>
<td>Kretschmer &amp; Kollenberg (2011)</td>
</tr>
<tr>
<td>Valcent</td>
<td>Texas, USA</td>
<td>Economist.com (2010)</td>
</tr>
<tr>
<td>Vertical Farming Systems (VFS)</td>
<td>Singapore</td>
<td>AVA(2011)</td>
</tr>
<tr>
<td>VertiCrop</td>
<td>Vancouver, Canada</td>
<td>Localgarden (2012)</td>
</tr>
</tbody>
</table>

Table 3 provides evidence that it is indeed possible to build an urban farm, as has been done on a variety of locations in the world. In the article by Nelson (2007), Gene Giacomelli truthfully states: “questions of safety, quality and sustainability are pushing farming in a host of other directions.” However, detailed information on how to capture value from these urban farms still remains off to a large extent, although Graff in an article on InnovationNewsDaily.com (2011) remarks: “a vertical farm must be able to produce enough food to cover the cost of its day-to-day operations and, ultimately, the capital cost of the building’s construction (or renovation).” Based on the press articles, it can be concluded that mechanisms to capture value remain unknown, at least in public. A clear distinctive business model for this type of farming has not been established. This complements the academic literature gap mentioned previously and forms the base for the research in this thesis.

3.1.4 Value creation and value capture

The terms ‘value creation’ and ‘value capture’ have up till now been mentioned multiple times in combination with the term ‘business model’. Therefore, these terms are discussed briefly in this section. Porter (1985, 38) defines value as “the amount buyers are willing to pay for what a firm provides them.” According to Bowman & Ambrosini (1998), this value is created by firms through the production and sale of products. Porter (1985) continues by stating that value can be created in numerous ways, like differentiation along the supply chain or raising buyers’ performance or lower buyers’ costs. Further sources of value creation could be linkages with suppliers or other channels, location or policy choices (what activities to perform and how). Regarding urban farming, value is thus primarily created for a firm through the production and sale of urban farming products. This value is subsequently captured by a firm if it profits from the sale of these products. Particularly, if the value exceeds the cost involved in creating a product, a firm is profitable (Porter, 1985). In the case of the main topic in this thesis, an urban farm is profitable if the sale of urban farming products exceeds the cost needed for creating these products. As mentioned before, a method for capturing value is by using a business model. This topic is discussed in the next section.

3.1.5 Business models

As the literature review on urban farming indicated, a business model for urban farming had up till now not been published in academic literature nor in complementary news articles. This section explicates the importance of business models, formulates a definition for this thesis and elaborates on the various objectives and functions of a business model. This combined information will provide a rationale behind the composition of a business model. This also forms the base for the operationalization stage in this research, elaborated in the section four. In the final part of this section, the chosen business model for this research project and associated argumentation is written.
The importance of business models has been emphasized by numerous academics (Chesbrough, 2007; Chesbrough 2010; Margretta, 2002; Osterwalder, 2009). To accomplish something in the real world, it is proven to first model and then elaborate these changes before implementing. If this mental representation is first considered by people, it is more conformable to practice the changes in real life (Petrovic, Kittl & Teksten, 2001). A business model is in general approached from a more practical perspective from which two questions take a central position. These questions ask how money is made in a certain business and what the underlying economic logic is that explicates how value can be delivered to customers (Magretta, 2002). Further, Osterwalder (2009, p.15) states: “the concept must be simple, relevant and intuitively understandable, while not oversimplifying the complexities of how enterprises work”. Shafer, Smith & Linder (2004) support this by emphasizing the fact that the definition should be as simple as that it can be fairly easily understood, remembered and communicated. The latter also suggest that integration and synthesis of earlier work is required.

Regarding the content, most definitions in the literature mention a framework, architecture, tool or representation. From this it can be concluded that a business model links various elements. These elements all have some kind of interest in being part of this framework. Also, many authors emphasize the creation and capture of value of this product or service. Thus, necessary elements are linked together to create and capture value. For a profit-oriented company, a profit element naturally needs to be included. In Appendix D a list of business model definitions is provided. Taking the definitions used in the literature and the elements above into account, the definition that will be used in this research proposal will be:

“A business model is a framework of elements, representing activities and people from inside and outside a company, that are linked together in order to deliver and capture value and by doing that, make profit from a product or service.”

When discussing business models it is also important to emphasize what the objective is for constructing business models. Why do we study them and what are the functions of business models? Chesbrough (2010, p.1) states that: “A mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model.” In other words, a successful business model is the key to value creation. Moreover, Chesbrough (2003) describes the role of a business model to create a heuristic, simplified cognitive map that links the social domain of outputs to the technical domain of inputs. Further, a good business model is said to remain essential for the success of every organization, whether incumbent or starter (Magretta, 2002). Paleti & Giaglis (2003) and Osterwalder & Pigneur (2002) performed a literature review and listed a number of frequently cited objectives for studying business models. First, it is important to understand the key elements and mechanisms in a specific business domain and their relationships. Next, it is important to communicate and share the knowledge regarding business models among stakeholders, both in business and technology. Also, it is advisable to identify options for continuously changing and improving the incumbent business model. Another objective is the specification of valid requirements for information systems that are supporting a business model. The final objective is the need for continuous experimentation with innovative business concepts to determine how business models can be adapted to new concepts.

Besides the objectives to study and utilize business models, it is important to note what the functions of a business model are, emphasizing more the business model’s role on how to create value and capture value. It has been described simply as an overview of what the business does and how the business makes money doing this (Weill, et al, 2005). Chesbrough & Rosenbloom (2002) listed six functions of a business model. These functions are:

1. The articulation of the value proposition. In other words, how are we going to create value for our customer?
2. The identification of a market segment. For which user is the technology useful and what the purpose for using the technology is.
3. The definition of the value chain within a company that is required to create and distribute the product.
4. An estimation of the cost structure and corresponding profit potential.
5. A description of the firm’s position in the value network which links suppliers and consumers. This includes identification of potential competitors.
6. The formulation of the competitive strategy necessary to gain and maintain an advantage over rivals.

In summary, a business model is a model composed before activities in reality are implemented. In this model, the methods for value creation and value capture are displayed. This value creation and value capture is further divided into the above listed six functions. The goal of this model is to create a framework of elements from which an organization can eventually make a profit. This approach is applied in the construction of a business model for urban farming in this thesis.

As part of the literature review and to ensure internal validity, an analysis of a number of business models elaborated on in the academic literature was executed. The business models that were reviewed are listed in Appendix E. One business model was selected as a basis for the conceptual model in this research. This is the business model by Johnson, Christensen & Kagermann (2008), depicted in figure 5 on page 28. Grounded reasoning for selecting this business model and the specific business model functions and elements in the context of urban farming will be explained in section 3.2.

Chesbrough (2006) stated that the rising cost of technological development and shorter product life cycles have resulted in a change in innovation economics in the past decades. Urban farming is also subject to a number of (technological) development challenges that have to be tackled by innovations, as literature indicated. Chesbrough (2006) therefore suggests that business models have to become more open. If this is also true for the business model of urban farming, is investigated in this thesis. To elaborate on what is exactly meant by an open business model, the subject of open innovation is comprehensively discussed in the next section.

### 3.1.6 Open innovation

Next to the acknowledged changes in the economics of innovation, Germer, et al (2011) states that interdisciplinary cooperation needs to take place to meet the technological challenges that are present regarding urban farming at this moment. These two aspects hypothesize the involvement of an open innovation approach into the business model for urban farming in this thesis. Therefore, this section firstly defines open innovation and subsequently lists a couple of examples of real-life examples in which the open innovation perspective was applied to emphasize the real-life context of open innovation. After this, the rationale behind the rise of the open innovation perspective is elaborated. Finally, the costs and revenue alterations due to an open business model are illustrated.

The open innovation topic has received increased attention in the past decade. Henry Chesbrough, in his book ‘Open Innovation: The New Imperative for Creating and Profiting from Technology’, defines the open innovation paradigm as: “one that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology” (Chesbrough, 2003, p.xxiv). Rising cost of technology development and shorter product life cycles has increased incentives for companies to engage in open innovation activities in recent times (Chesbrough, 2006). Urban farming, as stated, also interfaces with the technology industry. Consequently, open innovation is integrated in this thesis and the construction of a business model for urban farming.

Three examples to explain the different application of the open innovation perspective are:
Proctor & Gamble set up the ‘Connect & Develop’ program to encourage ideas for new products to not only come from inside the organization. In the years that followed, P&G managed to create new brands by licensing technologies from outside. This resulted in several successful products like Olay Regenerist, Swiffer and Crest Spinbrush (Chesbrough, 2006; Huston & Sakka, 2006).

The company Lucent invented digital video but concluded that the market was not ready for this technology. Therefore Lucent Digital Video was formed as a spin-off, being a separate company. This company continued to develop the technology and after a couple of years sales started to increase significantly. Lucent noticed this and concluded that the market was now prepared for the digital video technology. Thus it re-acquired the venture to optimally profit from its own invention (Chesbrough, 2004).

InnoCentive. This is a firm that functions as a knowledge platform where companies can post challenges that they have to cope with. Other companies can then react to these posts and new steps can be initiated where the company solves the challenge in return for some kind of reward or license. The firm that posted the challenge does not have to invest in this challenge and does not bear the risk (Chesbrough, 2006).

Senseo. Philips, a technology company, and Sara Lee, a producer of fast moving consumer goods, collaborated to develop the Senseo coffee machine. This machine was built to quicken the process of making a cup of coffee and used customized coffee ‘pads’ as ingredient for a cup of coffee (Du Chatenier, et al, 2009).

Logically, the main difference with the former closed innovation model is that firms no longer perform their R&D activities in-house but combine internal and external ideas and knowledge for the development of competitive products. Figure 5 below display the main difference between the closed and open innovation paradigm.

The rise of the open innovation concept has been caused by four ‘erosion’ factors of the original closed innovation paradigm. First, it has become easier and more common for skilled and educated workers to change jobs. On top of this, the number of this type of workers has also increased. This has resulted in a situation in which it is much more difficult for a company to keep knowledge in-house. Second, the availability of venture capital on the market has increased drastically in the past two decades. This venture capital increased the temptation for employees in a large corporation to join starting ventures with attractive risk/reward compensations. Third, due to the competing pressure for shorter product life cycles, the metabolic rate for the processing knowledge has increased. Because of this, companies chose rapidly in selecting and not selecting new product ideas resulting in a huge amount of ideas ‘being placed on the shelf’. Employees have however found methods to commercialize these ideas. The final erosion factor occurred because of the increasing capability of external suppliers. These external suppliers may move faster with other companies and serve a wider range of markets. Subsequently, inventory of ideas and technologies may be exploited without the original company benefiting from it (Chesbrough, 2003; Enkel & Gassmann, 2004; de Jong et al, 2008).
Shortly after the recognition of the open innovation paradigm saw the introduction of the open business model in the academic literature. In simple terms, once a company innovates together with others, it cannot claim the complete revenue; the revenue has to be shared as well. This requires organizations to change the ‘traditional’ business model. As mentioned, Chesbrough (2006) identified two trends in the technology sector; (1) the rising cost of technology development and (2) product life cycles are becoming shorter. Due to these changes, companies started pursuing a more open business model. This created a shift in the costs and revenues of an organization, as depicted in Figure 6 on the next page. If urban farming companies are to pursue a more open business model, the above stated had to be taken into account.

![Figure 6, The new business model for Open Innovation (Chesbrough, 2006)](image)

As stated, when organizations want to become more open in their innovation activities, they must combine internal and external ideas to improve their technologies or create new technologies. This can be done by for instance collaborating with other firms or sharing knowledge on a platform. Literature has not confirmed that this is currently happening in the urban farming business. What the literature did confirm is that interdisciplinary cooperation (Germer, et al, 2009, p.248); technological breakthroughs (Vogel, 2008, p.753) and government support (Despommier, 2009b) are required to meet the challenges of urban farming. Moreover, additional literature has proved that multiple urban farms currently exist in the world. Sharing knowledge concerning the urban farming business on a platform might therefore enhance the process of tackling the development challenges in urban farming. As mentioned though, this may affect the revenue that can be gained by organizations.

To investigate how collaboration on the subject of urban farming might take place, with whom to engage in collaboration or knowledge sharing activities and how these activities might affect the (technological) development challenges, the open innovation approach in included in the business model. This might in turn provide an answer to sub-research question 1. How the open innovation approach is exactly included in the business model and together with the other gained knowledge construct the conceptual model for this thesis, is explained in the next section (3.2).
3.2 The Conceptual Model

In section 3.1.5, it was brought up that the business model documented by Johnson, Christensen & Kagermann (2008) was selected for application in this thesis (depicted in figure 7 on the next page). The selection was made after a comparison analysis of a number of academically published business models (see also Appendix E). The business model was selected based on the following reasons. First, although the article is focused on the reinvention of a business model and the recognition for change, there is a specific focus on the identification of elements of a business model. As stated on page 62: “By systematically identifying all of its constituent parts, executives can understand how the model fulfills a potent value proposition in a profitable way using key resources and key processes” (Johnson, Christensen & Kagermann, 2008, p.62). Thus, in the case of this thesis, this business model can be used to identify the elements of the business model for urban farming. Second, this business model provides a clear distinction between the elements responsible for the value creation and the elements responsible for the value capture. Namely, the elements ‘Customer Value Proposition’ (CVP) and ‘Profit Formula’ define the creation of value (both for the customer and the organization). The elements ‘Key Resources’ and ‘Key Processes’ describe how the value is captured (Johnson, Christensen & Kagermann, 2008, p.61). Thirdly, Johnson, Christensen & Kagermann, (2008) emphasize the complexity of the interdependencies between the elements in a business model and clearly visualize this in their business model with mutual pointing arrows. Because this thesis also focuses in particular on the interrelatedness of the elements in a business model, this business model connects to the objectives in this research. Fourthly, the operational functions of a business model described by Chesbrough and Rosenbloom (2002) in section 3.1.5 are all represented in the selected business model. Being operational, it is expected that this can contribute to the identification of the elements of the business model for urban farming. Specifically, the functions ‘value proposition’ and ‘cost structure’ are literally depicted in the selected business model. The function ‘identification of the market segment’ is synonym for the ‘target customer’, classified in the element CVP. The structure of the value chain and the position in the value network emanate from the combination of the elements Key Resources and Key Processes. Hence, the processes that are performed in an organization determine the position of the organization in the value chain and this is turn determines which resources are needed. The formulation of a solid competitive strategy is the result of a unique CVP, which is the result of an efficient combination of the elements Key Resources, Key Processes and Profit Formula, also depicted in the selected business model.
Summarizing, the four elements in the business model above and their interrelatedness had to be identified regarding the subject of urban farming. Also, an open innovation approach had to be included in the business model to investigate if this may contribute to tackle the developmental challenges in urban farming.

Table 1 in section 3.1.1 listed the urban farming categories as published by Mougeot (2000). These categories will be, to a large extent, used to indicate the broad content of the elements in the business model for urban farming. Hence, there are a lot of similarities between on-land urban farming and urban farming researched in this thesis. Also, both types of urban farming have the goal: food production for dwellers. By dividing these categories among the four elements of the business model, the conceptual model for the research in this thesis is constructed, of course supplemented with integration of the open innovation approach.

The CVP for urban farming is determined by the products that are offered and the customers for whom the products are produced and sold. These products depend on which of the three technologies (hydroponics, aeroponics and aquaponics, see also Appendix B) are applied. The Profit Formula is determined by the products that are sold and the scale of the production and sale. These determine the revenue of the urban farm. As pointed out, the products are intended for local consumption, thus the size of the population of an urban area determines the scale of production. Obviously, the economic activities, in other words the production cost, also impact the profit formula. These determine the costs. This also confirms the destination of the products, namely trade and not self-use. The Key Resources and the Key Processes are determined by the economic activities (production phase, process phase, and distribution and trade phase) and the location of the urban farm as well as the collaboration activities.

If interdisciplinary cooperation is to occur regarding the technologies for urban farming, this influences the key processes and the key resources in the business model. For instance, the processes design and product development (mentioned in the referential business model by Johnson, Christensen & Kagermann (2008)) may be influenced by collaboration. This is turn determines which key resources are to be applied by for example with which organizations collaboration will take place and for what purpose an organization engages in collaboration. To integrate this in the business model, a sub-element ‘collaboration activities’ is added. In the key resources element, the partnerships and alliances are emphasized.
The above explained specification of the referential business model for urban farming results in the conceptual model for this research, depicted in figure 8. Justification of the research method for examining this conceptual model as well as elaboration on the data collection and analysis methods is explained in the next section.
4. Methodology

This section focuses on the methodology for empirical research into the conceptual model. First, the reasons for a case study analysis are briefly explained. The subsequent two sub-sections elaborate and argue on the data collection strategies and data analysis methods.

4.1 Case Study Analysis

As mentioned in section 1.4, case study research was selected to evaluate the conceptual model. Primarily, case studies are a favorable research method for answering ‘how’ (and ‘why’) questions (Yin, 1989), making it suitable to answer the main research question in this thesis. Although the research intends to evaluate the composed conceptual model, it is important that this evaluation is performed in a way that allows for the collection of a wide scope of information. Hence, the conceptual model was composed using available literature but it could very well be that elements, sub-elements or other information have to be added to increase the chances and opportunities of value creation and value capture. Thus, the collection of exploratory data with a certain amount of depth is desirable, also for answering sub-question 1, regarding the integration of an open innovation approach in the business model and 2, regarding the future scenarios. This asks for the collection of information from people’s minds. Case studies allow for this type of detailed examination (Flyvbjerg, 2006). Further, specifically for business models, case studies can be used to test the validity of the constructs (in this thesis referred to as elements) and the designed ontology (the business model for urban farming), confirming application of case study research in this thesis (Osterwalder, 2004).

Although case studies are characterized by combining various data collection methods like archives, interviews, questionnaires and observations (Eisenhardt, 1989), the research in this thesis focuses mainly on interviews. The novelty of the subject and the limited available knowledge regarding urban farming do not allow for the use of questionnaires or observations in this research. Construct validity is however enhanced by performing an economic data analysis of a single case. The next section discusses the data collection.

4.2 Data Collection

Unit of analysis

In case study research, an important component is the unit of analysis. This unit is typically related to the main research question (Yin, 1989). The units of analysis in this research are the elements and sub-elements in the conceptual business model for urban farming (sub-elements are defined and being part of a general element. For example, the location is a sub-element in the element key resources).

Interviews

Semi structured interviews were conducted in this research. Expert knowledge was predicted as providing the most thorough data and required depth in this data for evaluation of the conceptual model. This expert knowledge is logically obtained by conducting interviews. Semi structured interviews were preferred over unstructured and structured interviews for numerous reasons. As the units of analysis are the elements and sub-elements of the conceptual model, these will be discussed more or less systematically, creating a structure in the interviews. However, to evaluate the elements and sub-elements, these will have to be discussed in more depth, allowing the interviewees to elaborate on their visions, experiences and opinions. To allow for some creativity and diversity in the answers, a more unstructured approach per (structured) discussion of each element is preferred, creating a semi-structured interview (Diefenbach, 2009). For instance, in the literature review section
it was mentioned that similar products to the ones from urban farming already exist for competitive prices. This might require a certain amount of creativity in the determination of the customer value proposition. Similar to the content of the business model elements, the interrelations within the business model are based on the conceptual model. Due to the fact that other relations may be discovered that enhance the business model, a certain amount of depth is necessary. Furthermore, the exact collaborative input of the business model is a fairly undiscovered sub-topic that was annexed in the business model as are the scenarios that are to be discovered. Thus, a more unstructured approach is preferred here within these sub-topics. To further enhance depth and creativity in the answers of the respondents, the technique of probing was applied. According to Mack et al (2005b, p.43), “Probes are neutral questions, phrases, sounds, and even gestures interviewers use to encourage participants to elaborate on their answers and explain why or how.” In case of any form of indistinctness of the responses or lack of sufficient depth in the answers, probes were applied. Finally, a semi-structured approach enables comparison across respondents in the data analysis phase.

To influence the diversity of gathered data, a ‘Triple Helix approach’ was used to identify the respondents. This approach is derived from the Triple Helix Framework by Leydesdorff & Etzkowitz (1998) which embraces an academic-industry-government relation as a key component in an innovation strategy. In this thesis therefore, respondents occupying positions in academic, industry and government organizations were selected. Their knowledge and responses to the interview questions could eventually be integrated in the evaluation of the conceptual model. Academics were selected based on their expert knowledge on urban farming and especially their publications in the categories of urban farming listed in table 1. People employed in urban farming organizations were selected based on their expert knowledge on business in urban farming. People from governmental organizations, in thesis referred to as municipal officials, were selected based on their expert knowledge on strategic elements of food in a city. In total, 51 people, both Dutch and foreign were selected as respondents.

All 51 potential interviewees were approached, either by e-mail or ‘cold’ telephone call. To the non-responsive people of the first ‘e-mail round’, a second e-mail was sent to ask for their willingness to participate in the research. In the end, sixteen interviews were conducted, resulting in a response rate of 31%. All interviews were recorded with permission of the interviewees. Twelve interviews were performed face-to-face with Dutch people or foreign people working in the Netherlands in a by them selected secure environment. Four interviews were performed using the communication tool Skype. All of these four interviews were with foreign people. The average interview lasted 49 minutes.

From the conducted interviews, fifteen interviews were used as data from which again six interviews were conducted with practitioners. Another six interviews were conducted with academics. Three respondents were municipal officials. According to Guest, Bunce & Johnson (2006) interviews should be conducted until a point of saturation is reached. This is complemented by Ritchie et al (2003) stating that resource availability also influences the saturation point. The interviews conducted for this research are partially based on this resource availability. Nonetheless, the amount falls within the acceptable margin for academic research as stated by Guest, Bunce & Johnson (2006). On top of this, the saturation point is reached if similar answers start emerging as more interviews are performed and by this, complete elaboration of the concepts was reached (Corbin & Strauss, 2007). For each of the three respondent categories, this occurred at respectively six, six and three. Table 4 on the next page visualizes the interviewees in their categories.

Three versions of interview questions were composed, containing eleven up till twelve questions and a varying number of sub-questions and probes. The first five questions were asked to all respondents. These general questions concerned the business model, the stakeholders involved in urban farming, the possibilities for an open business model and the opportunities and threats for urban farming. The final six questions were ‘respondent-specific’. The three versions of the interview questions are located in Appendix F

[34]
Table 4, Categorized respondents

<table>
<thead>
<tr>
<th></th>
<th>Dutch Nationality</th>
<th>Foreign Nationality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practitioner</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Academic</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Municipal Official</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

After the first round of interviews (one with a practitioner, one with an academic and one with a municipal official), the answers per question were reviewed. After this review, one question in the second part of the interview for practitioners and one question in the second part of the interview for academics were deleted. This due to the fact that the answers to these questions had a lot of overlap with others questions or sub-questions in the interview. A sub-question concerning the short term versus the long-term opportunities for urban farming was added to get a clearer indication of the respondents of the long-term versus the short-term opportunities. Also, it was decided that more probing had to be conducted during the question elaborating on the open business model for urban farming, mainly because respondents sometimes lacked sufficient knowledge on these open business models.

Economic data

The literature questioned the feasibility of urban farming for a number of reasons explained earlier in this document. Nonetheless, the literature review also listed a number of real-life urban farms currently operating or being built. Another real-life urban farm was created by a consortium of industry parties and academics in Japan. Lead by Mirai, this collaboration has succeeded in creating a profitable urban farm (Shimamura, 2012). To enhance the construct validity in this thesis, economic information regarding this urban farm was analyzed. Also, this information could provide useful information concerning the element Profit Formula in the conceptual model. Explanation of the analysis method of the economic data is explained in the next section.

4.3 Data Analysis

Interview data analysis preparation

Due to the fact that some of the interviews were conducted in Dutch and some in English, the Dutch interviews had to be translated into English prior to the analysis phase. To perform this translation in an academically responsible way, the ‘back translation technique’ by Brislin (1970) was applied. When using this technique, an initial translator (the author of the thesis) translates, in this case, the Dutch transcripts into English transcripts. Then, a second translator does the same without having seen the earlier translation. Next, the initial translator can compare the two translations and evaluate the quality of the translation. In this research, a fellow student was asked to translate two English transcripts (transcripts of interviews with respondents Ac.EN.#1 and Pr.EN. #1; labels are explained in the next section). The comparison revealed no significant differences in translation. Therefore, it is assumed the remaining transcripts were also translated accordingly.

Labeling

Each respondent was given a label, a code that would be noted directly after a quote, a discovered pattern, theme, category or idea. These quotes are mostly used in section 5 where the results are elaborated. A few sample labels of different respondents and their answers are given directly below:

- Ac.NL.#1: A Dutch academic
- Pr.EN. #2: A foreign practitioner
- Mu.#1: A municipal official
Constant comparison analysis

To ensure an analytical analysis of the interview transcriptions, a constant comparison analysis was executed. This method allows for a flexible and creative development towards theoretical findings (Glaser & Strauss, 1967; Leech & Onwuegbuzie, 2012). The absence of sufficient knowledge surrounding the value creation and capture opportunities in urban farming logically connects with the quest for creative possibilities. Constant comparison analysis also allows for the assembling overarching themes and patterns, through thorough categorization of the collected data, thus the performance of cross-case analysis. A detailed elaboration of the interview data analysis and the various integration steps is depicted in Appendix G.

In the first step, each interview was coded separately, allowing for an unlimited amount of 2-5 word codes referring to the subject-related content. Anecdotal parts of the transcript were also included to maximize creative input. By taking a broad initial approach, a base was created from which codes and adjacent themes could be integrated. Pieces of text that embraced similar content were marked with the same code. In the end, 92 categories were identified. Some categories referred to obvious business model-related terms like finance (f), distribution (d) or restaurant customers (c) but other terms introduced new concepts like city purchasing power (cpp) and private grow systems (pgs).

To discover underlying patterns across interviewees, all interviews were re-read several times. It was also kept in mind that three types of interviewees were used, and differing patterns between these groups (the Triple Helix approach) might also emerge. In the process of discovering cross-respondent themes, categories could be placed in multiple areas of overlap and connection. In this process, some categories were also integrated to form new, overarching terms. To illustrate this, vegetable products, fruit products, and chicken products were merged under the phrase ‘products with a relatively small profit margin’. This resulted in reduction of the number of categories to 49.

After first indications of emergent themes, the interview data and the given categories were further examined. This resulted in nine main themes, indicating a more abstract level of terminology. Some of the themes were again combined to form a dimension. These themes and dimensions were linked to the elements and sub-elements in the conceptual model in the results section (The dimension are from this point on referred to as categories). Following this, the findings and implications from this research can be formulated.

To assess whether the coding was performed in a trustworthy way, two independent, academically educated people were asked to perform a coding consistency check and divide the 92 categories from among broader categories. After these activities were executed, the researchers concluded that to a large extent, the dimensions identified in his analysis were similar to the broader categories identified by the reviewers.

Economic data analysis

As mentioned, economic data was gathered concerning a profitable urban farm in Japan. This data was analyzed by conducting a Net Present Value (NPV) calculation and a Pay Back Period (PBP) calculation. By calculating the NPV, one can rule on the feasibility and profit gained in the future of an investment made at present. The PBP determines the time that is required to earn back an investment that is made (Pindyck & Rubinfeld, 2009). The data used for the calculations is publicly available on the World Wide Web (Shimamura, 2012). Calculating these values complements the research because it assists in determining the economic activities that have to take place within the element profit formula in the conceptual model. Further, it provides a numerical overview of the costs and revenues. Also, it can support any findings regarding the profit formula elements and the values can be taken into when the scenario analysis is performed to determine future opportunities in urban farming. How the interview data is used for this scenario analysis, is explained in the next section.
Interview data analysis for scenario building

Urban farming has been defined as one of many possible sustainable solutions for the future. To determine the changes that might occur in the future and how these changes might impact urban farming, a scenario analysis was performed using the data from the interviews. The method for performing this analysis is explained below. The results of the scenario analysis are explained and illustrated in section 6. The contribution of this analysis is twofold. First, by pointing out possible directions for the future of urban farming, this might encourage academic research in previously undocumented directions. Secondly, the scenarios and the probable changes might provide readers with a clearer picture for business development in this sector in the future.

A scenario is defined as a “product that describes some possible future state and/or that tells the story about how much such a state might come about.” (Bishop, Hines & Collins, 2007, p.8). This scenario study may be conducted for many different subjects like climate change (Parry et al, 2004), ICT (Ducatel et al, 2001) or drug development (Croft et al, 2006). Once these scenarios are set, it allows different parties to anticipate to possible upcoming changes. Scenarios relevant for the subject of this thesis concern the production and distribution of food in the world. Hence, urban farming is alternative way to produce (and distribute) food. The distribution of food is intertwined with fossil fuel prices (Despommier, 2011) and as a result, food prices are influenced by fossil fuel prices. Besides this, the development of urban farming related technologies might also be of importance to mention.

Bishop, Hines & Collins (2007) published an overview on various scenario development techniques. To maintain internal validity all listed techniques were analyzed and the Global Business Network (GBN) Matrix was selected. This matrix is based on two dimensions of uncertainty, referred to as polarities. The resulting four cells give situations that evolve from the combinations of the polarities on the axis.

Initially first documented by Schwartz (1991), this technique is referred to as “the gold standard of corporate scenario generation” (Millet, 2003, p.16). The forms the primary reason for application of this technique in this thesis. Further, this technique allows for the evolvement of four significantly different future states due to the polarities on the axis, giving a profit-oriented organization (like Siemens) the opportunity to mirror itself to each of the four states. Also, the scenarios are based on judgments, which connect to the qualitative nature of research in this thesis.
5. Results

This section discusses the results of the evaluation of the business model. The categories identified during the constant comparison analysis are linked to the elements in the conceptual model and discussed in the following order: (1) CVP, (2) Profit Formula, (3) Key Resources and Key Processes in section 5.1. The results of the economic data analysis are also included in section discussing the profit formula and briefly in the section on key resources and key processes. Section 5.2 discusses the results regarding the scenarios analysis. Figure 9 depicts an overview of the results which will be discussed in detail in the upcoming sub-sections.

5.1 The Business Model

5.1.1 Customer value proposition

The categories linked to the customer value proposition are (1) products and (2) social acceptance. As depicted in the business model by Johnson, Christensen & Kagermann (2008), products determine the ‘job to be done’ for the customer and are logically related to the sub-element products in the conceptual model. The identified mix of urban farming products are discussed below. Three types of customers were identified but these customers are found to be to a large extent determined by factors influencing the social acceptance of urban farming (products). These are also discussed below.
Products

Four product categories were recognized. The first category concerns food products with a relatively low profit margin. Products mentioned by the interviewees were for example vegetables, fruits, chicken, fish or mushrooms. Given the fact that these products have a low profit margin, it is obvious that these products have to be produced and sold in bulk. This immediately addresses the issue of available space in a city for bulk production. Further, interviewees suggested that these products would only be sold to regular customers and hospitality firms such as restaurants.

The second category also concerns food products, but these food products have a more exclusive characteristic and overall a relatively higher profit margin compared to the first product category. Specific products mentioned by the respondents were sprouts, herbs or flowers. These products could be produced and sold in smaller quantities and still generate a similar amount of revenue as the above named category. This suggests that these types of products are more suitable for urban production where available space is often an issue of concern. Whichever price the low profit or high profit margin products are sold for, respondent Mu.#1 remarks: “production must occur in a way that is competitive with the global market”.

The third category embraces a fridge-like ‘personalized’ grow system that could be used by for instance normal citizens or restaurants. These devices are from this point on referred to as Private Grow Systems (PGSs). The idea is practically the same as the definition that is given to urban farming in this thesis, only on a smaller scale. In the ‘fridge-like’ apparatus, an artificial climate would be created in which the necessities for plants to grow, namely CO₂, water, nutrients and light, could be provided. Further, multiple stacked layers where different kinds of products could be cultivated are available. This would allow dwellers to produce for example their own set of vegetables at home. The device could however also be used by hospitality firms. Consumer friendly usage of these devices is logically an important part of the product. One can think of simple switches to alter the light intensity, color, or water supply. Several prototypes of these devices have already been built and are currently tested according to respondents Pr.EN.#3 and Pr.NL.#3. On the contrary respondent Pr.EN.#3 confessed: “I leased machines for a while….However, people starting making their own and in the end I got very little back from the leasing”. Furthermore, it potential is emphasized by others states interviewee Ac.NL.#3: “Home-growing systems, that could be something that is going to happen.”

The final category covers a number of products that were mentioned by the respondents during the interviewees but none of whom have ever been produced in urban farming. The production of algae for biofuels, the production of pharmaceuticals, even the products or insects as meat substitute was mentioned by Ac.NL.#4 as an option. Because of the creation of an artificial climate and the ability to control what goes into the products, several healthy additions to products could be made. This could for instance make products more attractive to regular consumers or might be served to hospitalized people whereby the products may enhance the cure process. Table 5 on the next page lists the results for this section.

Summarizing, (food) products with a low profit margin and a high profit margin can be distinguished. Also, private grow systems were found as a product category. This is not a food product but system containing various technologies for ‘personalized’ production’. The final category concerns possible future products. Each product category was connected to potential customers.
### Table 5, Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Potential customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Products with relatively low profit margin</td>
<td>Regular customers and retail</td>
</tr>
<tr>
<td></td>
<td>Hospitality firms</td>
</tr>
<tr>
<td>2. Products with relatively high profit margin</td>
<td>Regular customers and retail</td>
</tr>
<tr>
<td></td>
<td>Hospitality firms</td>
</tr>
<tr>
<td></td>
<td>Healthcare sector</td>
</tr>
<tr>
<td>3. Private grow systems</td>
<td>Regular customers and retail</td>
</tr>
<tr>
<td></td>
<td>Hospitality firms</td>
</tr>
<tr>
<td></td>
<td>Healthcare sector</td>
</tr>
<tr>
<td>4. Possible future products</td>
<td></td>
</tr>
</tbody>
</table>

#### Social acceptance incentives

For urban farming products to become a part of society, they have to be accepted by food strategists and the consumers (or B2B customers). This current lack of social acceptance might be due to the disruptive character of this kind of food cultivation. Two interviewees enlighten the disruptiveness of this innovative way of cultivating agricultural products (Pr.NL.#1, Pr.EN.#3). The social acceptance can be influenced by a number of factors, as the interview data denotes. The cognitive motives to purchase UF products may be related to certain circumstances that might occur around the regular food supply. A relatively recent example was explicated by Pr.EN.#3 and refers to the consequences of hurricane Sandy in October 2012. Many transportation mechanisms temporarily eliminated by the storm. This resulted in empty shelves in supermarkets and worried clients. Many shelves were empty because food supply comes for a substantial part via air transportation. According to Mu.#2, these and other situations have encouraged similar dependant cities like London and Vancouver to reconsider their food strategies. Food scandals such as with the EHEC-bacteria in cucumber in 2011 in Germany (Mu.#2) and the salmon contamination in late 2012 (Pr.NL.#2) in the Netherlands, could also create incentives for more local, controlled food production as an alternative for the currently instituted system. Approaching the potential of urban farming from a vision that maps uncertainties in the (near) future, might encourage incentives for development and social acceptance, pronounces respondent Ac.NL.#4.

When looking at the utilization of renewable energy technologies, people often compare the energy prices with energy prices coming from traditional energy technologies and eventually choose the cheapest one. Due to the face that the energy prices of renewable energy prices in most cases are higher than prices from traditional technologies, the renewable energy technologies stagnate in their dispersion. A comparable situation could occur with products from urban farming. Therefore “production should occur in way that competes with the global market” (Mu.#2). On top of that, the Dutch consumer has been found to be extremely critical when it comes to food purchase. This is related to significant levels of competition. “Our prices are so horribly low, that it is very difficult to do other things” (Ac.NL.#3). It is therefore important that urban farming products are accommodated to the average or perhaps even below average purchasing power of a city if the products are to become competitive (Ac.NL.#5).

Education seems to play an important role when it comes to various aspects of urban farming. Nonetheless than ten out of the fifteen interviewees claim that there is link with educative elements. First, Pr.EN.#1 envisions “upper-middle class people” and “health-conscious individuals” as its primary customers and thinks a lack of public education might impede their growth opportunities. Here, it is assumed that the two groups of people have in general a higher education level. In line with this, higher educated people thus may also play an vital part in increasing the awareness and a role for fresh graduates might be to bridge the awareness gaps (Ac.EN.#1). These graduates might even have been engaged in an internship with an urban farm (Pr.NL. #2, Pr.EN.#1).
The involvement of some kind of tourist attraction might also increase the social acceptance in society for urban farming. From the viewpoint of a tourist, one respondent ironically said: “I’m going to take a look in the Red Light District and the LED Light District” (Mu.#2). The pioneer-like character of these urban farms might become tourist magnet and increase the city value, making it an interesting issue for politicians or city planners (Pr.EN.#2). Restaurants could also distinguish themselves from competitors by cultivating their own products in PGSs, this is already happening on a small scale with rooftop gardens (Mu.#3). Table 10 lists the results for this section.

Social acceptance towards urban farming (products) might be created by natural circumstances or by the ability to offer urban farming products at competitive prices. Also, stimulation to purchase urban farming products and familiarization with urban farming may be established using education. Finally, integrating tourist activities in urban farming may also contribute to creating a more socially accepted status for urban farming.

Table 6, Social acceptance incentives

<table>
<thead>
<tr>
<th>Social Acceptance Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Necessity due to circumstances</td>
</tr>
<tr>
<td>2. Competitive pricing</td>
</tr>
<tr>
<td>3. Educational elements</td>
</tr>
<tr>
<td>4. Touristic elements</td>
</tr>
</tbody>
</table>

5.1.2 Profit formula

The categories linked to the profit formula are (1) revenue possibilities and (2) economic data. The revenue possibilities give an impression of the products (and services) that could be sold to generate revenue. The economic data provide an overview of the economic activities related to urban farming, indicating the various costs and giving an impression of the sub-element scale (of production). Further, it offers an idea of the profitability of an urban farm.

Revenue possibilities

Resulting from the product categories that were identified, a list can be made of the possibilities how to generate revenue in urban farming. These revenue possibilities connect the profit formula to the CVP. Table 7 lists these revenue possibilities.

Table 7, Revenue possibilities

<table>
<thead>
<tr>
<th>Revenue possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lease PGSs</td>
</tr>
<tr>
<td>2. Sale of PGSs</td>
</tr>
<tr>
<td>3. Sell low-profit margin products</td>
</tr>
<tr>
<td>4. Sell high-profit margin products</td>
</tr>
<tr>
<td>5. Sell high-profit margin products for healthcare market</td>
</tr>
<tr>
<td>6. Integration in city cycles</td>
</tr>
<tr>
<td>7. Product purchase subscriptions</td>
</tr>
<tr>
<td>8. Combine location with hospitality options</td>
</tr>
<tr>
<td>9. Hybrid model</td>
</tr>
</tbody>
</table>
Economic data

As brought forth in the methodology section, an NPV analysis was performed by using the data from an urban farm realized by a consortium in Japan. Using this data might reveal the economic activities that influence the costs in the business model element profit formula and provide information on which processes and resources are related to urban farming. Included in this farm are a number of items that are also taken into account in the calculations. These items and associated numerical data are briefly elucidated in table 8 on the next page.

Table 8, Information urban farm (Shimamura, 2012)

<table>
<thead>
<tr>
<th>Item Type</th>
<th>Item</th>
<th>Elucidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Building size</td>
<td>1,100 m² (total production area: 4,536 m²)</td>
</tr>
<tr>
<td></td>
<td>Crop</td>
<td>Lettuce (10,080 heads produced per day, 10% loss)</td>
</tr>
<tr>
<td></td>
<td>Crop price (Japan)</td>
<td>€ 4,35 converted from Japanese prices</td>
</tr>
<tr>
<td>Investment</td>
<td>Building</td>
<td>New construction</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>Utility set up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Irrigation systems, lighting systems, others</td>
</tr>
<tr>
<td>Operating costs</td>
<td>Salaries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials</td>
<td>Packaging material, seeds, lights, fertilizer</td>
</tr>
<tr>
<td></td>
<td>Utilities</td>
<td>Energy use and water use</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depreciation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other costs</td>
<td>Maintenance, consulting</td>
</tr>
</tbody>
</table>

In the cost analysis, a number of assumptions were done in the determination of the NPV and the PBP:

- It is assumed the building costs are similar to the building cost in the Netherlands.
- Apart from a 10% loss, it is expected all products that are produced are also sold. This assumption is also used in the reference Shimamura (2012).
- Rounded costs were used. As the financial data is used to provide a brief overview of the costs and revenues, the costs were rounded and not calculated to the precise euro.
- An exchange rate from Japanese Yen to Euro was used on March 1st 2013. (1 Euro = 121,42 Yen). For this, an exchange rate website was used
- As mentioned, only one type of crop was produced. This is also based on the available data from the reference Shimamura (2012).
- The crop price was that of Japanese products. Considering the revenue, it is assumed that Japanese are willing to pay more than €4 for a lettuce head. Lettuce heads is the Netherlands are a lot cheaper but as the data is literally copied; the Japanese crop price is used.
- In the calculations a discount rate of 4.62 was used for the Netherlands (EC, 2013)

Appendix H depicts the NPV analysis for the urban farm. A total profit € 39,685 (NPV) is made over a period of 15 years (PBP almost 15 years). This figure indicates that the profitability of urban farming at this moment is up for questioning. The PBP is also depicted in Appendix H and notes almost 15 years. In conclusion, this doubts the attractiveness of investing in urban farming at this moment due to a high crop price and a long payback period in one invests in urban farming.

Besides an indication of the NPV and the PBP, the economic data provide a detailed overview of the costs that are associated with urban farming. The items listed in the middle column in table 8 depict this.
5.1.3 Key resources & key processes

The categories linked to the key resources and key processes are (1) economic data, (2) stakeholders, (3) location and (4) collaboration. The economic data, as explained above, gives an indication of the (sub-element) economic activities that are to be executed. These economic activities were categorized in section 3.2 as production, process and distribution activities. As mentioned, the middle column in table 8 gives an overview of these activities. The stakeholders are related to these activities as well as partnerships and alliances and were found to be divided in three categories. Location possibilities logically related to the sub-element location. The collaboration section is related to the sub-elements collaboration activities and partnerships and alliances.

Stakeholders

Among the mentioned stakeholders, a distinction was made between stakeholders on the supply side, the installation and operation side, and the demand side of the business. Of the fifteen interviewees, ten recognized the important role of the (local) authorities when it comes to realization of urban farming. Not only because of the necessity to adapt the legislation and regulation for urban food production (Pr.EN.#1, Ac.NL.#2, Ac.NL.#3), the facilitation of the necessary processes (Mu.#1, Mu.#3), bring together of the required parties (Mu.#3) but also in general the responsible party for the food supply of an urban area. Therefore, the (local) authority interfaces with the supply side, the installation and operation side, and the demand side of urban farming.

The role of universities and research institutions in the business (model) of urban farming is somewhat dispersed when the answers of the respondents are compared. A primary role, as is the same in other areas of research, is reserved for the collection and documentation of knowledge (Ac.NL.#2). Other interview data suggests a role for universities and research institutes in the development of LED lighting systems (Pr.EN.#1), advanced grow systems (Ac.NL.#3) and aquaponics systems (Pr.NL.#2). But, a number of respondents don’t envision these parties being involved in any way in the urban farming business because there are also commercial organizations that can produce these necessities (Pr.NL.#3, Pr.NL.#1, Ac.NL.#5). They believe no significant new knowledge from universities is required for urban farming. On the contrary, a lot of research that was done in the past was in collaboration with universities (Pr.NL.#1, Pr.EN.#1, Pr.EN.#2, Pr.EN.#3), especially abroad. Due to the fact that significant amounts of data have not yet been registered and this data seems to be crucial if one intends to get investors for commercial business on board (Pr.EN.#1, Pr.EN.#3), a supporting role in the registration process of this data seems to be reserved for universities and research institutes. One has to keep in mind though that in the Netherlands; the funding of research nowadays often requires collaboration with commercial organizations (Ac.NL.#2). Impersonation of the supply side as well as the installation and operation side thus seems obvious.

Apart from the stakeholders mentioned above, multiple interviewees executing different professions envision the supply side to consist of technology producing and developing stakeholders such as Siemens, Philips and Orbitec. Especially regarding the lighting, respondents indicate that progress in being made in the energy efficiency of the lighting but are not at the preferred level yet. Further, real estate owners and developers are important players on the supply side as are the suppliers of for instance the seeds of crops and fertilizers.

On the installation and operation level, a wide variety of stakeholders were named, varying from entrepreneurs, distribution parties, installers, energy supplying companies, an experienced cultivation organization, construction companies, and employees (operators). These employees could be engineers, agronomists, volunteers, interns, full time employees (FTE’s), reintegrated prisoners or reeducated long-term unemployed citizens.

Competition, when reviewing the interview data, seems to depend on the processes that occur within the urban farm. If only production takes place within the urban farm, traditional farming firms and food producing greenhouses are likely to be the main competitors. Once the products are sold at the production location, every store or market that sells comparable products becomes competition. If distribution is also done by the owner of the urban farms, distribution organizations
also become competitors. Competition may even come from restaurants, cafes or bars if a hospitality location is also directly connected with the urban farm and sells urban farming products. Local competition among urban farms only seems to exist in the city of Chicago in the USA (Pr.EN.#1). Table 9 lists the results for this section.

Summarizing, stakeholders are necessary on the supply side and the demand side of urban farming. Besides this, stakeholders are also recognized for the installation, operation and maintenance of urban farming.

<table>
<thead>
<tr>
<th>Stakeholder categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Supply side stakeholders</td>
</tr>
<tr>
<td>2. Installation, operation and maintenance stakeholders</td>
</tr>
<tr>
<td>3. Demand side stakeholders</td>
</tr>
</tbody>
</table>

Location

Several aspects regarding the location of an urban farm were brought up by the interviewees. The use of empty buildings was one of these. Theoretically, this type of solution would solve two problems. Deserted office space or empty buildings used for other purposes in the past could be filled with food production systems and these buildings would be given a new life. Also, buildings are located in urban areas, enhancing the local food production ideas. Pr.EN.#1 and the accompanied firm are already utilizing these opportunities and thereby distinguish it from rooftop farmers: “What we do, we take older buildings that are pretty much abandoned and rent them for extremely inexpensive prices and then we build and grow inside those buildings, so it is a completely artificial environment”.

Another possibility for the production location would be to automate it as much as possible. The main advantage that comes with the use of for instance robotic elements, is that humans cannot contaminate the production, an issue raised by interviewee Ac.NL.#5. Furthermore, by automating parts of the production process, an often large part of the operational cost, namely labor cost, can be minimized. This is confirmed by interviewee Pr.EN.#2, saying: “It’s the solution not to have too many employees because it’s a big cost”. This might compensate the relatively low profit margin that urban farming products possess.

Another cost-reducing measure could be to sell the products at the same location as where they are produced. Logically, distribution cost would be prevented. This distribution part of the value chain of products in traditional agriculture requires early harvesting moments, affecting taste and nutritious content of the products and in general is costs a company money: There is a lot of cost involved to get the product from the farmer to the customer” (Pr.EN.#2). On top of that, it seems a realistic side issue because the urban farms are (to be) located in cities where most of the consumers are settled and grocery trips are part of dwellers’ habits.

As explained in the previous section, one of the product possibilities is PGSs. Besides usage in homes and hospitality firms, multiple devices might even be suitable as food production sites in empty or partly occupied buildings. These PGSs could even solve temporary vacancy concerns because they only have to be transported to the location and no further adaptation of the location in necessary. Large occupied office buildings could even reserve a floor for this type of local food production which would allow them to produce extremely fresh products and contribute to its sustainability image.

Because of its location inside a densely populated area, the urban farm could be integrated into the various cycles that are present in a city or could be established in the future. Theoretically, this was described by McDonough and Braumgart (2002) as the Cradle-to-Cradle principle. One of the possibilities is to utilize abundant heat flows in a city, a goal of Pr.NL.#2 and Pr.EN.#2. This would require collaboration with energy producers, consumers and distributors in a city. According to the vision of Pr.EN.#2: “Company X is a part of the sustainable cities concept and this means that our ......
will never be stand alones and they will be integrated with energy companies and so in the city”. Multiple academics addressed the integration in waste streams. By doing this scarcely natural resources such as phosphate could be retrieved. “There are only two countries in the world that excavate phosphate on a reasonable scale, China and Morocco. It is predicted that we will run out of phosphate earlier than we will run out of fossil fuels. Phosphate is however a crucial building block for agricultural plants, which simply cannot be without” (Ac.NL.#4). Recycling of minerals was also mentioned as a feasible option in this course of action. Separated waste, both from the urban farm, or from other parts of the city could also be used to generate energy by incineration. Table 10 lists the results for this section.

Summarizing, urban farms could be located inside empty buildings. Further issues identified regarding the location are the possibility to automate production and sell the products at the production location. Further, PGSs could be installed at various locations. A final category concerns the ability for the location to be integrated in the cycles of a city as mentioned in the introduction.

Table 10, Location possibilities

<table>
<thead>
<tr>
<th>Location possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inside empty buildings</td>
</tr>
<tr>
<td>2. Automate production</td>
</tr>
<tr>
<td>3. Sale on location</td>
</tr>
<tr>
<td>4. Application private grow systems</td>
</tr>
<tr>
<td>5. Integration in city cycles</td>
</tr>
</tbody>
</table>

Collaboration

Many respondents appoint the lack of grounded production data for the ‘indoor’ production processes and the inference to experiment more as an argument to engage in collaborative activities (Pr.EN.#1, Pr.EN.#2, Mu.#1, Ac.NL.#2). Interviewee Pr.EN.#3 refers to this data as “Standard Operating Procedures” (SOPs). If these are composited by aggregating knowledge, multiple parties making similar mistakes could be prevented. Simultaneously, respondents Ac.NL.#2 and Pr.EN.#3 point out that public research funding institutions oblige other, mostly commercial organizations, to account for part of the funding cost and that this is also necessary for the urban farming The analysis of the interview data revealed that a platform to encourage for example entrepreneurship in urban farming does not exist in the Netherlands (yet) (Ac.NL.#1, Ac.NL.#3). However, the necessity to generate a platform is acknowledged by multiple respondents (Mu.#1, Pr.NL.#1, Pr.EN.#1, Pr.EN.#2, Ac.NL.#1, Ac.NL.#3), for instance: “I think the available knowledge has to be shared if we want to achieve something on the short term” (Pr.EN.#1). Opposite to collaboration opportunities, various respondents also recognize the fact that a commercial organization’s primary goal is to generate income and exposing knowledge may eventually result in a lack of income because competitors utilize your knowledge for their personal goals (Pr.EN.#3, Ac.EN.#1). In the literature this is referred to as Arrow’s information paradox (Takenaka, 2008). Another interviewee believes collaboration should occur solely to rearrange the supply chain for urban farming products because it is drastically different from the current (food) supply chain (Pr.NL.#1).

Some respondents believe the opinion and knowledge of the public should be integrated in urban farming activities, referring to this as “the wisdom of crowds” (Mu.#1), “citizen science” (Pr.EN.#3) or “the innovative power of the citizens, the emancipated exploratory citizen” (Ac.NL.#4). Remarkably, these interviewees come from all three ‘backgrounds’. Respondent Mu.#2 even believes an open source model involving consumers should be used to find the right SOPs for urban farming products. Table 11 lists the results for this section.
Summarizing, collaboration could be initiated to gather data for growing urban farming products, to speed up the development of the technologies required for urban farming and to establish a platform for knowledge exchange. Finally, collaboration could be done with customers and consumers.

<table>
<thead>
<tr>
<th>Reasons for collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To gather data</td>
</tr>
<tr>
<td>2. To speed up development</td>
</tr>
<tr>
<td>3. To establish a platform and exchange knowledge</td>
</tr>
<tr>
<td>4. To utilize crowd</td>
</tr>
</tbody>
</table>

### 5.2 Scenarios

The data revealed that urban farming is nowadays subject to a number of impediments. These impediments are discussed in the next section. Removing or mitigating these impediments in combination with the incentives to engage in urban farming caused by non-humanly caused changes might lead to number of opportunities. These opportunities are discussed after the impediments section. Using this information and other collected data, the scenarios could be constructed and the changes for urban farming in these scenarios could be determined. The final section of this section (5.2) elaborates on this.

### Current impediments

The lack of data logically also creates an impediment for growth in urban farming. This lack of data is a mutual result of the lack of pilot projects. The necessity of these pilot projects is emphasized by Pr.NL.#2: “Another view from financiers is required. A couple of exemplary projects are necessary for this. At the moment that a clear business case exists, banks will provide capital sooner”. This is confirmed by Pr.EN.#1, explaining: “A test lab has to be opened and a miniature urban farm built to prove to investors that it works”. Mu.#3 further explains that in a city like Amsterdam, a pilot project will let dwellers and the urban environment in general become familiar with this new type of production, calling this ‘the finding of the hype’. In other words, there should be room for experimentation.

Another impediment of urban farming is the lack of the need of consumers to purchase these products. In other words, the current food system is accepted as it is. An aggregate number of arguments related to this issue came from the respondents. When looking specifically at the Netherlands, its food security level is extremely high. It is even at a level that together with the US and France, the Netherlands had been ranked as possessing the highest level of food security (Mu.#1). Besides, when looking from a global perspective, there seems to be enough arable land still available. A quote from interviewee Pr.EN.#2: “As long as there is arable land and there is soil for food production, people will produce on land, but a shortage will occur in the future”. Zooming in on Europe, the EU is responsible for the food supply of its nations. Thus, the whole of Europe is viewed as one and as a result, room for experimentation is harder to realize compared to a situation where there is more a more decentralized food strategy (Mu.#2), which is the situation in China, where the mayor of a city is responsible for the food strategy of that city (Mu.#2). In the current food system, beans are cultivated in Kenya and shipped to for instance the Netherlands. Although these might create excessive fossil fuel consumption (because these beans could also be produced in the Netherlands), Pr.NL.#3 stated: “Beans from Kenya are harvested by hand, this creates employment and thus makes the story more complex than just the production”. This is complemented by Ac.EN.#1: “Beans from Kenya go to the UK but help the Kenyan economy”.

The disruptive character of new products or services is associated with a longer adoption period, as history tells us. When looking at other industries than urban farming, it sometimes takes 30 years to reach a significant production level. Combined with the statements regarding the current
A current problem addressed both by national (Pr.NL.#2) and international (Pr.EN.#1) interviewees is the fact that current regulations are totally not aligned with the urban farming activities. Pr.EN.#1: “A lot of cities in the US are not adjusting their laws and codes to the fact that UF exists”. Respondent Ac.NL.#1 states the following about the history of this potential hazard for implementation: “Modernism is cities ……means that things are clearly and efficiently separated. With urban farming, you talk about the paring of two fundamentally different parts, a city and farming. This houses a complexity…”. Moreover, regulative and governmental adaptations can create incentives for urban farming. Something alike happened in Singapore where the government decided that the local food production percentage had to increase from 5% to 15%, creating financial incentives for new production methods (Ac.NL.#3). Table 12 lists the results for this section.

The impediments could be removed or mitigated by human activities. For instance, research into the SOPs or facilitation of the implementation of urban farming using subsidies. Besides this, natural forces like global climate changes could create incentives for engagement in urban farming activities. Combining the two factors above creates opportunities for urban farming. These opportunities are discussed in the next section, distinguishing national from international opportunities.

Summarizing, the lack of data interrelated with the lack of pilot projects together form an impediment for urban farming. Further, the established food system forms an impediment as well as the predicted length of standardization to produce food from urban farming. Further, current regulations have been found to not be accommodated for urban farming.

<table>
<thead>
<tr>
<th>Table 12, Current impediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current impediments</td>
</tr>
<tr>
<td>1. Lack of data</td>
</tr>
<tr>
<td>2. Lack of pilot projects</td>
</tr>
<tr>
<td>3. Threats from current system</td>
</tr>
<tr>
<td>4. Length of standardization</td>
</tr>
<tr>
<td>5. Regulative adaptations and facilitation</td>
</tr>
</tbody>
</table>

National opportunities

The national opportunities cover the urban farming potential in the Netherlands. According to Ac.NL.#1, the potential arises from the current threats that exist around urban farming in the Netherlands. “There lie the chances of the success or failure of developing realistic urban farming”. This is, as stated earlier, supported by interviewee Ac.NL.#4, who believes one should look at uncertainties in the future to determine the opportunities of urban farming.

Interestingly, the link with healthcare was acknowledged by three respondents, all of whom academics (Ac.NL.#2, Ac.NL.#3, Ac.NL.#4). The ability to control the environment and the content of the products cultivated in urban farming opens perspectives towards this sector. However, a more profound substantiation of how this link could be established could not be given by any of the academics. On the contrary Practitioner Pr.NL.#3 stated: “sprouts contain a very high content of antioxidants, this is something you can play with”. Respondents Pr.NL.#1 and Pr.EN.#3 complement the importance of controlling this content, alluding to guaranteeing certain amounts of nutrients in products and thus being able to control the sugar content of the product.

Another opportunity links urban farming to (integrated) area development and redevelopment according to multiple interviewees. Currently in the Netherlands, there exists stagnation in this (real estate) market and this creates chances for urban farming. The use of empty buildings was already explicated as a possibility for future production location. Next to this, every city has wasteland where urban farming could be housed. This wasteland, in many cases, already

[47]
contains one or more buildings that could be redeveloped for urban farming. Respondent Mu.#2 talks about utilizing urban farming to increase the value of parts of the city. Regulatory facilitation could oblige developers to reserve an area for urban farming activities in. Consecutively, Ac.EN.#1 mentions the possibility to incorporate food production into the expansion of a city, something that is not happening nowadays.

The emergence of a niche market for urban farming products in the Netherlands was an obvious opportunity, also in relation with the current situation regarding food production (as is explained in the next paragraph) (Ac.NL.#5). This niche market would focus on products like mushrooms (Ac.NL.#3). “In the Netherlands the focus should be on high-quality, nutritious and tasteful products” (Pr.NL.#1)

International opportunities

The high level of food security (Ac.NL.#3, Mu.#1) in the Netherlands caused by the well-developed food production industry and a climate that allows diversified food production on arable land are grounded arguments to look cross the border when it comes to the opportunities for urban farming. Likewise, the Netherlands doesn’t possess any real metropolitan cities nor is it expected that cities in the Netherlands are going to grow into metropolitans in the future, something that increases the potential of local food production (Ac.NL.#2). Areas where the impact of climate change is influential on food production might also increase incentives for UF: “I think with climate change, we have to protect our crops. Already today there is more rain where it is raining and it is more dry where it is dry” (Pr.EN.#2). Moreover, the population growth up to nine billion people in the year 2050 (Pr.NL.#1, Ac.NL.#2, Ac.NL.#4). This is accompanied by a loss of fertile soil in the world of 50% (Ac.NL.#4), a growing gap between the global consumption and the available resources (Ac.NL.#1, Pr.EN.#1) and the urbanization trend creating another 10.000 cities worldwide in the next 40 years (Pr.NL.#1, Ac.NL.#2).

From a global perspective, an ever present problem is the distribution of food and food security. Whereas most Western countries drown in the immense amounts of food that are available, there are many locations in the world where the quest in food is a daily matter for survival. The ability to create an artificial climate creates opportunities in parts of the world that are for instance very much dependant on import of food. Countries and regions named are located in the “Global South” (Mu.#1), the Middle East (Mu#2, Pr.EN.#3, Ac.NL.#3), Africa (Pr.NL.#1, Ac.NL.#4), Russia (Ac.NL.#3, Pr.EN.#3, Pr.NL.#1), China (Mu., 2 Ac.NL.#3, Ac.NL.#4, Pr.NL.#1), Japan, (Pr.EN.#1, Pr.NL.#3), India (Pr.NL.#1), Sweden (Pr.EN.#2) and the USA (Ac.NL.#3, Pr.EN.#1, Pr.EN.#3). In some of these areas, there is a limited amount of arable land for food production. In other areas, there is a (upcoming) lack of fresh water or the climate conditions make food production on land impossible. If these current conditions are associated with global trends like climate change, population growth in certain areas or reduction of availability of fossil fuels, an increased need for urban farming may be created.

The Netherlands was mentioned multiple times as being a potential prominent player in urban farming due to the cultivation knowledge (Ac.NL.#5) and the innovating knowledge economy (Ac.NL.#1). “We are already developing technologies. Dutch greenhouses are an export product just like lighting and seeds….if we keep doing this opportunities will remain” (Ac.NL.#5). Academic Ac.NL.#3 complements: “I hope we can use urban farming as a ‘high-tech’ country as a nursery for new technologies”. From this, it can be concluded that if urban farming will not develop onto a significant scale in the Netherlands, it doesn’t mean that there is no role in the development of this industry for the Netherlands.

In the current food system, every average Western meal travels 3000 km and for every calorie that we produce, ten calories of fossil fuels are necessary (Ac.NL.#4). Also, beans produced in Kenya are consumed here (in the Netherlands) while we are very capable of producing them ourselves (Pr.NL.#2), just like we are consuming apples in winter times that are grown in New Zealand (Ac.NL.#4). There exists a big problem in the distribution of food worldwide (Mu.#2).
Moreover, there is a certain dependence on this evolved system that bears its risks. For instance, once a German doctor revealed in the media that the EHEC-bacteria came from Dutch cucumbers, the whole Dutch cucumber industry nearly went bankrupt (Mu.#2).

**Scenarios for urban farming & future opportunities**

Section 4.3.5 elaborated on the selection for the GBN-matrix for scenario prediction. This indicates the necessity to come up with two axes in which polarities are depicted. To keep an initial broad focus on the possibilities for polarities, three types of references were used. The first set of polarities is derived from the megatrends as formulated by Siemens in their strategic documentation (Siemens, 2011a). These are considered because these megatrends are based on thorough analysis by Siemens of the future, consider a wide range of impacts that the trends may have, and due to the fact that this document is partly written for Siemens, connects to the company. Adaptation of the megatrends resulted in the polarities 1-4. The second set of polarities is based on the statements from the respondents in the interviews. Especially the answers to the final question regarding the urban farming scenarios were examined in detail. This resulted in the polarities 5-11. The final polarity is based on the literature review conducted prior to and during the writing up of this thesis. Being a related subject to the main topic and a sub-research question in this thesis, open innovation is also considered. Again, the topic is adapted to become usable as polarity. Table 13 presents a list of all the considered polarities

<table>
<thead>
<tr>
<th>1. Urbanization vs. Rurality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Demographic changes vs. Constant demographics</td>
</tr>
<tr>
<td>3. Globalization vs. Localism</td>
</tr>
<tr>
<td>4. Climate changes vs. Climate remains unchanged</td>
</tr>
<tr>
<td>5. Necessity local food vs. Food origin unimportant</td>
</tr>
<tr>
<td>6. Public support for UF vs. No public support for UF</td>
</tr>
<tr>
<td>7. Short term market demand vs. Long term market demand</td>
</tr>
<tr>
<td>8. Nationalistic food strategies vs. International food strategies</td>
</tr>
<tr>
<td>9. Real estate market picks up vs. Real estate market remains stagnated</td>
</tr>
<tr>
<td>10. Fossil fuel prices increase vs. Fossil fuel prices stagnate</td>
</tr>
<tr>
<td>11. UF as part in I.A.D.* vs. UF marked as isolated in a city</td>
</tr>
<tr>
<td>12. UF pursues open innovation model vs. UF pursues closed innovation model</td>
</tr>
</tbody>
</table>

*Integrated Area Development

On the X-axis in the matrix, the growth of cities is depicted. This axis overarches the polarities 6 and 9 as will be explained. The left side of the matrix represents the stagnation of the growth and establishment of cities. In other words, equilibrium exists in the number of people entering a cities and the number of people leaving cities. Hence the term: ‘Equilicities’. The right side of the X-axis figures urbanization, a trend simultaneous with global population growth (Goudie, 2005; Despommier, 2009) and recognized by Siemens in their strategic documentation (Siemens, 2011a). Interviewee Pr.NL.#1 stated: “In the next forty years, another 10000 cities are going to be built”. This urbanization trend is believed to be region specific, in other words, in Europe a lot of cities are believed to stagnate in growth in the upcoming decades whereas cities in regions in Asia are believed to grow exponentially (Siemens, 2011a). The crucial role of the authorities in a city is confirmed by interviewees Pr.EN.#1, Ac.NL.#3 and Ac.NL.#2. Logically, this axis is selected because the degree of urbanization influences the potential of urban farming. Here it is assumed that a larger urbanized area has a greater necessity for urban farming.
The Y-axis represents the distinction between the expectations regarding the technological development of urban farming. This ‘Market Pull-Technology Push’-axis overarches the polarities 4, 5 and 10. The top of the axis envisions the need from the market for urban farming. This need may be a result of increasing ‘regular’ food prices which may be caused by predicted climate changes (Goudie, 2005) or reduced availability of fossil fuels (Goudie, 2005). Also, consumer willingness to be more independent and increased sustainable consciousness may influence the market need. Another argument for a distinction in the development of the urban farming is the radical character, brought forth by interviewees Pr.NL.#1, Pr.EN.#3. Therefore, there exists uncertainty in the adoption of urban farming. It is possible that the disruptiveness of urban farming won’t be able to influence the standardized current food system. In a situation in which there is no direct market demand for innovations, a ‘technology push’ situation may occur. The market could also signal the need for something new and by doing this, new solutions to a problem may be developed. This is called a ‘market pull situation (Tidd, Bessant & Pavitt, 2005). Figure 10 on the next page visualized the GBN-matrix for urban farming, substantiated by factual references and remarks by interviewees. The next section discusses each of the four scenarios.

The first scenario was named ‘Gradual Adjustment’ and is a combination of a need from the market for urban farming products in non-growing cities. The need from the market could come from more environmentally conscious consumers or adaptation of rules and regulations to produce food for the city in a more sustainable way. However, because cities in these scenarios are not experiencing significant growth, urban farming has to be integrated in the existing locations and processes of a city. This implementation phase is expected to take some time, hence the name ‘Gradual Adjustment’. Prosperous Western cities are expected to fall in this scenario. The second scenario goes by the name ‘Collective Necessity’. This scenario visualized a situation in which there is a combination of market need and urbanization. Thus, in growing cities there arise opportunities for urban farming. This is expected to make the implementation phase a lot easier. Because regulative parties will also stimulate the implementation, a situation in which there will be a ‘Collective Necessity’ for urban farming is expected. Countries or regions in which exponential urbanization is occurring in combination with a climate that does not allow for traditional agriculture are predicted to fall under this scenario.

The third scenario is referred to as ‘Trendy Niche’. This scenario presents a combination of no direct market need for urban farming products and stagnating growth of cities. In this situation, the technologies required for urban farming will evolve gradually and it is expected urban farming will capture a niche market. One can think of an exclusive image that will arise for urban farming. A lack will of market need will however never give urban farming a ‘commodity status’.

The fourth scenario was named ‘Stimulated Share’. This scenario marks the combination of an urbanization trend and a lack of market need. Due to this urbanization trend, a regulative stimulant for urban farming will arise but the lack of customer need will slow the development and adoption of urban farming. Therefore a market share will be gained in time due to governing support but this will take time. In the findings section, this information will be used to answer sub-research question 2 regarding the influence of the scenarios on urban farming.
Figure 10, Scenarios
6. Discussion

This section will discuss the research questions posed in the introduction. A discussion on the main findings is followed by the academic implications and the managerial implications of the research. The final section elaborates on the limitations of this thesis and indicates avenues for future research.

6.1 Findings

This thesis was initiated in order to investigate how a business model can be composed in order to create value and capture value from high-tech urban farming. Further investigation intended to examine if an open innovation approach is to be included in this business model. Also, an inquiry into which scenarios could emerge that might affect urban farming in future was executed. Each element from the conceptual model will be discussed separately in the next paragraphs. Following this, the findings on the scenarios will be reviewed.

The business model

The element CVP in the conceptual model consists of the sub-elements products and customer. Regarding the products, this thesis focused on the cultivation of crops for food purposes (p.24). Results confirmed the cultivation of crops for food purposes. Regarding these food products, two categories were found. One category embraces food products with a low profit margin like salad. The other category embraces products with a relatively high profit margin. Examples of this kind of products are herbs and sprouts. These two categories confirm the focus of the patented stackable containers for indoor crop production by Hessel, et al (2003). Also, three kinds of customers were identified in this research: regular customers and retail, hospitality firms and customers in the healthcare sector. Hospitality firms emerge as a specific customer for more exclusive products, probably also having a higher profit margin. This latter type of customer connects to a new type of product for which urban farming could be deployed. Because in high-tech urban farming, humans are able to control the ingredients in the cultivation process, adding a specific nutrient might stimulate the presence of certain substances in crops which might in turn stimulate in curing diseases or preventing the vulnerability for certain diseases once consumed by humans. This product category seems to open up a whole new area of research. Therefore, it will be further discussed in the section indicating avenues for further research. The final type of product, the private growth system, also emerges as a completely unidentified category. These products are not food but rather miniature, personalized systems in which food can be cultivated. These systems could for instance be installed in houses of hospitality locations for personal food production. However, research indicated that these systems are still pretty much in their ‘pilot’ phase.

Another key finding related to the customer value proposition is the apparent lack of social acceptance regarding urban farming (products). In the Netherlands, this seems to be caused by a solid incumbent food system. However, if urban farming products could be offered at competitive prices or the necessity for local products arises, the ‘job to be done’ for customers would become more attractive. The application of education to shift consumption trends to more locally cultivated products was also acknowledged by Grewal & Grewal (2012, p.9).

The element profit formula in conceptual model distinguished revenue and costs. Revenue consists of the products and the scale of production whereas costs are determined by the economic activities. The research indicated a number of revenue possibilities as was depicted in table 7. An important finding here is that multiple revenue possibilities are advised to be combined in a hybrid model. A logical argument for this is the relatively low profit margin that can be obtained from food products as well as the necessity for a variety of food products from consumers. Further, purchase guarantees could be obtained by for instance product purchase subscriptions. By selling (or leasing)
PGSs, one would probably be able to receive a higher profit margin. Further, Despommier (2009) also illustrated a hospitality location in his artist impression of an urban farm (see also Appendix A). On the cost side of the profit formula, it was found that integration in city cycles (like energy, water or waste cycles) could diminish the production cost. Inclusion of hospitality was also acknowledged by Despommier (2009; 2011a; 2011b), although he did not specifically associate this with cost reduction. The results from the economic data analysis provided an overview of the investment and operations in a real-life urban farm. Although Despommier (2009) also depicted parts of the operations in his artist impression, the economic data overview provided a more detailed picture of which costs and the quantity of the costs. Furthermore, the results of the economic analysis showed that an urban farm can be profitable but using a relatively high price for products and taking in mind that the investment in such an urban farm is not very profitable and has a relatively long payback period. Currently, it can be assumed unthinkable that dwellers are going to pay more than €4 for a crop of salad (see also table 8. To a certain extent, this confirms the current skepticism towards urban farming elucidated in the introduction (Bomford, 2010; Monbiot, 2010). However, if technological development can result in a reduction of the production cost, urban farming may indeed become a ‘regular’ profitable business in the future. From the findings explained above, it can be derived how to create value in a business model for urban farming.

The other two elements in the conceptual model are the key resources and the key processes. The findings for these two elements are discussed together due to the fact that there is a lot of overlap in what they consist of. In the conceptual model, these elements consist of the sub-elements economic activities, location and collaboration activities. As mentioned, the economic data analysis provided a somewhat detailed overview of the activities associated with the production. Therefore, this gives an idea of the economic activities that have to take place. What the research does not indicate though is which activities for instance may be outsourced (because this saves costs). Neither do the results for example indicate how much what kind of equipment costs. On the contrary, table 8 does give an idea of how many products can be cultivated on what surface.

Multiple stakeholders and associated resources were identified and categorized in (1) supply side stakeholders, (2) installation, operation and maintenance stakeholders, (3) and demand side stakeholders. Which stakeholders are for instance related to which economic activities still remains somewhat unclear, although various assumptions can be made here. For example, the construction of the building is outsourced to a construction company. One key stakeholder worth mentioning is the local authorities, as was also mentioned in the literature (Silverman, 2013). The local authorities can facilitate the implementation of urban farming by easing the current regulations and thus removing certain impediments. Besides this, the local authorities could also assist in creating a more socially accepted status of urban farming products. Another key stakeholder that emerged is technology companies. Traditional agriculture often makes optimal use of the sunlight as a free energy source in the cultivation process. Replacing this source with artificial sunlight immediately increases energy consumption and energy cost. Technology companies therefore possess a crucial role in increasing the artificial lighting efficiency and associated reduction in energy costs and consumption. Furthermore, technology companies could fulfill a role in the development of automated cultivation processes explained below.

Regarding the location, research confirmed the use of empty buildings as production locations (Despommier 2009; Despommier, 2011b). This could turn out be a serious opportunity in the Netherlands because there is currently a lot of vacant space in buildings (De Volkskrant, 2013). Further, the acknowledgement of automated production is confirmed by Hessel, et al (2003) and the integration of the location in city cycles is confirms the literature by Despommier (2009). Application of private grow systems to fill for instance empty floors in buildings and use these for large-scale purposes emerges as a new possibility for a location. As mentioned, including a hospitality place in the location for sale on location was brought forth in the research.

The final set of findings concern collaboration possibilities for urban farming. In line with the choice for a ‘Triple Helix’ approach among respondents, the findings also suggest that each of the three parties should play a role in the development and implementation of urban farming. Results
further denote that the feasibility of urban farming and with this the profitability is accompanied with a number of challenges. A collaborative approach between all three parties in the triple helix therefore seems to be the direction in which this research points to tackle the challenges. In line with the necessity to produce data concerning the SOPs, production of scientific knowledge through integration of industry-government-university relation seems logical (Leydesdorff & Etzkowitz, 1998).

Besides this, a key finding indicates the preference of customer involvement in the development of urban farming. Information of customer involvement in the literature seems to be unavailable but the results foresee this involvement with justified demand of necessary products and increasing the social acceptance among the public. Also, the development of the PGSs could be accompanied by users. In line with what was written by von Hippel (2001, p.6), “manufacturers cannot know what a user wants to the depth and detail that the user does”. Huston & Sakkab (2006) also recognized this customer involvement in Proctor & Gamble’s innovation model. When combining the developmental challenges ahead, the lack of available data about the SOPs and the preferred customer involvement, a collaborative approach towards urban farming seems inevitable. With the current high R&D cost and relatively short product life cycles (Chesbrough, 2006), the quest for the SOPs and the customer preferences, a collaborative, open approach should be integrated in the business model. This also answers and confirms sub-research question 1. On top of this, results in the social acceptance section confirmed the radical character of high-tech urban farming, also recognized by Reinato et al (2006). Often, disruptive, radical innovations take a significant amount of time to be dispersed among customers and the life cycle is estimated to last much longer than incremental innovations (O’Conner, 2005). According to O’Conner (2005, p.4), “If discoveries can be sourced from external parties as well as internal groups, and the innovation required to nurture those discoveries into business opportunities becomes more interactive with market and technology partners sooner, the lifecycle of RI can be substantially shortened.” Thus, the speed of radical innovations can be increased if a more open model is pursued.

Summarizing, from the findings explained above, it can be derived how to capture value in a business model for urban farming. Together with the elements CVP and profit value representing the value creation, this research has provided detailed information on what, to the extent of the research, the business model for urban farming consists of.

Scenarios

The final set of findings concerns the future opportunities for urban farming. The GBN-Matrix distinguished two types of developments that are likely to influence the future opportunities for urban farming: the growth of cities and the development of urban farming related to market need. In countries or regions where cities are not growing any more on a significant scale it is predicted urban farming is harder to implement compared to cities that are still growing considerably. Not only will it be easier to implement urban farming in new to-be built parts of a city, but authorities in cities that are growing are expected to be more concerned about their city’s food strategy and thus are more likely to have an open attitude towards urban farming. Many Western cities, especially in the Netherlands are believed to be categorized as stagnating in growth, opposed to the arising and enlarging cities in the BRIC-countries (Brasil, Russia, India & China). The second type of influence depicts the technology push-market pull contraposition. Whether urban farming gains a position in the market due to consumer need or a technology evolution leads to a market share has an impact on the future of urban farming and the speed of development. Increasing health consciousness among dwellers of threats to the current food system could influence the market need whereas omittance of these circumstances may result in a slower, more niche market future for urban farming. Generally, and keeping in mind that there are technological challenges ahead, the largest opportunities will emerge in regions where cities are growing and consumers will in time purchase urban farming products instead of regular agriculture products. Obviously, authorities may influence this market demand through subsidies etc. In regions where the current food system is characterized
by a stable and guaranteed supply of agricultural products, is it predicted the urban farming impact will be limited. Here, a niche market may be captured. A niche market or a broader, regular consumer market will logically affect the business model for urban farming as will the speed of technology development to meet the challenges ahead. Summarizing, national opportunities will emerge in a niche market and international opportunities allow for a more large-scale production in the future.

In final conclusion, research confirmed the necessity to include all four elements of the conceptual model in the business model for urban farming. Regarding the products, a clear distinction can be made between actual food products and miniature ‘personalized’ growing systems (PGSs). Moreover, an open innovation approach is recommended to meet the technological challenges, create the required SOPs, and increase the awareness and acceptance of urban farming products among consumers. Illuminating on the future opportunities, the growth of cities and accompanied governmental support as well as market need are found to influence the creation of opportunities in urban farming.

6.2 Academic Implications

The findings described above have several implications for academics. First of all, high-tech urban farming can be considered a relatively new topic, when looking at the amount of academic articles that have been published and their publication date. However, the available knowledge has indicated that urban farming is, as a sustainable solution for the future, an interesting research domain for food security. The knowledge from this research can therefore be used for future research in urban farming.

Second, a ‘design science’ research design was used for the composition and evaluation of a business model in this thesis. Using this design in business model research implicates that composition of a business model in other industries can also be applied to perform thorough and structured research.

Third, the research demonstrated that whenever technological development plays a role in the opportunities of an industry, an open innovation approach should be considered to tackle the technological development challenges, especially in current times with shorter product life cycles and higher development cost.

Fourth, the scenario analysis also contributed to this research. Whenever upcoming industries are studied, a scenario analysis could be considered to rule on the opportunities in an (upcoming) industry. Nonetheless, a scenario analysis will never be able to guarantee what is going to happen in the future.

6.3 Managerial Implications

Multiple implications can be extracted from this thesis for managers. Primarily, this research shows that urban farming in a profitable way is possible. Although the research was limited to only one crop and a relatively high price was requested for the product, it is feasible to grow products in an artificial environment and thereby guaranteeing various substances in the content of urban farming products. The performed research showed a number of products from which revenue could be created. Here, a clear distinction was made between food products and technology products. Due to an overall low profit margin on food products, managers should also consider the development of PGSs. Research also implied a combination of (edible) products (and technologies) could determine the CVP for consumers. Managers should take this into account when composing their business model for urban farming.

In the general sense, research implied that an open innovation approach should be considered if managers intend to perform business activities in an upcoming industry and that these
activities should be included in the business model. Specifically for high-tech urban farming, manager should consider the local authorities as a collaboration partner. Discussions on the necessary regulative adaptations to implement urban farming could be a start. Results implicated another possible partner, particularly in the developmental phase, namely the end consumer. In case of the edible products, this would imply engaging with consumers in their preferred product combinations that could be offered. Or, customers could be involved in the marketing of products, illuminating the advantages of urban farming products over others. Also, getting in contact with Asian urban farmers could provide useful collaborations.

Zooming in on the previously unidentified product category healthcare products, managers (in for instance the pharmaceutical sector) could consider investigating how the content of urban farming products could be stimulated to cultivate health-enhancing products as a new industry division. Again, collaboration with experts in plant cultivation seems obvious here.

Finally, the use of scenarios might be more useful for managers than academics as academic research is often more concerned with studying the past or the present instead of the long-term future. Managers in more strategic positions however, could use the implications of the scenarios analysis to consider whether to invest in urban farming activities in specific regions of the world.

6.4 Limitations and Avenues for Further Research

The performed research is subject to a number of limitations. These limitations though introduce a number of avenues for future research. First of all, research and the interviewees were limited to Dutch and English publications and speakers, respectively. Research on the contrary pointed out that a lot of investigation in urban farming is currently being performed in Asia in the nations Japan and South-Korea. A linguistic barrier limited access to this information as well as the possibility to engage researchers from these areas in an interview. Cross-national research with the mentioned nations, possibly even using an interpreter might be optional for the future.

Secondly, a limited amount of data has been published up till now concerning the subject of urban farming. This may question the validity of the research performed here although respondents from multiple countries and backgrounds were utilized. Limitations in the data availability are specifically the case when it comes to the possibilities to link urban farming with healthcare, something mentioned by multiple respondents but lacked concreteness. The content of urban farming products could be researched in order to find out which substances could be influenced that could for instance enhance the curing process of patients or tackle more general societal problems like obesity. Cultivation of herbal medicines may even be considered. Theoretically, flower require the same ingredients as edible plants to grow, indicating that research into ornamentals might be reveal the feasibility of growing these in artificially controlled climates.

Thirdly, the choice for (almost) pure qualitative research limited the possibility to perform quantitative research among dwellers to reveal their vision and willingness to purchase urban farming products. This could be further expanded to actual involvement of consumers in the development process of urban farming products. Other quantitative research could illuminate the willingness or vision of technology companies to participate in urban farming development in the future. Fourthly, previous research and results from this thesis discussed the possibility to integrate urban farming in water, waste or energy cycles in an urban area. Specific research into quantities has not been performed and may provide a more detailed overview into these opportunities.

Finally, a scenarios analysis always contains questionable aspects as it intends to elucidate future situations. Especially in this thesis their validity can be compramnted because of the limited amount of previous publications in this thesis. Cross-sectional and longitudinal data could further examine this at a later stage.
7. References

7.1 Publications


Veenhuizen, R., & Danso, G. (2007). *Profitability and sustainability of urban and periurban agriculture*. FAO.


### 7.2 Online Resources


Appendix A: impression of a high-tech urban farm

Figure 11, A high-tech urban farm (Despommier, 2009)
Appendix B: urban farming techniques

1. Hydroponics
Hydroponics is a cultivation method in which plants grow without the use of soil. Instead, the plant’s roots are suspended in, flooded with or misted with the nutrient solution that a plant requires to grow. Hydroponics offers the ability to grow plants in places where traditional agriculture cannot take place. Hence, plants can be grown in many different places. Further, hydroponics uses about 10% of the water that is needed for traditional agriculture. Hydroponics also offers a shorter harvesting time (Turner, n.d.). Figure 9 depicts a hydroponics system.

![Figure 12, Hydroponics (WordPress, 2012)](image)

2. Aeroponics
Aeroponics is sometimes referred to as a variant of hydroponics as it is also a water based system. With aeroponics, plants are suspended on a tray and their roots dangle below. Beneath the tray a closed area in which mist containing water and nutrients is sprayed continuously, which the plants can then absorb. This technique embraces similar advantages as hydroponics (Turner, n.d.). Figure 10 depicts an aeroponics system.

![Figure 13, Aeroponics (Harwood, 2012)](image)
Aquaponics

In an aquaponics system, the cultivation of plants in combined with the production of fish. The effluent from a fish tank, containing fish manure, algae and decomposing fish feed is nutrient rich and is therefore used as liquid fertilizer to grow plants. These plants are often grown hydroponically. The hydroponic beds function, in turn, function as bio-filter so freshly cleansed water can be recirculated into the fish tanks (Diver, 2006). Figure 11 depicts an Aquaponics system.

![Aquaponics System Diagram](Wordpress, 2012)
Figure 15, Company structure (Siemens, 2011b)
## Appendix D: Business Model Definitions

<table>
<thead>
<tr>
<th>Definition</th>
<th>Reference</th>
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<tbody>
<tr>
<td>“A business model depicts the design of transaction content, structure, and governance so as to create value through the exploitation of business opportunities”</td>
<td>Amit &amp; Zott (2001)</td>
</tr>
<tr>
<td>“A business model provides a coherent framework that takes technological characteristics and potentials as inputs, and converts them through customers and markets into economic outputs”</td>
<td>Chesbrough &amp; Rosenbloom (2002)</td>
</tr>
<tr>
<td>“A business model consists of four interlocking elements that, taken together, create and deliver value. These elements are customer value proposition, key resources, key processes and profit formula”</td>
<td>Johnson, Christensen &amp; Kagermann (2008)</td>
</tr>
<tr>
<td>“An operating business model is the organization’s core logic for creating value. The business model of a profit-oriented enterprise explains how it makes money”</td>
<td>Linder &amp; Cantrell (2000)</td>
</tr>
<tr>
<td>“A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets”</td>
<td>Morris, Schindehutte &amp; Allen (2005)</td>
</tr>
<tr>
<td>“A business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences.”</td>
<td>Osterwalder, Pigneur &amp; Tucci (2005)</td>
</tr>
<tr>
<td>“A business model described the rationale of how an organization creates, delivers and captures value”</td>
<td>Osterwalder (2009)</td>
</tr>
<tr>
<td>“A business model describes the logic of a ‘business’ system for creating value that lies behind the actual process”</td>
<td>Petrovic, Kittl &amp; Teksten (2001)</td>
</tr>
<tr>
<td>“A business model is a blueprint for the way a business creates and captures value from new services or products”</td>
<td>de Reuver, Haaker &amp; Bouwman (2007)</td>
</tr>
<tr>
<td>“A representation of a firm’s underlying core logic and strategic choices for creating and capturing value within a value network”</td>
<td>Shafer, Smith &amp; Linder (2005)</td>
</tr>
<tr>
<td>“The essence of a business model is in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit”</td>
<td>Teece (2010)</td>
</tr>
<tr>
<td>“An architecture for the product, service, and information flows, including a description of the various business actors and their roles, and a description of the potential benefits for the various actors, and description of the sources of revenues”</td>
<td>Timmers (1998)</td>
</tr>
<tr>
<td>“A description of the roles and relationships among a firm’s consumers, customers, allies and suppliers that identifies the major flows of products, information and money, and the major benefits to participants”</td>
<td>Weill &amp; Vitale (2001)</td>
</tr>
</tbody>
</table>
Appendix E: reviewed business models

The diverging definitions on business models have resulted in multiple components. Alt & Zimmerman (2001) were among the first to compound the components into six generic components into a ‘common denominator’ (Alt & Zimmerman, 2001, p.5). These six components are listed below and also depicted in figure 7:

- Mission
- Structure
- Process
- Revenue
- Legal Issues
- Technology

Figure 16, A business model by Alt & Zimmerman (2001)

Hedman & Kalling (2003) propose that every business model should contain seven causally related components. These are (1) customers, (2) competitors, (3) offering, (4) activities and organization, (5) resources, (6) supply of factor and production inputs. The seventh component covers the dynamics of a business model over time and is therefore referred to as a longitudinal process component. The model, as can be viewed in figure 8, integrates firm-internal aspects that transform factors to resources. This is done by various activities which in a structure which in create offerings and products that can be introduced in the market.
The components that should be part of a business model could also be divided into primary components like mission, target market, value proposition, resources, key activities, value chain and cost and revenue model and underlying components. The underlying components outline the wider business and social environment for implementation. Environmental factors in this case are market trend, regulation and technology. Integrating these components results in the generic framework depicted in figure 9. This framework was generated after a literature review on the components (Paleti & Giaglis, 2003).

Morris, Schindehutte & Allen (2005) state, based on a literature review, that a business model is a framework in which three increasingly specifying levels of decision making are worked out. These levels are (1) the foundation level, (2) the propriety level and (3) the rules level. The foundation level must address six questions. These are:

1. How do firms create value?
2. For whom will the firm create value?
3. What is the firm’s internal source of advantage?
4. How will the firm position itself in the marketplace?
5. How will the firm make money?
6. What are the entrepreneur’s time, scope and size ambitions?

The propriety level concerns the creation of unique combinations of the earlier established components. The final, rules level, then specifies the guiding principles to ensure that the elements from the previous levels are reflected in outgoing strategic actions. (Morris, Schindehutte & Allen, 2005)

Another business model discussed in the literature review is one made up nine building blocks (Osterwalder & Pigneur, 2009). Here, a business model does not include competition because it is not an internal part of it, although it is obviously related. The nine building blocks are displayed in figure 10. As figure X shows, the nine blocks are divided over four areas of a business, namely infrastructure, offer, customer and finance.

![Figure 19, A business model by Osterwalder & Pigneur (2009)](image)

The final business model discussed is one by Chesbrough (2003) and depicted in figure 11. This business model is displayed as a cognitive map across different domains, the technical domain and the social domain. Challenges for managers active in highly technical and uncertain markets need to connect these new technologies to (new) markets in order to pursue opportunities.

![Figure 20, A business model by Chesbrough (2003)](image)
Appendix F: interview questions

1. General questions

1. Can you briefly tell us about yourself and your organization?
   a) What is your function within the organization?
   b) In which business unit are you active?

2. What components are essential for the construction of the general business model for urban farming regarding:
   ➢ Technologies/equipment;
   ➢ Partners;
   ➢ Customers;
   ➢ Suppliers;
   ➢ Processes;
   ➢ Information channels.
   a) Why are these components essential?
   b) Can you prioritize these components?

3. Which stakeholders are likely to become part of the general value chain for urban farming? Why these specific stakeholders?
   ➢ Customers
   ➢ Competitors
   ➢ Suppliers
   ➢ Research institutes
   ➢ Universities
   ➢ (Municipal) government(s) (officials)
   ➢ Distributors
   ➢ Owners
   ➢ Investors
   ➢ Employees
   a) Can you prioritize these stakeholders?

4. What is your vision towards the establishment of a general open business model for UF?
   a) Why do you think this would/would not be applicable?
   b) What is your opinion on the establishment of an innovation and communication platform for integration of disciplines and exchange of experiences for UF?

5. What are, according to you, the biggest threats and opportunities UF faces? (repeat most important points)
   a) Why?
2. Specific questions for practitioners

1. What are, according to you, the primary general steps for the establishment of a potential new industry like UF? \textit{(repeat most important points)}
   a) Can you elaborate on those steps?
   b) What do these steps implicate for you as a practitioner?

2. What is your vision towards the following aspects of an urban farm and why do you think these options are feasible/unfeasible:
   a) Integrated use of renewable energy technologies (solar panels or windmills on the roof, WKO-installations, biomass processing plant)
   b) The capture of CO\textsubscript{2} (either from industry and transported through pipelines or from outside the buildings)
   c) A processing plant for the products inside the building

3. Which technologies are necessary for implementation of an urban farm?
   a) What is function of these technologies?
   b) How can the acquisition and installation of these technologies be facilitated?
   c) How can the current relatively high cost of the required technologies be reduced?

4. What kind of crops do you think, when looking at economics and technological possibilities, can be (best) produced inside buildings?
   a) What is the influence of the crop choice on the design of the facilities necessary for UF?
   b) What kinds of crops are not attractive to cultivate inside buildings?

5. Regarding customers, what is your vision on the primary market segment urban farmers should focus on?

6. What could be possible scenarios in the general development of UF? \textit{(repeat most important points)}
   a) In what way should the business model be adapted to these scenarios?
3. Specific questions for academics

1. What is your general opinion on urban farming?
   a) Why?

2. Which other purposes could urban farming have in a city? (repeat most important points)
   a) Could you elaborate on these purposes?

3. What is your vision on urban farming as a key option for integrated area development in urban areas in the distant future?
   a) Why?

4. What is your vision on the long term for commercial implementation of urban farming?
   a) What do you think of the role of the Netherlands as experimental location for UF for future exportation?

5. What kind of crops do you think, when looking at economics and technological possibilities, can be (best) produced inside buildings (using artificial lighting)?
   a) Why are these crops suitable?

6. What could be possible scenarios in the general development of UF? (repeat most important points)
   - Scale
   - Countries
   - Governmental support
   b) In what way should the business model be adapted to these scenarios?
4. **Specific questions for municipal officials**

1. Which role would a municipal government have in the value chain/business model of UF?  
   a) Why would the municipal government have this role?

2. What kind of regulatory obstacles could the implementation of UF encounter? *(repeat most important points)*  
   a) How could these obstacles be dealt with?

3. What could be the role of the municipal government in the first steps or facilitation of an upcoming new industry like UF?  
   a) Could you give an example of how the municipal government acted in the beginning stages of another industry?

4. Which other purposes could urban farming have in a city? *(repeat most important points)*  
   a) Could you elaborate on these purposes?

5. What is your opinion on the possibilities for a pilot project (in the Amsterdam region)?  
   a) Would you explain that further?

6. What could be possible scenarios in the general development of UF? *(repeat most important points)*  
   - Scale  
   - Countries  
   - Governmental support  
   c) In what way should the business model be adapted to these scenarios?
Appendix G: analysis method

*Categories (phase 1 analysis)*

- (t) types business models
- (p) products, general
- (usp) unique selling points
- (l) location
- (c) collaboration, general
- (i) integration, general
- (f) finance, general
- (d) distribution
- (s) standardization necessity
- (o) ownership
- (e) education
- (ap) automated production
- (sb) stakeholders buildings
- (sc) stakeholder consumers
- (sot) stakeholder research & development
- (ss) stakeholder supplier
- (sv) stakeholder volunteer
- (se) stakeholder education
- (so) stakeholder operators
- (sco) stakeholder competitor
- (sf) stakeholder financier
- (sd) stakeholder distribution
- (s.entre) stakeholder entrepreneur
- (sm) stakeholder municipal government
- (sci) stakeholder citizens
- (sh) stakeholder healthcare
- (sr) stakeholder restaurants
- (sho) stakeholder horticulture industry
- (cu) collaboration universities
- (cd) collaboration disadvantages
- (cc) collaboration crowd
- (ca) collaboration advantages
- (cp) collaboration platform
- (cst) collaboration with city
- (csc) collaboration supply chain
- (kc) opportunities from collaboration
- (ks) opportunities, strategic
- (ksl) opportunities from integration in city (closing, integration of cycles)
- (kco) opportunities consumer
- (kst) opportunities in city
- (kp) opportunities products
- (ka) opportunities general
- (kon) opportunities outside the Netherlands
- (kh) opportunities healthcare
- (kNed) opportunities in the Netherlands
opportunities, business
opportunities through necessity
opportunity municipal government
opportunities food security
opportunities food security
opportunities education
opportunities direct link consumer producer
opportunities empty buildings
opportunities job creation
niche market opportunities
cultural/social integration
integrated area development opportunities
threats, implementation
threats from market
threats from city
threats current system
threats from finding financiers
threats municipal limitations
threats from other systems
necessity pilot
necessity data
processing of products on location (packaging etc)
products, insects
products, vegetables
products, herbs
products, pharmaceuticals
products, fish
products, chickens
products biofuels/energy raw materials
products, fruits
products, mushrooms
products that can be cultivated in the shadow
products using a minimum amount of energy
products not suitable
products, exclusive
products, flowers
customers, regular
customer, restaurants
customer, specific
customer, retail
role R&D in the Netherlands
private grow systems
multiple opportunities
revolutionary character UF
necessity multiple carriers
link with healthcare
recreation/tourism
city purchasing power

Total: 93 categories
Category reduction and merging (phase 2 analysis)

All categories listed directly under a ‘new’ underlined term are from this part on fall under this term

(t) types business models
(p) products, general
(usp) unique selling points
(l) location
(c) collaboration, general
(i) integration, general
(f) finance, general
(d) distribution
(s) standardization necessity
(o) ownership
(e) education
(ap) automated production
(cu) collaboration universities
(cd) collaboration disadvantages
(cc) collaboration crowd
(ca) collaboration advantages
(cp) collaboration platform
(cst) collaboration with city
(csc) collaboration supply chain
(ci) cultural/social integration
(bi) threats, implementation
(bm) threats from market
(bs) threats from city
(bcs) threats current system
(bf) threats from finding financiers
(bml) threats municipal limitations
(bos) threats from other systems
(np) necessity pilot
(nd) necessity data
(pol) processing of products on location (packaging etc)
(cureg) customers, regular
(cures) customer, restaurants
(cusp) customer, specific
(curet) customer, retail
(rR&DN) role R&D in the Netherlands
(pgs) private grow systems
(mo) multiple opportunities
(rev) revolutionary character UF
(mc) necessity multiple carriers
(lh) link with healthcare
(re/tou) recreation/tourism
/cpp) city purchasing power

Stakeholders supply side
(sb) stakeholders buildings
(sot) stakeholder research & development
(ss) stakeholder supplier
Stakeholders installation/operation/maintenance side

(sf) stakeholder financier
(sm) stakeholder municipal government
(sho) stakeholder horticulture industry

Stakeholders demand side

(sc) stakeholder consumers
(sh) stakeholder healthcare
(sci) stakeholder citizens
(sr) stakeholder restaurants
(sd) stakeholder distribution

Opportunities outside the Netherlands

(kc) opportunities from collaboration
(ks) opportunities, strategic
(ksi) opportunities from integration in city (closing, integration of cycles)
(kco) opportunities consumer
(kst) opportunities in city
(kp) opportunities products
(ka) opportunities general
(kh) opportunities healthcare
(kb) opportunities, business
(ktn) opportunities through necessity
(kmg) opportunity municipal government
(kfs) opportunities food security
(kcc) opportunities controlled content
(ke) opportunities education
(kcp) opportunities direct link consumer producer
(keb) opportunities empty buildings
(kjc) opportunities job creation
(nm) niche market opportunities
(iad) integrated area development opportunities

Opportunities inside the Netherlands

(kc) opportunities from collaboration
(ks) opportunities, strategic
(ksi) opportunities from integration in city (closing, integration of cycles)
(kco) opportunities consumer
(kst) opportunities in city
(kp) opportunities products
(ka) opportunities general
(kh) opportunities healthcare
(kb) opportunities, business
(ktn) opportunities through necessity
(kmg) opportunity municipal government
(kfs) opportunities food security
(kcc) opportunities controlled content
(ke) opportunities education
(kcp) opportunities direct link consumer producer
(keb) opportunities empty buildings
(kjc) opportunities job creation
(nm) niche market opportunities
(iad) integrated area development opportunities

Products with a relatively low profit margin
(pv) products, vegetables
(pf) products, fish
(pc) products, chickens
(pfr) products, fruits
(pm) products, mushrooms

Products with a relatively high profit margin
(pe) products, exclusive
(pf) products, flowers
(ph) products, herbs

Products possible but that have not been produced up till now
(pi) products, insects
(pb) products biofuels/energy raw materials
(pPha) products, pharmaceuticals

Total: 50 (integrated) categories
Themes and patterns identification (phase 3 analysis)

The categories per theme are given in the brackets behind the various phrases

1. Impediments
   - Lack of data (nd, f)
   - Lack of pilot projects as proof (np, f)
   - Lack of necessity among consumers (bcs)
   - Length standardization (s)
   - Technological development (np, nd, cp)
   - City regulations

2. Products
   - Private grow systems (PGSs) (pgs)
     - To fill floors of buildings (keb)
     - To sell to consumers (+retail sale) (cureg, curet)
     - To sell to hospitality firms (cures, cusp)
     - For healthcare sector (lh)
   - Products with a relatively low profit margin (cureg, curet)
   - Products with a relatively high profit margin (cureg, curet)
   - Products possible but that have not been produced up till now

3. Collaboration
   - To gather data (cu, np, nd)
   - To realize pilot project (cu, np, nd)
   - To reach social acceptance (cc, cst, cp)
   - To speed up development (cp, cu)
   - To establish a platform (cp)
   - To utilize crowd (cc)

4. Stakeholder
   - Supply side
   - Installation/operation/maintenance side
   - Demand side

5. Business model types
   - Lease PGSs (t)
   - Product purchase subscriptions (t)
   - Lease space in buildings with PGSs inside (t)
   - Sale (and maintenance) PGSs (t)
   - Hybrid model (t)
   - Integration in city cycles (t)
   - Necessity multiple carriers (mc)

6. Social acceptance
   - Education (e)
   - Tourism (re/tou)
   - Necessity due to circumstances (ktn)
7. Location
- Use empty buildings (keb)
- Integration city cycles (ksi)
- Automate production (am)
- Sale on location (d)
- Use/ no use PGSs (pgs)

8. Opportunities inside Netherlands

9. Opportunities outside Netherlands
### Table 15, Net present value of an urban farm

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Table 15, Net present value of an urban farm.